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Contents

MPC1 Pure Core 1

General

The paper provided sufficient challenge for the very able candidates whilst at the same time allowing weaker candidates to demonstrate basic skills such as differentiation, integration, handling surds and completing the square. The non-calculator restriction caused difficulties for many who could not handle fractions or basic multiplication and division. It was pleasing to see many candidates well prepared for this unit and presenting their solutions clearly. Those who did not do quite so well might benefit from the following advice.

- The gradient of AB where A is (a, c) and B is (b, d) is $\frac{d-c}{b-a}$ and not the reciprocal of this expression.
- The straight line equation $y - y_1 = m(x - x_1)$ could often be used with greater success than always trying to use $y = mx + c$.
- The minimum point of $y = (x+p)^2 + q$ has coordinates $(-p, q)$.
- The only geometrical transformation tested on MPC1 is a **translation** and this word must be used rather than shift or move etc.
- When asked to use the Factor Theorem or Remainder Theorem, no marks can be earned for using long division.
- The condition for y to be decreasing at a given point is that $\frac{dy}{dx} < 0$ at that point and the condition for y to be increasing at that point is that $\frac{dy}{dx} > 0$.
- A quadratic equation has equal roots when the discriminant is zero ($b^2 - 4ac = 0$)

Question 1

Part (a)(i) Although most obtained the correct gradient, some omitted the negative sign (particularly those who relied on a sketch for their evaluation) and some had a fraction with the change in x as the numerator which immediately scored no marks. Quite a few found mid-points (possibly since that had appeared on previous examinations) and others added the coordinates instead of finding the differences in their quotient expression for the gradient.

Part (a)(ii) The use of their gradient to obtain the given equation was the most successful method. Those using $y = mx + c$ had a tendency to introduce a new 'c' by doubling both sides but then substituted their value back into the original equation. The most successful candidates used the formula $y - y_1 = m(x - x_1)$. Some re-arranged the given equation to check the gradient then checked one set of co-ordinates; others checked two points and indicated that a straight line has the form $ax + by = c$.

Part (b) Those using substitution often began by using an incorrect rearrangement of one of the equations. If they attempted elimination, sometimes only part of an equation was multiplied by the appropriate constant. Many added the equations instead of subtracting. Of those who wrote $14y = -7$, just as many obtained an incorrect answer of $y = -2$ as the correct answer of $y = -\frac{1}{2}$.

Part (c) The condition for perpendicularity was generally known but some were unable to evaluate –1 divided by – 1.5. A few omitted the – sign while some referred to the equation $3x + 2y = 17$ and gave a gradient of $-\frac{1}{3}$. Once again, those determined to use $y = mx + c$ often made errors in the constant due to the fractional coefficient of x. Quite a few did not use the point A as instructed, choosing to use the point C instead.

Question 2

Part (a) Many candidates began by finding the correct values of p and q . A few wrote $(x – 4)^2$ and some added 16 instead of subtracting 16 so $q = 35$ was sometimes seen.

Part (b) Very few chose to consider the expression they had in part (a). Practically all candidates decided to find the discriminant instead but its evaluation was often incorrect. Not everyone quoted the expression for the discriminant, $b^2 - 4ac$, correctly. Some attempted to refer to the fact that the curve was completely above the x-axis but did not, in general, complete their argument.

Part (c) The graphs here were disappointing. Although most drew a quadratic shape, there seemed to be little reference to their part (a) and many just tried to plot a few points. Most were able to state the intercept on the y-axis. However, sometimes the point (0.19) was shown as the minimum point or a straight line intercept. Several curves were drawn only in the first quadrant, regardless of whether the quoted minimum point was (–4.3) or (4.3).

Part (d) This was not well answered. The term **translation** was required but generally the wrong word was used or it was accompanied by another transformation such as a stretch. The most common incorrect vector stated was $\begin{bmatrix} 8 \\ -19 \end{bmatrix}$.

Question 3

Part (a) Most candidates answered this part correctly. A few included the 7 or thought the derivative of the first term was $7x$ and the – sign was sometimes lost.

Part (b) Many substituted $x = 1$ correctly, though it was apparent that they did not recognise this value of –10 to be the gradient of the tangent. Many correctly found y as 5 but stopped there. Again, some correct attempts at the tangent equation using $y = mx + c$ foundered and quite a large number attempted to find the equation of the normal.

Part (c) Use of the value of $\frac{dy}{dx}$ was the only acceptable method here. Evaluations of y at different points or finding the second derivative were common but earned no marks.

Question 4

Part (a) Almost everyone recognised that multiplication of the two brackets was required but there were numerous errors with $7\sqrt{5}$ instead of $12\sqrt{5}$ being common and –2 or –4 instead of –3. Although most dealt with the first term correctly and obtained 20, many added $12\sqrt{5}$ and $-\sqrt{5}$ wrongly to get $-11\sqrt{5}$.

Part (b) This part was answered more successfully with $\sqrt{\frac{75}{3}} - \sqrt{\frac{27}{3}}$ being the neatest method. Some failed to complete correctly from $\frac{2\sqrt{3}}{\sqrt{3}}$ to 2 and gave an answer of $\sqrt{3}$. A few went 'all round the houses' but got there eventually. Some tried to cancel out $\sqrt{3}$ but only considered one term in the denominator. Multiplying top and bottom by $\sqrt{3}$ caused some problems. A few attempted to combine the 2 terms in the numerator and wrote $\frac{\sqrt{48}}{\sqrt{3}}$ which of course is also an integer!

Question 5

Part (a)(i) Most candidates differentiated correctly. However a few made a slip or misread one of the terms.

Part (a)(ii) Although most managed to substitute 2 into their derivative some made numerical errors and some used y or the second derivative. Most who realised that they should equate their derivative to zero (or at least showed their intention though never inserting the = 0) then tried to factorise or use the formula (though it was clear that some did not recognise the quadratic equation as such). It was disappointing that the bracket $(3x–14)$ often produced the solution $x = 14$ instead of $\frac{14}{3}$, and the solution of $x = 2$ did not always appear.

Part (b)(i) The integration was also completed correctly by most candidates, although the $28x$ was occasionally wrong and some 'hybrid' processes led to terms such as $-\frac{20x^3}{3}$.

In part (b)(ii) almost everyone attempted to substitute 3 into their integral but their problems with the ensuing fractions often took pages to resolve, and although most ended 'magically' with the required answer there were many errors en route. A few substituted into the original expression for y instead of the integrated expression.

Part (b)(iii) This part was quite well done although again there were errors in evaluating both $\frac{1}{2}\times 21\times 3$ and $56\frac{1}{4}-31\frac{1}{2}$. Some candidates confused length with area and merely used Pythagoras`s Theorem to find the length of the hypotenuse of the triangle. Those who chose to integrate the equation of the straight line were sometimes successful but many made arithmetic errors.

Question 6

Part (a) Although many candidates showed that p(3) = 0, many lost a mark for failing to include a statement of the implication. Some candidates appeared ignorant of the Factor Theorem and used long division and therefore earned no marks in this part.

Part (b) Only about half of the candidates were able to complete this part, although most made an attempt. The term $x^2 - x$ confused some. A few failed to write a **product of factors** even though this was requested.

Part(c)(i) As the question requested the use of the Remainder Theorem, finding p(2) was the only acceptable method here. Many attempted long division and scored no marks.

Part (c)(ii) There were many full solutions either by multiplying out and comparing coefficients they are both valid methods or by using long division. The majority of candidates showed poor algebraic skills and were unable to find the correct values of a and b. No credit was given for stating the value of r obtained in part (i) unless the values of a and b were correct. Full marks were earned by able candidates who simply wrote down the correct values of a, b and r by inspection.

Question 7

Part (a)(i) It was apparent that some candidates had not covered this part of the specification and they made no progress. Most who had done so, earned the marks here. However a few wrote $(x+2)^2$ or even $(x–2)^2$ and then gave the centre as (– 2,0) Some managed to incorporate the 7 with the y term so wrote the coordinates of the centre as (2,–7).

Part (a)(ii) Most candidates were successful in finding the correct radius. However some forfeited one mark by 'meddling' with their equation and putting 18^2 or $\sqrt{18}$ on the right hand side of the equation.

Part(b) This part was rarely attempted. Even where a correct diagram was drawn, few recognised that the chord would be bisected. Many assumed that the triangle was right-angled at the centre of the circle. Others drew tangents instead of a chord.

Part (c)(i) Many made little progress here. However, it was good to see more able candidates coping well. A few fell at the final line writing (k–1) instead of (k+1); a few lost a mark by not introducing '= 0' as part of the equation of the circle and simply added '= 0' at the end of several lines of working so as to match the printed answer. Many made a slip in squaring (2k–x) and some made gross errors such as writing this as $4k^2 + x^2$ or $4k^2 - x^2$. Others 'simplified' the equation to $(x–2) + (2k–x) = \sqrt{18}$.

Part (c)(ii) Those candidates who made progress here needed both knowledge and algebraic skills and only a small minority completed this part correctly. However more earned some method marks. Use of the correct condition on the discriminant was required but some just tried to solve the equation using the quadratic formula or used ' > 0' instead of ' = 0'. A few attempts at completing the square were seen but most failed to equate the expression to zero.

Part (c)(iii) Many candidates who had made no progress in the rest of the question stated that the line would be a tangent to the circle; however several candidates wrote at length about various transformations and completely missed the point.

MPC2 Pure Core 2

General

Presentation of work was generally very good. Most candidates answered the questions in numerical order and completed their solution to a question at a first attempt. The vast majority of candidates appeared to have sufficient time to attempt all the questions in the 90 minutes.

Once again, too many candidates had not been reminded to complete the boxes on the front cover to indicate the numbers of the questions they had answered.

Teachers may wish to emphasise the following points to their students in preparation for future examinations in this unit:

- To show a printed value quoted to one decimal place it is necessary to write down a value to at least two decimal places.

- Write down formulae before substituting values. Use formulae which involve given information directly, for example, in Question 3(b)(i) since the common difference is given, use $S_n = \frac{1}{2}n\left[2a + (n-1)d\right]$ rather than $S_n = \frac{1}{2}n(a+l)$. When asked to show a printed result, ensure that the final line of the solution matches it. If the question asks for 'the value of n' only one value should be given in the final answer.

- The notation used in the formulae for the binomial series as printed in the formulae booklet should be understood.

- The correct terminology should be used when describing geometrical transformations. 'Translation' was required in Question 6(d)(i) and 'Stretch' was required in Question 8(a). 'Tr.' is not an acceptable alternative for 'Translation'.

Question 1

Most candidates were able to quote and use the correct formula for the area of the sector to obtain the printed answer for θ. In part (b), a higher proportion of candidates than last year realised that the perimeter of the sector included the two radii. Some weaker candidates quoted formulae from page 8 of the formulae booklet without understanding the meaning of them. For example, the'd' in '$A = \frac{1}{2}\int r^2 \mathrm{d}\theta$' was given the value 10 (presumably the length of the diameter).

Question 2

It was disappointing to find a significant minority of candidates not using the sine rule to answer part (a). Those candidates who used the sine rule frequently failed to gain the final mark because they did not indicate a more accurate value to justify why the angle was 23.2º correct to the nearest 0.1º. In part (b), many candidates were able to find the area of the triangle by quoting and using the formula $\frac{1}{2}ab\sin C$, although too many used the wrong angle, 23.2º, for C. Those who used $\text{Area} = \frac{1}{2} \times \text{base} \times \text{height}$ were less successful.

Question 3

Part (a) was answered well by either counting on or by using the formula for the nth term, u_n, of an arithmetic series as given on page 4 of the formulae booklet. However, it was surprising to see a significant number of candidates 'unable' to evaluate 1 + (9)6 correctly. Although some candidates used S_{10} instead of u_{10}, this type of error was less common than in previous years. Part (b)(i) was answered well by the average and better candidates but many answers to part (b)(ii) consisted of non-integer values of n or more than one value of n.

Question 4

The binomial expansion continues to cause candidates problems. Many candidates made a correct start to part (a) but then poor manipulation with signs and powers of 2 led to incorrect work. Some candidates quoted the formulae printed on page 4 of the formulae booklet but then showed a lack of understanding as '1.2' was interpreted as '$1\frac{2}{10}$' rather than '1×2'. Only the more able candidates were able to deal correctly with parts (b) and (c) with many others making the errors '$(2+x)^9 = 2(1+\frac{x}{2})^9$', '$(2+x)^9 = 2(1+x)^9$' or even, in part (c), ignoring the 2 completely. Some able candidates wasted time by finding the complete expansions in parts (b) and (c).

Question 5

This question on logarithms was answered better than questions on the same topic last year although this area of the specification continues to cause problems for candidates. Most candidates appreciated that $2\log_a 6$ is equal to $\log_a 6^2$ but then a significant number of candidates made the error of equating $\log_a 36 - \log_a 3$ to $\frac{\log_a 36}{\log_a 3}$. Examiners expected to see an intermediate stage between '$\log_a x = \log_a 36 - \log_a 3$' and the printed answer. In part (b), many candidates were able to write the left-hand side of the given equation as a single logarithm but then could not move out of logarithms. A significant number of answers did not involve the constant *a* or gave the answer as '$5y = 7^a$'. Although the question asked for *y* in terms of *a*, examiners condoned a final answer left as $5y = a^7$.

Question 6

This question proved to be a good source of marks for many candidates. Most candidates answered both parts of (a) correctly although the usual errors, $3^\circ = 0$ or $3^\circ = 3$ and $3^x = 27 \Rightarrow x = \sqrt[3]{27}$ were seen. The trapezium rule, required in part (b), was generally well understood although some candidates are still mixing up 'ordinates' and 'strips' or failing to use sufficient brackets correctly. Although many candidates scored well in parts (c) there were others in (i) who used the relevant law of logarithms incorrectly or others who failed to indicate that logarithms had been used at all. In (ii) not all candidates realised that a simple substitution of 13 for 3^x in $k = 27 - 3^x$ with evaluation was all that was required. Descriptions of transformations continue to pose a problem for candidates. Many candidates gained partial credit for their sketches but both marks were rarely awarded.

Question 7

This question also proved to be a good source of marks for many candidates. The examiners expected to see some intermediate evaluation before the printed answer was quoted in part (a)(i) after the substitution of 4 for *x* in the given equation. Most candidates gave the correct value for the power *k* although the wrong values $\frac{1}{2}$ and $-\frac{1}{2}$ were both seen in part (a)(ii). Candidates were generally able to differentiate the given expression to find the second derivative in part(a)(iii) but some believed that the sign of the *x* value rather than the sign of the second derivative determined the nature of the stationary point in (iv). In part (b) a significant number of candidates gave the equation of the tangent instead of the normal or used the gradient of the normal as −12. Finding the integral in part (c)(i) was well answered although, somewhat surprisingly, the integration of −7 caused as many problems as the integration of the other two terms. The final part of the question proved to be beyond many average candidates who forgot to insert the constant of integration in answering the previous part. The hint 'Hence', which should have suggested the use of the answer to (c)(ii) was not always picked up. It was not uncommon to see the equation of the curve given as a linear equation, normally the tangent at *P*.

Question 8

This question was answered badly by the majority of candidates. In part (a) the examiners required the word 'Stretch' and either the correct direction or the correct scale factor before awarding either of the two marks. It was not uncommon to see the wrong scale factor $\frac{1}{2}$ and the wrong direction (parallel to the *y*-axis). Many weaker candidates who attempted part (b) started by writing the incorrect statement '$x = \tan^{-1} 6$'. Many better solutions were spoiled by manipulation errors illustrated by $\frac{1}{2}x = 1.249,\ 4.3906. \Rightarrow x = 0.6245, 2.1958$. Part (c) was by far the worst answered part on the paper. Only a very few candidates realised that $\cos\theta = 0$ satisfied the given factorised form of the equation. The vast majority multiplied out the brackets and then cancelled the $\cos\theta$ factor. A mark was awarded to a significant number of candidates for knowledge of the identity ‘ $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ ’ in this part of the question.

MPC3 Pure Core 3

The examination was accessible to the majority of the candidates with few very low marks being seen. Many candidates appeared to have been well prepared, being able to score high marks. Candidates seemed to have managed their time well with few incomplete scripts seen.

General

Candidates should ensure that their calculators are in the correct mode in questions on numerical methods. Working should be to a greater degree of accuracy than the final answer if there is a given answer. Algebraic working should be precise with no ‘fudges’. Candidates should expect that an answer from one part of a question could be needed in another part of the question

Question 1

Part (a) This was well answered by the majority of candidates. Many fully correct responses were seen and if there were errors it was usually in the conclusion.

Part (b) Very few incorrect responses seen.

Part(c) Very well answered. Some candidates lost the final mark since they did not write their answer to 3sf. Other errors involved the use of an incorrect iteration $\sqrt[3]{x_n + 7}$.

Question 2

Part (a) This was very well answered by the majority of candidates. Where errors occurred it was where candidates left their answer in terms of *u* or failed to multiply by the derivative of 3*x.*

Part (b) This question proved difficult for many of the candidates although fully correct responses were seen. Most were able to achieve part marks for d*u*/d*x* = 2 and many realised they had to write the integral completely in terms of *u*. It was at this stage factors of $\frac{1}{2}$ were missing or d*x* was incorrectly replaced by d*u*. A few candidates who correctly evaluated the integral in terms of *u* failed to put the expression back in terms of *x*.

Question 3

Part (a) Those candidates who appreciated sec *x* = 1/cos *x* were usually able to evaluate the first answer of 1.37 radians. When candidates went on to complete this part correctly although 4.51 was a common error from $x+1.37$. Answers in degrees were not common but they were seen.

Part (b) This part was answered very well by the majority of candidates when the most appropriate trigonometrical identity was used when candidates changed the equation into one involving sin *x* and cos *x*, errors often did occur.

Part (c) Most candidates were able to successfully factorise the quadratic and many went on to complete the question correctly. Marks were lost by 'extra’ values within the range being given. Candidates were not penalised for extra answers outside the given range.

Question 4

Part (a) Candidates scored well on this question with many correct graphs seen. Problems that occurred were in the gradients of the graphs being parallel or failure to label the points (2,0) and (0,4).

Part (b)(i) The most successful candidates on this question were the ones who used $x^2 = (2x - 4)^2$. The solution of $x = 4$ was a common response seen on its own. A surprising number followed $3x = 4$ by $x = \frac{3}{4}$.

Part (b)(ii) The majority of candidates who obtained two values for x in part (i) were successful in obtaining the method mark for their extreme points but incorrect inequalities were seen.

Question 5

This question proved to be a good source of marks for many of the candidates. Its structure enabled candidates to progress even if they were unsuccessful with some of the parts.

Part (a)(i) Reasonably well done. Errors were with the derivative of e^{2x}. Common errors were e^{2x} and $2x\,e^{2x}$. A number of candidates added a '+ c' when they were differentiating.

Part(a)(ii). Usually correct, with errors, if seen, similar to those in the previous part.

Part (b)(i) The majority of candidates answered this correctly.

Part (b)(ii) Very well answered by the majority of candidates.

Part (b)(iii) Again very well answered with many totally correct responses. The major error apart from those who used the incorrect equation $e^{2x} - 5\,e^{2x} + 6$ was the evaluation of $e^{2\ln 3}$ which was often seen as 6 rather than 9. Possibly the evaluation of $e^{2\ln 2}$ as 4 was fortuitous for some candidates.

Part (iv) Similar to part (iii) with similar errors, the major one being the evaluation of $4e^{2\ln 3}$ as $4 \times 6 = 24$. This resulted in an answer of -6 and hence loss of accuracy marks.

Question 6

Many candidates lost marks on this question from careless work or failure to write answers to the correct degree of accuracy.

Part (a) Many candidates correctly used the mid-ordinate rule although the final accuracy mark was often lost for an answer of 4.078. Some candidates tried the trapezium rule and consequently scored zero marks.

Part (b)(i) Although many candidates obtained the correct method mark $\frac{dy}{dx} = x \times \frac{1}{x} + \ln x$, a significant number who reached this stage were unable to cope with $x \times \frac{1}{x}$ and equated it to 0, giving an answer of $\ln x$.

Part (b)(ii) Many candidates failed to realise the connection with the previous part. A significant number of candidates just wrote down the correct answer with no method indicated.

Part (b)(iii) Many candidates scored the method mark; some for the correct substitution and many for following through their answer to b(ii). Some candidates lost the accuracy mark for not writing the answer in exact form but going straight from (5ln5 - 5) – (1ln1-1) to 4.047. Surprisingly, a number of candidates could not evaluate -5 – (-1) correctly.

Question 7

Part (a) This was well answered by most candidates with many obtaining full marks. Where errors occurred it was mainly in the numerator of the derivative with incorrect signs.

Part (b) This was poorly answered with axes often not labelled. Graphs were often imprecise and did not show the asymptotic behaviour at $\frac{\pi}{2}$.

Part (c) Very well answered by the majority of candidates. Rounding again was an issue with a common incorrect answer of 4.90.

Question 8

Part (a) This was very poorly answered by the majority of candidates. Range is a topic that is not very well understood by candidates.

Part (b) This was reasonably well answered. Errors occurred where candidates, on interchanging *x* and *y,* tried to work with $x = 2e^{3x} - 1$.

Part (c) This was poorly answered by most of the candidates. Many candidates obtained the correct differentiation of the ln function but lost marks because they omitted to multiply by $\frac{1}{2}$. This resulted in the very common incorrect answer of $\frac{2}{3}$.

Question 9

Part (a) Reasonable attempts were made by most candidates.

Part (b)(i) Many candidates answered this correctly but there were many errors such as dividing by 2 first or writing $\sin^{-1} 2x$ as $1/\sin 2x$

Part (b) (ii) This part was usually answered correctly. The usual error was the inclusion of a negative sign.

In part (c) although some candidates gave fully correct responses the majority were only able to do the first part to get $\frac{dy}{dx} = \frac{2}{\cos y}$.

MPC4 Pure Core 4

General

The performance of candidates ranged from some excellent scripts with some candidates showing a sound knowledge and understanding of the specification, to scripts which indicated the candidates were poorly prepared as they demonstrated little knowledge and understanding. However, most candidates were able to show some achievement and others produced some high quality mathematics in response to all the questions. Most candidates attempted the questions in the order they were set on the paper, and most presented their work clearly. Some candidates had a tendency to leave a question unfinished and return to it later; or start a second attempt, not making it clear what their intended answer was. Candidates were penalised where such lack of clarity occurred. Most candidates attempted at least some of the parts of all eight of the questions.

Question 1

Part (a)(i) Most candidates correctly answered this; even those who did not usually went on to assume that $(x-2)$ was a factor of the polynomial.

Part(a)(ii) Most candidates were successful here, but those who used division rather than the requested factor theorem gained no credit as they had not answered the question. Similarly those candidates who just wrote $\mathrm{f}\left(-\frac{1}{2}\right)=0$ were penalised because without showing some arithmetic, they had not demonstrated the result; a conclusion interpreting the result of zero, was also required.

Part (a)(iii) the intention here was that candidates would use inspection, having found two factors in parts (i) and (ii). Although many did this, other candidates proceeded by division, either by a linear factor or the quadratic factor, and thus took more time than was necessary. Most candidates successfully factorised the polynomial, although methods, and thus the time taken, did vary considerably, some using $(ax+b)$ for the third factor, multiplying out and equating coefficients.

Part (b) Most candidates did this correctly, although some apparently could not factorise $3x^2-6x$ or went only as far as $3\left(x^2-2x\right)$, and either did some illicit cancelling or abandoned the attempt. A relatively large number of candidates interpreted "simplify" as meaning put the expression into partial fractions. Although this was accepted, it took a great deal of time-consuming algebraic manipulation to get the correct result, and few did so.

Question 2

Part (a) There were many errors made in both signs and coefficients in both the x and x^2 term. The common errors were $-3x$ and $3x^2$, the latter from $\frac{(-3\times-2)}{2}$. A coefficient of 10 was also seen, from 12/1.2, where the factorial had been misunderstood.

Part (b) Here the expectation was that candidates would replace x in their answer to (i) with $\frac{5}{2}x$ and many did so, whereas others just started again ignoring the 'hence'. Their answer was often inconsistent with part (a). A common error was poor notation, such as missing brackets in $\left(\pm\frac{5}{2}x\right)^2$ or failure to square the $\frac{5}{2}$. Those who did the latter, and showed no working, received no credit.

Part (c) Relatively few candidates could quote the range correctly, although most knew it was something to do with $\pm\frac{5}{2}$ or $\pm\frac{2}{5}$ which were used in an inequality or with a not equal to sign. Those who tried to work it out starting from $|x|<1$ were generally more successful.

Part (d) Although some excellent answers were seen, relatively few candidates could carry out the required manipulation of the indices correctly. Most realised they were to use their answer to part (b) but gave answers in which a, b and c were not integers, without apparently noting the fact. However, there were incidences of poor algebra, such $\left(\dfrac{4}{2-5x}\right)=2-\dfrac{4}{5x}$, whilst others managed to manipulate the given expression into a quadratic expansion.

Question 3

There were many good answers to this question, with full or nearly full marks.

Part (a) Partial fractions is an area that is generally known well, although the presence of the 3 led some candidates to make an error, some ignoring it altogether, and others not multiplying it by the common denominator. Some candidates simplified the given expression by dividing it out, which was perfectly valid. Those candidates who substituted $x=1$ and $x=\dfrac{1}{3}$ usually found the coefficients correctly; many candidates who chose to set up simultaneous equations by equating coefficients made an error.

Part (b) Virtually all candidates knew they were to use the partial fractions to do the integral and that it involved $\ln(3x-1)$ and $\ln(x-1)$, and very few nonsense "integrations" were seen. The common errors were in the coefficients with the $\dfrac{1}{3}$ from $3x$ being missed, or the coefficients given as fractions $\dfrac{1}{6}$ and $\dfrac{1}{4}$.

Question 4

This question in general was not done well. A lot of candidates indicated a poor knowledge of trigonometric identities and a lack of experience in manipulating them. The Specification states that the double angle formulae should be learnt.

Part (a) Although most candidates could recollect or work out the identity for $\sin 2x$ this was not the case for $\cos 2x$ where many variations on incorrect answers were seen; some were correct but not in the requested form.

Part (b) Candidates were given credit for attempting to use their versions of $\sin 2x$ and $\cos 2x$ together with $\tan x=\dfrac{\sin x}{\cos x}$. Those who started on the left hand side often omitted a common denominator of $\cos x$, some just putting it back into their work to get to the given answer. Those who started on the right hand side were generally more successful, but most candidates worked from both sides together, often making errors in their manipulations, such as omitting brackets and thus not multiplying out correctly. Many managed to make the two sides become equal after some invalid manipulation.

Part (c) Most candidates made the solution of this equation far more involved than was intended or is necessary. Few realised they could use the answer from part (b) and make use of, if $pq=0$ then $p=0$ or $q=0$ and thus write down the solutions, with little more work. Some candidates did write down some correct solutions with no working seen, which was accepted. Many manipulated either form of the equation, into sines and cosines often making errors and abandoning the attempt. Many derived the cubic equation $\sin x-2\sin^3 x=0$ or something close to it, but still did not realise that $\sin x=0$ was a solution. Of those who did get to correct solutions, the solution 225°, was often missing.

Question 5

Most candidates did well on this question, and even if some showed in part (a) that they apparently could not solve a quadratic equation, the implicit differentiation required in part (b) was generally done well.

Part (a) Most candidates substituted $x=1$ correctly, and solved the resulting quadratic equation, usually by factorising, although some attempted a solution by non quadratic techniques, and usually made an error.

In Part (b) Many clear derivations were seen here, although candidates often dropped a mark through not equating their expression to zero during the derivation. The other relatively common error was in the product rule, where some candidates were not convincing in their use of signs and whether or not $\frac{dy}{dx}$ was attached to a term.

Part (c) Most candidates successfully used the answer given to calculate the values of the derivatives, with some sign errors being made. Some used their own version of the derivative whereas some left the result in term of y, not realising they were to use the result of part (a).

Part (d) This part of the question defeated most candidates. Although most realised the derivative had to be set to zero, they could take it no further, and many who did write down $y - 6x = 0$ then couldn't see how to proceed. Some candidates actually "cross multiplied" to get $y - 6x = 2y - x$, usually before abandoning the attempt. Some candidates were convinced this part of the question was to do with the second derivative and did a great deal of work for no credit. Some used the given answer of $33x^2 - 5 = 0$ and solved it for x before abandoning or doing things such as substituting into the expression for the gradient.

Question 6

Most candidates gained some marks on the vectors question, particularly in parts (a) and (b)(i). Some candidates persist in using coordinate notation instead of components, and this was penalised.

In part (a) although the vector $\overrightarrow{OC}$ could just be written down, some candidates subtracted the zero vector before doubling the result. Virtually all candidates knew how to find the vector $\overrightarrow{AB}$, although sign and arithmetic errors were fairly common.

Part (b)(i) Most candidates did this successfully by first finding the vector $\overrightarrow{AC}$ and then calculating its modulus. Those candidates who did not show why they were squaring 3 and 4 to get the result, were penalised. In part (b)(ii), most candidates showed that they can calculate an angle between two vectors, but rather fewer showed they could choose the correct two vectors with the correct directions. The angle was given in the question as BAC and so candidates were expected to work with $\overrightarrow{AB}$ and $\overrightarrow{AC}$ or $\overrightarrow{BA}$ and $\overrightarrow{CA}$. Many candidates had a direction incorrect on one of these vectors, whereas many more used position vectors, or vectors where it just was not clear where they had got them from. Some candidates calculated the lengths of the sides of the triangle and used the cosine rule, often successfully.

Part (c) Answers ranged here from a well set out high quality demonstration of the result, to considerable illicit manipulation of vectors to get the given result. Most candidates knew a zero scalar product was involved, but many were not at all clear in what way. Here, and also in part (b), some candidates gave their evaluated scalar product in the form of a column vector, rather than as a scalar which is incorrect and was penalised. Some just worked with the vector $\overrightarrow{OP}$ but still managed to "derive" the result.

Question 7

Many full mark answers were seen to this question with candidates demonstrating confidence in solving the equation. Some lost the last mark, or two, through incorrect manipulation to the requested $y = f(x)$ form. Finding the value of the constant after inverting to $y = -\frac{1}{3x^2}$ was the common error. Poorer attempts showed no knowledge of the separation of variables technique, and candidates attempted to use integration by parts. Others made errors in the algebra, or in the integration or did not include a constant. Integrating $\frac{1}{y^2}$ to an expression involving a ln function was fairly common.

Question 8

Most candidates struggled with part (a) of this question, indicating inexperience, or non understanding, of the formulation of a differential equation from a context situation.

Part (a) Despite the question explicitly requesting a differential equation for $\frac{\mathrm{d}x}{\mathrm{d}t}$ many candidates just wrote down an expression for x.
A commonly seen differential equation was $\frac{\mathrm{d}x}{\mathrm{d}t} = kx$ which candidates then proceeded to solve, despite the question stating that a solution of the differential equation was not required. Of those who could translate the given information into correct symbols, a symbol t for time, often found its way into their expression, and then often in an exponential form. Many attempts using the exponential function were seen, suggesting many candidates associating anything to do with differential equations with exponential forms. Those candidates who did give a correct differential equation in part (i) usually found a correct value for the constant of proportionality k. However, there were also many attempts from a partially correct part (i) where the given values of 1000 and 200 were confused, the latter often being taken as a value of time. Other candidates put forward the incorrect argument that the population would be equal to 1200 at time $t = 1$.

Part (b)(i) Virtually all candidates scored at least one mark here; the common error being to round off 5.545 to 5.6 or not to round it at all.

Part (b)(ii) Many candidates solved this equation correctly, although it was not always clear just how they had done it. Most candidates used the technique as per the mark scheme, although some worked successfully from $\mathrm{e}^{30} = \left(\frac{4x}{5000 - x}\right)^4$. Of those who went awry, the error usually involved an incorrect manipulation of the logarithm expression, including ignoring the ln altogether, or stating $4\ln 4 = \ln 16$. Some started correctly with $7.5 = \ln 4x - \ln(5000 - x)$ but obtained $\mathrm{e}^{7.5} = 4x - (5000 - x)$. Others made relatively simple errors in signs or coefficients in their manipulation towards a solution.

MFP1 Further Pure 1

General

Most candidates were well prepared for the demands of this paper, though there was a sizeable minority for whom this was not the case. The level of algebraic competence was good, but candidates for this paper should be very familiar with simple binomial expansions such as that of $(1 + h)^3$, so that they do not have to spend time working them out in the stressful situation of an examination, with a consequent loss of time and a danger of making mistakes. Another algebraic skill which candidates should practise more is the extraction of common factors. In Question 3 it was noticeable that few candidates spotted the common factors n and $(n + 1)$, though they are present in nearly all questions set on this topic. In Question 9 part (b)((i) many candidates correctly obtained a discriminant $4(k - 1)^2 - 12(k - 1)$, but it was extremely rare to see a candidate using the common factors in simplifying this expression.

Question 1

This opening question provided most candidates with a very good start to the paper, with full marks or nearly full marks earned. It was pleasing to see that almost all candidates gave the correct values in part (a), with no sign error for the sum of the roots, and that a very large proportion of candidates were careful to insert a minus sign and 'equals zero' in their equation in part (c). In part (b) (i) some candidates wrote down the correct expansion, while others worked it out laboriously from first principles. Some failed to understand the word 'Expand' and instead gave simply a numerical value. An even more unexpected mistake was to quote, or rather misquote, a formula for $\alpha^3 + \beta^3$ and write the absurd statement $(\alpha + \beta)^3 = (\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta)$. Luckily for these candidates, only one mark was lost and the rest of the question was often completed successfully.

Question 2

For most candidates this was an 'all-or-nothing' question. Either they knew what to do and usually carried it out efficiently, or they appeared to have no knowledge of this topic. Some worked to only three decimal places throughout the question and lost accuracy in the final answer, which cost them one mark. Others carried out three incrementations instead of only two, and again the penalty was only one mark for this misunderstanding.

Question 3

Fortunately for those candidates who failed to extract the common factors, the algebra was not too heavy for them to expand both of the well-known expressions and to arrive at the correct answer without too much trouble. A mistake which occurred distressingly often was to 'drop' a numerical factor such as $\frac{1}{6}$, as if the candidates were solving an equation.

Question 4

Many candidates who performed well on the rest of the paper made serious errors here. Most candidates knew that a 'plus-or-minus' sign should come in somewhere, and likewise that a term $2n\pi$ was needed at some point, but combined these elements in a totally inappropriate way. Again, most candidates knew that division by 3 would be needed, but many performed this division too soon or, equivalently, failed to divide **both** of their terms by 3.

Question 5

Most candidates carried out the matrix multiplications accurately in part (a) of this question. In part (b) many candidates stated correctly that the required transformation was a rotation, but often gave the angle as 45º anticlockwise rather than clockwise. Attempts at part (c) were rarely completely successful. Many candidates found that $\mathbf{M}^8$ was the identity matrix but then went on to say that $\mathbf{M}^{2006}$ must also be the identity matrix. Others gave the same answer as in part (a) (i), or gave the correct answer without any indication as to their reason for doing so, or with incomplete reasoning.

Question 6

Part (a) of this question seemed to take many candidates unawares. They knew that the conjugate of z was $x - \mathrm{i}y$, but claimed that the conjugate of $z + \mathrm{i}$ was $x - \mathrm{i}y + \mathrm{i}$ or that it was simply $z - \mathrm{i}$. Most candidates were aware of the required approach to part (b). They expanded the right-hand side of the equation and then equated the real and imaginary parts, giving two simple simultaneous equations which they could solve. In many cases their efforts were marred by sign errors or by the omission of a 2 when expanding the term $2\mathrm{i}z$.

Question 7

In order to gain full marks in this question it was necessary to use the correct standard technical words 'stretch' and 'translation'. In part (a) most candidates did indeed use the word 'stretch', but very rarely with the correct scale factor. The candidates were not always familiar with the process of completing the square, but when they did carry out this requirement correctly they usually went on to give the correct transformation in part (b).

Question 8

This question tested three of the techniques in the calculus and numerical methods sections of the specification. Many candidates, though coping reasonably well with the algebra in part (a)(i), failed to apply the appropriate technique for differentiation from first principles in part (a)(ii). There was a much better success rate with the Newton-Raphson method in part (b) and with the use of an improper integral in part (c). A common mistake in the latter part was a confusion of signs leading to the value -1.

Question 9

Part (a) of this question allowed most candidates to earn marks, the examiners being lenient this time with regard to misuse of notation such as 'vertical asymptote = 2'. In part (b)(i) the majority of candidates were familiar with the required method, obtaining a quadratic equation in x and then considering the discriminant of this quadratic. Unfortunately many candidates made a sign error in manipulating the quadratic equation and so were unable to obtain the printed answer. It was distressing to see how often a candidate would falsely claim to have reached the answer legitimately.

Part (b)(ii) revealed much confusion in the minds of many candidates, who seemed to make a connection between 1 as a critical value of k and 1 as a value of x at the stationary point. Others went through two calculations, in effect repeating work already done earlier in the question, one leading to the conclusion that y could not be 1 on the curve, and the second leading correctly to the required point. Most attempts at the sketch of the curve in part (c) were either all correct or completely wrong. Occasionally a candidate would earn just one mark out of three for drawing a curve which approached the asymptotes in the correct way, or for drawing the middle branch correctly. It was not uncommon to see the middle branch completely omitted, presumably because it did not appear on the candidate's graphics calculator.

MFP2 Further Pure 2

General

The overall standard of response to this paper was good. There were many scripts scoring high marks and relatively few very poor ones. It should be stated, however, that in some in cases marks could have been increased had proper methods been shown. This applies particularly to the parts of the question paper where the answer is printed. Solutions where printed answers are given must have sufficient back-up by way of method to score full marks.

Question 1

Many candidates experienced difficulty in finding the values of A and B in part (a). They seemed to want to equate the left hand side of the identity to $\frac{C}{r}+\frac{D}{r+1}$, thus ignoring the fact that the powers of r in the numerator and denominator were equal. Generally the most successful candidates were those who rewrote the left hand side of the equation as $1-\frac{1}{r(r+1)}$ with the subsequent expressing of $\frac{1}{r(r+1)}$ in partial fractions. If candidates were successful in finding the values of A and $B,$ they usually went on to complete part (b) correctly. The main source of error in this part, if mistakes were made, was to overlook the fact that that the constant term, as well as the variable terms, had to be summed from 1 to 99. The constant term was often left as 1.

Question 2

This was a very well-answered question with the vast majority of candidates either gaining full marks or losing one mark through faulty arithmetic. Very occasionally a candidate differentiated $t^2 + t^4$ or integrated $t^2 + t^4$, but wrote down $\frac{t^3}{3} + \frac{t^4}{4}$.

Question 3

Again, this question proved to be a good source of marks for many candidates. Some candidates in part (a)(i) mixed the exponential forms for $\cosh x$ and $\sinh x$, whilst others, having expressed $\cosh x$ and $\sinh x$ in exponential form correctly and having arrived at $-\mathrm{e}^k + 2\mathrm{e}^{-k} = -1$ were unable to take the final step which led to the printed result. There was, also, not always a very convincing reason for the rejection of $\mathrm{e}^k = -1$ in this part of the question. A very common error in part (a)(ii) was to write $2k - k - \ln 2 = 0$ after the printed answer, leading to the correct answer by totally incorrect mathematics. Part (b)(i) was usually answered well, as was part (b)(ii), apart from those candidates who thought that the derivatives of hyperbolic functions followed the pattern of the derivatives of trigonometrical functions and so incurred sign errors. The explanation for the rejection of solutions to $\mathrm{e}^{2x} = -2$ was more convincing in this part of the question than was the rejection of $\mathrm{e}^k = -1$ in part (a)(ii). Part (b)(ii) was usually correct.

Question 4

Responses to this question were usually quite good and it was pleasing to note some quite accurate neat diagrams using a ruler and compasses. Errors in parts (a)(i) and part (a)(ii) were usually errors of sign. For instance in part (a)(i) the centre of the circle was sometimes taken to be the point $(-3, 2)$ or even $(3,2)$ and in part (a)(ii) the half line would be drawn from either $(0,1)$ or $(-1,0)$. Just occasionally the radius of the circle was taken to be 2, or the direction of the line was taken to be $+\frac{\pi}{4}$ or $+\frac{3\pi}{4}$. In part (b), a substantial number of candidates thought that the set of points must involve an area and consequently shaded some region in their sketch.

Question 5

Apart from the occasional sign errors, part (a) was answered well. Where sign errors did occur there was some faking to establish the printed answers in part (b). Part (b) is an example of what was mentioned at the beginning of this report in that with all three answers being printed, sufficient working needed to be shown in order to obtain full credit. Whilst most candidates knew roughly what was required for part (c), few candidates could express their argument succinctly. A number of candidates attempted to divide the cubic equation by z–2*i* with varying success. Probably the commonest method of approach in part (d) was to substitute β for z in the quadratic equation in z and then to equate real parts. Equating real parts led to $\beta^2 = 1$ from which a substantial number of candidates assumed that $\beta = 1$ instead of considering the imaginary parts of the equation as well.

Question 6

Although there were some good solutions to part(a) of this question it did show in many cases a lack of understanding of the theory of indices. It was quite common to see 8×15^n written as a 120^n and $8 \times 8^{n-2}$ as 64^{n-2}. There was also a lack of clarity in part (b). It was not unusual to see the first line of the inductive proof to state "Assume result true for $n = k$ i.e. that $\mathrm{f}(k) = 15^k - 8^{k-2}$" to be followed by "$\mathrm{f}(k+1) - 8\mathrm{f}(k)$ is a multiple of 7", showing a lack of understanding of the proof by induction in the case of multiples of integers. Some candidates tried to establish the result for $n = 1$ in spite of being told that n was greater than or equal to 2. A substantial minority of candidates ignored the hint in part (a) and in part (b) considered $\mathrm{f}\left(k+1\right)-\mathrm{f}\left(k\right)$ with a measure of success.

Question 7

Although part (a) of this question was standard work it was surprising to see many candidates fail to obtain full marks. The commonest errors were either to express the six roots of $z^6 = 1$ in the form $a + \mathrm{i}b$, or to give the roots in the range $0 \text{ to } 2\pi$. A few candidates wrote down the 6 roots as $\mathrm{e}^{\frac{k\pi i}{3}}$ with $k = \pm 1, \pm 2, \pm 3$. In part (b), parts (i) and (iv) were often well done, but relatively few candidates spotted part (b)(ii) as the reciprocal of part (b)(i), and it was not unusual to see $\dfrac{w}{w^2 - 1}$ rewritten as $w^{-1} - w$.

Part (b)(iii) was beyond all but the most able candidates although quite a number arrived at $\dfrac{1}{\sin\theta \mathrm{e}^{\mathrm{i}\theta}}$ at which point their solutions usually petered out. There was a wide variety of reasons why the equation $\left(z + 2\mathrm{i}\right)^6 = z^6$ had only 5 roots with about 50% of them spurious. In part (c)(ii) only one or two candidates used the hints given in the earlier parts of the question, but instead, solved the equation $\left(z + 2\mathrm{i}\right)^6 = z^6$ from first principles by writing $z + 2\mathrm{i} = z\mathrm{e}^{\frac{k\pi \mathrm{i}}{3}}$ followed by $z = \dfrac{2\mathrm{i}}{\mathrm{e}^{\frac{k\pi \mathrm{i}}{3}} - 1}$.

Of the few serious attempts made by candidates at this part of the question, most solutions ended at the point indicated and only the most able candidates found the five roots of the equation in the required form.

MFP3 Further Pure 3

General

Presentation of work was generally good and candidates usually answered the questions in numerical order. Candidates appeared to have sufficient time to attempt all the questions and it was rare to find partial attempts at a question at different stages in the answer booklet. There were many excellent scripts and a large proportion of high marks.

Once again, many candidates failed to complete the boxes on the front cover to indicate the numbers of the questions they had answered. Teachers may wish to emphasise the following points to their students in preparation for future examinations in this unit:

- In a question on numerical solution of a differential equation, just listing values in a well-labelled table eliminates the possibility of receiving method marks if the values are incorrect. Candidates would be well advised to indicate, by showing the relevant formulae and substitutions in them, how the values in the table have been obtained.

- Writing down a formula in general form before substituting relevant values may lead to the award of method marks even if an error is made in the substitution.

- Candidates should be aware that polar coordinates are (r, θ) and not $(r\cos\theta, r\sin\theta)$

- The general solution of a second-order differential equation must contain two arbitrary constants.

Question 1

Most candidates gained very high marks for this opening question which tested the solution of a second order differential equation. In part (a) it was acceptable to differentiate the given result and substitute into the given differential equation. Although sign errors were seen, the vast majority who used this approach scored all three marks. Those who took a general form for the particular integral sometimes failed to find all the unknown constants.

Part (b) was generally answered correctly although some gave the final answer as $y = Ae^{4x} + Be^{2x} + 8x - 10 - 10\cos 2x$ '. Except for some careless slips in using $y'(0) = 0$ the final part of the question was answered well.

Question 2

This question which tested numerical solutions of differential equations was the best answered question on the paper. The most common error was the use of 2.1 instead of 2.25 in finding k_2. A significant number of candidates presented their values in the form of a well-labelled table but some included incorrect values with no indication where the error had occurred. As a result the method marks could not be awarded. Very few candidates failed to give their final answer to the required degree of accuracy.

Question 3

The vast majority of candidates started correctly by writing $= e^{\int \cot x \ \mathrm{dx}}$, and most went on to score the 3 marks. Some candidates, however, seemed to be unaware that $\int \cot x \ \mathrm{d}x$ is given in the formulae booklet and can be quoted directly. In part (b) some candidates had problems integrating 2sin*x* cos*x*, whilst others used inspection, converting to sin2*x*, substitution or integration by parts. Those who then divided throughout by sin*x* to get *y* explicitly sometimes failed to divide the term $'+c'$. In finding the constant of integration it was not uncommon to see $-\frac{1}{2}\cos\pi$ evaluated incorrectly as $-\frac{1}{2}$ or even 0.

Question 4

In part (a), some candidates started with $\frac{1}{2}\int_0^{2\pi} 6(1-\cos\theta) \ \mathrm{d}\theta$ and, without seeing a previous general formula, $\frac{1}{2}\int r^2 \ \mathrm{d}\theta$, examiners were unable to give the method mark. Although many candidates presented a correct solution for the area of the region bounded by the curve, errors in the squaring of $6(1-\cos\theta)$ were quite common. The method for integrating $\cos^2\theta$ was well understood and there was a lower proportion of sign errors in the subsequent integration than in the January 2006 exam. Although part (b) proved to be more of a challenge there were better than expected responses to both parts. The most common error was the use of $'r = 9'$ rather than the correct value $r = 3$. Also in part (i) some candidates gave the polar coordinates of the two points in the wrong form; basically (*x*, *y*). The most successful approach for finding the length of *AB* was to use $AB = 2r\sin\theta(=2y)$ although other correct methods included use of the cosine rule. Some candidates incorrectly assumed that triangle *AOB* was right-angled at *O*.

Question 5

Examiners expected to see the limiting process used in part (b). In part (a) common errors included substituting a 'large' number, usually a million, for *a* or writing $\frac{3\infty}{2\infty}$.

It is worth noting that the 'solution' '$= \lim_{a \to \infty} \frac{3a}{2a+3} + \frac{2}{2a+3} = \frac{3}{2}$ since $\lim_{a \to \infty} \frac{2}{2a+3} = 0$' is insufficient without due consideration of '$\lim_{a \to \infty} \frac{3a}{2a+3}$',

In part (b) it was surprising to see candidates giving the answer $\ln(3x+2) - 2\ln(2x+3)$' for the indefinite integral. A significant minority did not include any limiting process in their evaluation of the definite integral.

Question 6

This was a good source of marks for many candidates. Part (a) was answered well although lengths of solutions varied greatly and a few candidates failed to insert sufficient steps to convince the examiners that the printed answer had been obtained convincingly. In part (b), although the complementary function/particular integral approach was applied correctly by a number of candidates, use of the integrating factor was generally more successful. However some weaker candidates failed to multiply the right-hand side by the integrating factor before proceeding. The start of part (c) begins with 'Hence' without an 'or otherwise' so candidates were expected to use the previous results. Those candidates who tried to solve the differential equation directly generally failed to find the correct particular integral. Many candidates who used the correct method went on to score full marks but some others forgot to insert the constant of integration and ended with the general solution of a second-order differential equation with only one arbitrary constant. Also, surprisingly, $\int x \, dx$, was not always found correctly.

Question 7

Average and weaker candidates scored relatively few marks in this question. The vast majority of candidates gained the mark for their answer to part (a)(i) but in part (ii) a common error for the lower grade candidate was to replace y by $\cos x$ and write '$\sec x = 1 - \cos x + \cos^2 x...$' and then insert the expansion for $\cos x$. Those who used Maclaurin's theorem in part (a)(ii) were generally able to find correct expressions for $f'(x)$ and $f''(x)$ but struggled to find $f'''(x)$ and $f^{(iv)}(x)$. Those who attempted part (b) generally gained the first mark for a correct start and first derivative but a significant minority omitted a '2' when finding $f''(x)$ as $\sec^2 x \tan x$. Those candidates who started by writing $\tan x = \sin x \sec x$ and applying the expansions for $\sin x$ and $\sec x$ generally obtained the printed answer convincingly. In part (c) the expansion for $\tan 2x$ was generally correct and most used the relevant expansions but then a significant number of candidates did not show the division of both the numerator and denominator by x^2.

MFP4 Further Pure 4

General

At least one-third of the candidates for this paper failed to make a complete attempt at all the questions. Many scripts came to a halt half-way through Question 8, although it was not always clear whether this was because of a lack of time or because the candidate could not complete the question. On the whole, though, it would seem that the paper was a little on the long side. Marks scored covered the full range from 0 to 75, although there were few scores towards the extremes of this range.

A large minority of the candidates had an imperfect grasp of the topics, possibly having had to hurry through their preparation for the paper. These candidates seemed unaware of what the questions were asking them to do. Few candidates knew what to do with Questions 3 and 5, suggesting that perhaps their preparation focused on the now defunct MAP6 module rather than on the full range of topics appearing in MFP4. There was a tendency for candidates to spend large amounts of time and space setting down long explanations for points that simply needed to be noted. This could explain why so many candidates were unable to make a good attempt at all the questions. Most disappointingly, there was a general inability amongst the candidates to cope properly with minus signs.

Question 1

This starter question was handled very capably on the whole. In part (a), many candidates felt compelled to work out the angle itself, even though the question explicitly asked for just the cosine of the angle. Large numbers of candidates went on to find some other angle as well. Uncancelled rational answers, such as $\frac{24}{30}$, were acceptable here, but answers with uncancelled surds appearing were not awarded full marks. In part (b) (ii), very many candidates failed to see that the origin was a common point on the two given planes, and so spent some considerable time trying to find some other common point. A frequent error in this part was to give the equation of a plane rather than of a line.

Question 2

Most candidates answered this question very well, making intelligent use of the results given in the formula booklet. Once again, however, there was a significant proportion of candidates who gave an inappropriate answer, often $z = 0$, when asked for the invariant line in part (b).

Question 3

This was one of the questions for which many candidates seemed unprepared. Many showed no ability in manipulating determinants by using row or column operations. The number of candidates attempting to factorise the determinant by the factor theorem was very small. A few candidates gave the correct answer with little or no working, and these were given the benefit of the doubt. However, it should be noted that a direct approach to factorising determinants becomes less feasible as the degree of the terms increases. Only very capable students are likely to be able to use such methods successfully, although it is encouraging and impressive to see them do so.

Question 4

This was another question that caused difficulties, although most candidates managed to score some marks on it. A common mistake in part (a) (i) was to write $x = 0$, rather than $y = 0$, as the line of invariant points. In part (a) (ii) most candidates correctly identified the transformation as a shear, but a 'full geometrical description' required further detail about the shear beyond the equation of the line of invariant points. A satisfactory way to do this is to give an example of a point, not on the line of fixed points, and its image. Those candidates who were aware of this need usually chose (0, 1) or (1, 1) and gave the correct images both here and in part (b). A significant minority thought that the transformations for $\mathbf{A}$ and $\mathbf{A}^2$ were of completely different types.

Question 5

This was the worst answered question on the paper. Although seven marks were allocated to part (b), many candidates simply wrote down answers without justification. Few seemed to have a correct notion of the connection between the determinant found in part (a) and the number of solutions of the system. A curious mistake was to find values for x, y and z and then to conclude that there were three solutions to the system of equations. A small number of candidates, even though not answering part (b) correctly, were aware of the three possible answers and gave one of each. It was then possible for them to deduce the correct geometrical interpretations for each case and obtain the marks for part (c).

Question 6

This proved to be a profitable question for many candidates. In particular, the multiplication of two 3×3 matrices was handled very competently indeed, even though algebraic terms were involved. The odd error arising here did not prevent candidates from doing good work in the later parts of the question. They were not required to check that all entries of the product matrix gave consistent values for both t and k.

Question 7

This question was structured in such a way that errors or omissions in one part did not prevent candidates from attempting later parts. This helped most candidates to pick up marks according to their ability. Some candidates, however, appeared to have no knowledge of the vector work needed in the question, while others were so careless with minus signs that it was not always possible to see which operations they were trying to carry out.

Question 8

The algebraic nature of this question caused many problems, particularly in part (b). For part (a), most candidates had little difficulty in following the standard routine for finding eigenvectors, although many caused themselves problems by failing to simplify the second eigenvector from $\begin{bmatrix} a+b \\ -b-a \end{bmatrix}$ to $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$. Any correct form was acceptable for the eigenvectors, and if mistakes occurred the candidates could still carry on and earn follow-through marks.

As mentioned above, many candidates did not make any serious attempt at part (b). Of those who did try this part, the overwhelming majority made life particularly hard for themselves by failing to do some fairly simple algebraic processes, such as factorising. Thus, the product $\begin{bmatrix} b+a & 1 \\ b-a & -1 \end{bmatrix}\begin{bmatrix} b^{11} & 0 \\ 0 & -b^{11} \end{bmatrix}\begin{bmatrix} \frac{1}{2b} & \frac{1}{2b} \\ -\frac{a-b}{2b} & -\frac{a+b}{2b} \end{bmatrix}$ could have been made to look so much easier by taking out the factors of b^{11} and $\frac{1}{2b}$ to get $\frac{1}{2}b^{10}\begin{bmatrix} b+a & 1 \\ b-a & -1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}\begin{bmatrix} 1 & 1 \\ b-a & -a-b \end{bmatrix}$.

It was also unfortunate that so many candidates were unable to find the inverse matrix for their choice of **U**. Some candidates saw that there was no need to find **U** and $\mathbf{U}^{-1}$ at all. The fact that $\mathbf{D}^{11} = b^{10}\,\mathbf{D}$ led them to the reasoning: $\mathbf{M}^{11} = \mathbf{U}\,\mathbf{D}^{11}\,\mathbf{U}^{-1} = \mathbf{U}\,b^{10}\,\mathbf{D}\,\mathbf{U}^{-1} = b^{10}\,(\mathbf{U}\,\mathbf{D}\,\mathbf{U}^{-1}) = b^{10}\,\mathbf{M}$, though not always expressed quite so concisely.

MS/SS1A/W Statistics 1A

General

It is pleasing to report that the overall performance on this paper showed some improvement over that on the June 2005 Paper and was more in line with that on the January 2005 and 2006 Papers. This improvement is reflected in a decrease in the percentage of candidates scoring fewer than 24 (raw) marks and an increase in those able to achieve in excess of 40 (raw) marks. Centres are to be congratulated on this improvement and it is hoped that some further improvement in overall standard can be made on future papers.

Most candidates made appropriate and correct use of Tables 1, 3 & 4 in the supplied booklet. A slightly greater proportion than on previous papers used the statistical functions on their calculators for Questions 1(a), 2(a) and 3(b)(ii). Nevertheless there remain a considerable number of candidates who carry out these calculations by unnecessary lengthy and time consuming methods. In the main, candidates gave sufficient accuracy in their numerical answers but a minority stated answers from use of the statistical functions on their calculators to fewer than 3 significant figures; something that was penalised and for which there is no real excuse. One other general point of note was the large number of candidates who ‘sat on the fence’ in answering Questions 3(b)(iii) & 5(b)(ii). When two pieces of information lead to apparently conflicting conclusions, candidates must decide on an overall conclusion in order to gain full marks. Centres are recommended to look, in particular, at the published Mark Scheme for these parts of the two aforementioned questions.

Question 1

This question gave the majority of candidates a positive start to the Paper with most scoring more than half marks. Save for numerical or algebraic errors made by some candidates using the formula, full marks were scored in part (a). In part (b), most candidates' answers implied little, or no, correlation and referenced 'number of pages' and '(recommended retail) price'. In part (c), most candidates were able to make a valid suggestion.

Question 2

Many candidates were able to score most, if not quite all, of the first 4 marks but dropped many of the marks for interpretations. Answers to part (a), particularly by those using the statistical functions on their calculators, were generally correct with thankfully fewer interchanging the values. Candidates opting for the use of formulae were less successful. In part (b), many candidates were able to indicate that their value indicated that pressure was decreasing over time but very few quantified this decrease correctly as 3.25 kPa **per month**. In part (c), most candidates merely stated, rather than interpreted, their correct value of 263 kPa, whilst far fewer related it to the recommended pressure of 265 kPa.

Question 3

This question proved a good source of marks for many candidates with the more able often gaining at least 11 marks. Answers to part (a)(i) were often correct as most candidates realised that 7.5 $\left(\frac{15}{2}\right)$ required $P(K \le 7)$ or $P(K < 8)$ and so scored full marks from tables. A small minority of candidates used $P(K = 7)$ or $\frac{P(K \le 7) + P(K \le 8)}{2}$. As in previous papers, part (a)(ii) continued to cause more difficulties almost always through use of P($K \le 3$ and/or $P(K \le 7)$. Knowledge of (an available source of) the relevant formulae for part (b)(i) was much improved with many fully correct answers as a result. When marks were lost, it was invariably for failing to find $\sqrt{3.6}$ for the standard deviation. Not surprisingly, only the very weakest candidates failed to score the 2 marks in part (b)(ii). In part (b)(iii), able and well-prepared candidates compared the two means (equal) and two standard deviations (different) but then often failed to commit to the overall conclusion of 'doubtful validity'. A small minority of candidates only compared $\frac{\bar{x}}{15} = \frac{6}{15} = 0.4$ with the value quoted (1 mark) or presented a qualitative argument as to the benefits of coaching (0 marks).

Question 4

Part (a) of this question was, as expected, accessible to all but the weakest candidates. Those candidates who simply extracted the necessary information from the table invariably scored most, if not all, of the 7 marks. Those who used a formula approach were generally less successful through assuming the independence of D and R and/or struggling in the application of a formula to the given information. Answers to part (b)(i) were usually correct but most answers to part (b)(ii) consisted of worthless subjective ramblings. Only the most able candidates attempted to provide quantitative evidence. This often involved showing that $P(D \cap R)$ was equal to $P(D) \times P(R)$ when a much simpler approach was to use the fact that previous answers to parts (a)(i) and (iii) were equal. Sometimes, despite correct working, candidates then concluded that the two events were not independent. Answers to part (c) were generally of a high standard although, when "not detached" was included, candidates lost 1 mark. A small minority of candidates ignored the phrase "in the context of this question" or evaluated the probabilities of the events and so lost all 4 marks.

Question 5

Many candidates scored full marks in part (a) and it was pleasing to observe the improvements in notation and presentation. On the rare occasions when marks were lost in part (a)(i), it was for standardising 1014 or 1014.5, rather than 1015; something that needs to be eradicated for the future. In part (a)(ii), some candidates obtained the correct final answer but not always by the most direct method; many others usually failed to carry out the necessary area change. In part (a)(iii), far too many candidates assumed that all that was required was to find the difference of their two previous answers and so scored no marks. Candidates who missed the link and so began afresh, often scored full marks. Candidates need to think more carefully about such linked parts to questions.

In part (b)(i), few candidates scored all 6 marks. Despite comments in a previous Examiners Report and the relevant formula for s^2 on page 10 of the supplied booklet, far too many candidates were unable to calculate the correct value for s from the given value for $\sum(y-\bar{y})^2$; something that must be addressed for the future. Other less frequent errors were due to an incorrect value for $\bar{y}$, an incorrect z-value or omission of $\sqrt{50}$. In part (b)(ii), the awarding of full marks was even rarer. Many candidates did not make it clear that they were comparing 500 (and not the sample mean) with their confidence interval, failed to indicate that 6 in 50 packets were underweight or stated no overall conclusion.

MS/SS1B Statistics 1B

General

It is pleasing to report that the overall performance on this paper showed a marked improvement to that on the June 2005 Paper and was in line with that on the January 2005 and 2006 Papers. This improvement is reflected in a decrease in the percentage of candidates scoring fewer than 30 raw marks and a marked increase in those able to achieve in excess of 50 raw marks. Centres are to be congratulated on this and on the numerous candidates able to achieve at least 70 raw marks.

Most candidates made appropriate and correct use of Tables 1, 3 &4 in the supplied booklet. A greater proportion, than on previous papers, used the statistical functions on their calculators for Questions 1(a), 3(a) and 5(b)(ii). Nevertheless there remains a small number of candidates who carry out these calculations by unnecessary lengthy and time consuming methods. The small number of candidates who also used their calculators to evaluate directly normal and binomial probabilities often had very limited success. In the main, candidates gave sufficient accuracy in their numerical answers but a minority stated answers from use of the statistical functions on their calculators to fewer than 3 significant figures; something that was penalised and for which there is no real excuse. One other general point of note was the large number of candidates who 'sat on the fence' in answering Questions 4(a)(iii) and 5(b)(iii). When two pieces of information lead to apparently conflicting conclusions, candidates must decide on an overall conclusion in order to gain full marks. Centres are recommended to look, in particular, at the published Mark Scheme for these parts of the two aforementioned questions.

Question 1

This question gave the vast majority of candidates a positive start to the Paper with most scoring more than half marks. Save for numerical or algebraic errors made by some candidates using the formula, full marks were scored in part (a)(i). In part (a)(ii), most candidates' answers implied little or no correlation and referenced 'number of pages' and '(recommended retail) price'. In part (a)(iii), most candidates were able to make a reasonable suggestion with author reputation been the most common. Again in part (b), most candidates identified that the correlation was 'strong' but too many omitted the adjective 'positive'. The second mark, for answers in context, was often not scored due to use of 'price' or 'recommended retail price' rather than 'sale price'.

Question 2

Many candidates scored full marks on this question and it was pleasing to observe the improvements in notation and presentation. On the rare occasions when marks were lost in part (a)(i), it was for standardising 199, 195, 199.5 or 199.9, rather than 200; something that needs to be addressed for the future. In part (a)(ii), many candidates obtained the correct final answer but not always by the most direct method; others usually failed to carry out the necessary area change. In part (a)(iii), far too many candidates assumed that all that was required was to find the difference of their two previous answers and so scored no marks. Those candidates who missed the link and so began afresh, often scored full marks. Clearly many candidates need to think more carefully about such linked parts to questions. In part (b), there was a marked increase in valid attempts at the distribution of the sample mean. Hence those better candidates who changed the standard deviation from 10 to $\sqrt{\frac{100}{4}} = 5$ usually scored 4 marks whilst those who stayed with 10 scored at most 1 mark.

Question 3

Many candidates were able to score most, if not quite all, of the first 4 marks and final 4 marks but dropped most of the marks for interpretations. Answers to part (a)(i), particularly by those using the statistical functions on their calculators, were generally correct with thankfully fewer interchanging the values. Candidates opting for the use of formulae were less successful. In part (a)(ii), many candidates were able to indicate that their value indicated that pressure was decreasing over time but few quantified this decrease correctly as 3.25 kPa **per month**. In part (a)(iii), most candidates merely stated, rather than interpreted, their correct value of 263 kPa, whilst far fewer related it to the recommended pressure of 265 kPa. In part (b)(i), many candidates scored full marks; those that did not either halved, rather than doubled their value from part (a)(i) or stated –6 (–6.5 rounded?) or –7.5 (error in 2×-3.25?). Answers to part (b)(ii) were generally correct or based on correct reasoning from part (b)(i), though a small minority used 263 rather than 265.

Question 4

In part (a)(i), many candidates scored all 5 marks. When this was not the case, it was usually due to an incorrect *z*-value or the omission of $\sqrt{10}$. Answers to part (a)(ii) were disappointing. All too often reference was made to the sample size being less than 30. Even those candidates who apparently realised that the weights of packets could be assumed to be normally distributed, simply made vague references to "it", "the data" or "the sample" and so lost the mark. In part (a)(iii), the awarding of full marks was rare. Many candidates did not make it clear that they were comparing 500 (and not the sample mean) with their confidence interval, failed to indicate that 3 in 10 packets were underweight or stated no overall conclusion. Correct answers to part (b) were also rare. The word 'Hence' together with an allocation of 1 mark should have suggested that lengthy working, as produced by many candidates, was not required.

Question 5

This question proved a good source of marks for many candidates with the more able often gaining at least 15 marks. Answers to part (a)(i) were almost always correct and usually by use of the formula. In part (a)(ii), most candidates realised that 7.5 $\left(\frac{15}{2}\right)$ required $P(K \le 7)$ or $P(K < 8)$ and so scored full marks from tables. A small minority of candidates used $P(K = 7)$ or $\frac{P(K \le 7) + P(K \le 8)}{2}$. As in previous papers, part (a)(iii) continued to cause more difficulties almost always through use of $P(K \le 3)$ and/or $P(K \le 7)$. Knowledge of (an available source of) the relevant formulae for part (b)(i) was much improved with many fully correct answers as a result. When marks were lost, it was invariably for failing to find $\sqrt{3.6}$ for the standard deviation. Not surprisingly, only the very weakest candidates failed to score the 2 marks in part (b)(ii). In part (b)(iii), able and well-prepared candidates compared the two means (equal) and two standard deviations (different) but then often failed to commit to the overall conclusion of 'doubtful validity'. A minority of candidates only compared $\frac{\bar{x}}{15} = \frac{6}{15} = 0.4$ with the value quoted (1 mark) or presented a qualitative argument as to the benefits of coaching (0 marks).

Question 6

Part (a) of this question was, as expected, accessible to all but the weakest candidates. Those candidates who simply extracted the necessary information from the table invariably scored most, if not all, of the 9 marks. Those who used a formula approach were generally less successful through assuming the independence of D and R and/or struggling in the application of a formula to the given information. Answers to part (b)(i) were usually correct but most answers to part (b)(ii) consisted of worthless subjective ramblings. Only the most able candidates attempted to provide quantitative evidence. This often involved showing that $\mathrm{P}(D \cap R)$ was equal to $\mathrm{P}(D) \times \mathrm{P}(R)$ when a much simpler approach was to use the fact that previous answers to parts (a)(i) and (iv) were equal. Sometimes, despite correct working, candidates then concluded that the two events were not independent. Answers to part (c) were generally of a high standard although, when "not detached" was included, candidates lost 1 mark. A small minority of candidates ignored the phrase "in the context of this question" or evaluated the probabilities of the events and so lost all 4 marks.

MS2A Statistics 2A

General

There were again some very good solutions seen to each of the questions on the paper. However, candidates still found that, where they had to use pure mathematical techniques in topics such as continuous random variables, they struggled to gain full credit.

Question 1

In part (a), the vast majority of candidates were able to state that $\lambda = 15$, with many going on to obtain full credit for the correct answer of 0.181. Candidates still had difficulty with the interpretation of 'more than' with the result that $\mathrm{P}(X \geq 18)$ or $\mathrm{P}(X > 18) = 1 - \mathrm{P}(X \leq 17)$ was often seen. In part (b)(i), several candidates used $\lambda = 7$ instead of combining the two Poisson variables X and Y to obtain $X + Y \sim \mathrm{P_o}(10)$. Interpretation of 'fewer than 15' was usually stated correctly as '≤ 14', with tables then used to obtain the required answer 0.917. In part (b)(ii), the idea of 'independence' was usually well understood although some candidates stated incorrectly that the variable was normal.

Question 2

Many candidates failed to realise that frequencies and not percentages must be used when constructing a contingency table. Consequently, in part (a)(i) , these candidates gained no credit. The majority of candidates were able to demonstrate the required techniques in part (a)(ii), albeit often using the given percentage values. Sensible conclusions in context and related to stated hypotheses were usually seen. In part (b), most candidates failed to answer the question set. Candidates were expected to compare observed and expected values. Instead, most simply made general comments about the 11–24 age group and, as a consequence, gained no credit.

Question 3

Most candidates made a very good attempt at part (a), especially in finding the mean of the given distribution. The previously common errors of leaving the answer as σ^2 when σ is asked for, or using $\mathrm{Var}(X) = \sum x^2 p$ were not usually seen. In part (b), the majority of candidates could arrive at

$\text{P}(1.95 < X < 4.15)$ but some were then unsure as to how to continue, not realising that this was equivalent to finding $\text{P}(2 \le X \le 4) = 0.78$.

Question 4

The use of calculus in questions of this type still seemed to be a popular, yet unnecessary, method for a small minority of candidates. Most were able to find the correct value of α in part (a), although it did defeat more candidates than expected. Part (b) was usually done well by those who used the correct formulae from the booklet. In part (c), many candidates failed to understand the concept of the magnitude of the error.

Question 5

In general, candidates scored well on this question, with most attempting to state the hypotheses correctly and then giving conclusions in context based on their findings. However, such conclusions were often too positive. In part (a), most candidates realised that a small sample from a normal distribution with unknown variance required the use of a t-distribution. Unfortunately there were too many candidates who failed to distinguish which tail they were using, simply stating $t_{crit} = 2.132$ from tables without then applying $t_{crit} = -2.132$ to the left-hand tail. As stated in previous reports, a diagram is often very useful in such questions to demonstrate the critical values and acceptance or rejection regions. Calculating the standard deviation from the information provided in part (b) of the question seemed to be problematic for many candidates; this despite the relevant formula being given on page 12 of the formulae booklet!

Question 6

In part (a), candidates showed poor ability in sketching graphs. Common faults were the omission of essential values on both axes, lines drawn as incorrectly passing through the origin on the interval [0 , 1] and the quadratic curve incorrectly drawn as convex on the interval [1 , 4]. In part (b)(i), the vast majority of candidates either ignored the required limits of 0 and *x* altogether, or used limits of 0 and 1. Consequently, although most stated the required answer, many lost a mark. Part (b)(ii) was usually completed correctly with the correct answer of 0.85 often seen. Part (b)(iii) was not done well. Very few candidates tried to 'verify' the given result. Instead, most attempted to calculate q_1 so that they could then show that its value fell within the given interval.

MS2B Statistics 2B

General

It was again very pleasing to see the many excellent solutions to each of the questions on the paper. On the whole, candidates seemed to have been very well prepared, with work on confidence intervals and hypothesis testing done especially well.

Question 1

In part (a), the vast majority of candidates were able to state that $\lambda = 15$, with many going on to obtain full credit for the correct answer of 0.181. Candidates still had difficulty with the interpretation of 'more than' with the result that $\text{P}(X \ge 18)$ or $\text{P}(X > 18) = 1 - \text{P}(X \le 17)$ was often seen. In part (b)(i), several candidates used $\lambda = 7$ instead of combining the two Poisson variables *X* and *Y* to obtain $X + Y \sim \text{P}_o(10)$. Interpretation of 'fewer than 15' was usually stated correctly as '≤ 14', with tables then used to obtain the required answer 0.917. In part (b)(ii), the idea of 'independence' was usually well understood although some candidates stated incorrectly that the variable was normal.

Question 2

This question was answered very well indeed by the majority of candidates. Most realised that in part (a), as the data represented a small sample from a normal distribution with unknown variance, the use of a t-distribution with a critical value of $t = 2.776$ was required. However, some candidates thought that the appropriate critical value(s) should be $t = 2.132$ or even $z = \pm 1.96$ or $z = 1.6449$. Almost all candidates gained the mark available for part (b).

Question 3

In part (a), although the vast majority of candidates were able to calculate the mean and variance of R, many failed to comply with the instruction 'calculate exact values', often writing their answers as rounded decimals. The correct answer of 8 was often seen in part (b)(i) but far too many candidates either misinterpreted 'at least 3' and thus calculated $\frac{3}{16} \times 32 = 6$, or in some cases $\frac{15}{16} \times 32 = 30$. A minority of candidates simply wrote $\frac{1}{4}$ as the answer instead of evaluating $\frac{4}{16} \times 32$. Weaker candidates usually just calculated 90% of 32 giving them an answer of 28.8. There were many good attempts at part (b)(ii) with the correct answer of 15 often seen.

Question 4

Many candidates failed to realise that frequencies and not percentages must be used when constructing a contingency table. Consequently, in part (a)(i) , these candidates gained no credit. The majority of candidates were able to demonstrate the required techniques in part (a)(ii), albeit often using the given percentage values. Sensible conclusions in context and related to stated hypotheses were usually seen. In part (b), most candidates failed to answer the question set. Candidates were expected to compare observed and expected values. Instead, most simply made general comments about the 11–24 age group and, as a consequence, gained no credit.

Question 5

Part (a)(i) was answered well by all but the very weakest candidates. However, there were still some candidates who used integration to achieve the required result instead of using $\mathrm{E}(X) = \frac{1}{2}(a+b)$ from the formulae booklet. There were many very pleasing solutions seen to part (a)(ii). Part (b) was usually done best by those candidates who used a diagram to demonstrate their understanding of what was required.

Question 6

In general, candidates scored well on this question, with most attempting to state the hypotheses correctly and then giving conclusions in context based on their findings. However, such conclusions were often too positive. In part (a), most candidates realised that a small sample from a normal distribution with unknown variance required the use of a t-distribution. Unfortunately there were too many candidates who failed to distinguish which tail they were using, simply stating $t_{crit} = 2.132$ from tables without then applying $t_{crit} = -2.132$ to the left-hand tail. As stated in previous reports, a diagram is often very useful in such questions to demonstrate the critical values and acceptance or rejection regions. Calculating the standard deviation from the information provided in part (b) of the question seemed to be problematic for many candidates; this despite the relevant formula being given on page 12 of the formulae booklet!

Question 7

In part (a), candidates showed poor ability in sketching graphs. Common faults were the omission of essential values on both axes, lines drawn as incorrectly passing through the origin on the interval [0 , 1] and the quadratic curve incorrectly drawn as convex on the interval [1 , 4]. In part (b)(i), the vast majority of candidates either ignored the required limits of 0 and x altogether, or used limits of 0 and 1.

Consequently, although most stated the required answer, many lost a mark. Part (b)(ii) was usually completed correctly. Several candidates wasted time in part (b)(iii) by considering the probability density function for $x > 1$ with the inevitable loss of most, if not all, of the available marks. Those candidates who did obtain a quadratic equation usually managed to solve it correctly and nearly always realised that one of their solutions was inadmissible. Part (b)(iv) was often done well, even by those candidates who failed to appreciate what was required in part (b)(iii).

MS03 Mathematics Statistics 3

General

The general standard of attainment on this first paper was very impressive. It was clearly evident that a large majority of candidates had been well-prepared by centres in most, often all, of the topics examined.

On most scripts, answers showed sufficient method and working in clear logical steps so that part marks were available when full marks were not. One general area for potential improvement is that on inferences from confidence intervals (Questions 1(b) & 5(b)(ii)) and conclusions from hypothesis tests (Questions 2(b) & 7(b)). All too often, one or more of these was expressed in a definitive form rather than quantified by the level of confidence or significance, or qualified by words such as “support” or “evidence”. Centres should be aware that statements implying “certainty” in such questions will continue to be penalised.

Question 1

This first question gave most candidates a sound start to the paper with many scoring full marks. When full marks were not scored, it was usually for using 0.8, rather than 0.836, for $\hat{p}$ in the expression for $\operatorname{Var}\left(\hat{p}\right)$.

Question 2

Almost without exception, candidates scored the 3 marks in part (a). When marks were occasionally lost in part (b), it was invariably for expressing hypotheses in terms of *r*, rather than ρ, or stating a definitive conclusion.

Question 3

Overall this was the best answered question on the paper with more than 65% of candidates achieving full marks; a credit to centres’ teaching of Bayes’ Theorem. On the rare occasions when full marks were not scored, it was generally in parts (a)(iii) and/or (b) for using other than Bayes’ Theorem.

Question 4

This was the first question on which more than a minority of candidates lost marks. As expected most candidates scored the first 4 marks though a small number calculated Var (*X*) as E(X^2) or found the latter using $\sum x_i p_i^2$. In part (b), about 50% of candidates ignored the fact that *R* and *S* were **not** independent $\left(\rho_{RS} = \frac{2}{3}\right)$ and so lost 4 marks. Of those candidates who did realise that Cov (*R*, *S*) was required, less than half were able to determine its correct value; this despite the formula given on Page 10 of the supplied Formulae Booklet. Clearly, future candidates need to be made aware of the effect of non-independence on the variance of a linear combination of two random variables.

Question 5

Part (a) was answered correctly by many candidates. However, all too often, marks were lost needlessly for either ignoring or using incorrect continuity corrections; perhaps something that candidates need to be more aware of in the future. In part (b)(i), the minority of candidates who started with $248 \pm z\sqrt{248}$ and then divided by 16 as a final step, invariably scored full marks. The majority of candidates who first divided by 16, then used $15.5 \pm z\sqrt{15.5}$ instead of $15.5 \pm z\sqrt{\frac{15.5}{16}}$ and so lost at least 2 marks. In view of this, centres may like to consider the 'safer approach' for the future. A small minority of candidates, for some unknown reason, worked with $\lambda = 12.5$. Save for definitive statements, follow-through answers to part (b)(ii) were generally sound.

Question 6

The more able candidates often achieved full, or almost full, marks on this question although in a considerable number of cases certain steps in the proofs left room for an improvement in explanations. Weaker candidates often omitted the entire question or collected the final 2 marks for deducing that $\text{Var}(X) = \lambda$ from the quoted results for $\text{E}(X)$ and $\text{E}(X(X-1))$.

Question 7

A large proportion of candidates scored well in parts (a) and (b). When marks were not scored, it was usually for one or more of the following reasons; expressing hypotheses in terms of $\bar{x}$ and $\bar{y}$, omitting 200 from the numerator of their z-value or using $\frac{65}{\sqrt{10}} + \frac{45}{\sqrt{20}}$ as the latter's denominator. Again many candidates scored the 2 marks available in part (c)(i) and centres are to be congratulated on the most impressive percentage of candidates who also scored the 5 marks in part (c)(ii) for calculating the correct value for the power. Having said this, it was then rare indeed for a candidate to score any marks in part (c)(iii). Most candidates appeared to have no real idea as how to express in words what their value for power, or alternatively Type II error, meant, never mind in the context of the question. This is another area that needs to be addressed for future examinations.

MS04 Mathematics Statistics 4

General

The overall standard of work was extremely high, showing that almost all of the candidates were well prepared for the examination with the result that all questions had many good answers. Answers were usually given to the appropriate degree of accuracy although there was a tendency to give 4 or 5 significant figure answers which, in general, was not penalised. The relevant pure mathematics knowledge was mostly well known, but weaker candidates sometimes fell down in this area. Finally, candidates demonstrated familiarity with the appropriate formulae and tables provided.

Question 1

This proved to be a good first question, as nearly all candidates were able to produce substantially correct answers. The most common error in part (a) was using incorrect degrees of freedom and, occasionally a candidate omitted the $(n-1)$ factor from $\frac{(n-1)s^2}{\chi^2}$. In part (b), some candidates omitted to say why they were rejecting $\sigma = 6$. The award of 2 marks should have acted as a prompt that a second statement saying that 6 did not fall in the confidence interval was required.

Question 2

This question was also well done by the vast majority of candidates although some went wrong early on by not using a binomial distribution to calculate the expected frequencies. It is important for candidates to read questions carefully; part (a) of this question clearly referred to a binomial distribution. Degrees of freedom, in both parts of the question, proved troublesome for some candidates and so weaker candidates were not able to make much progress with part (b).

Question 3

This was one of the questions that only most able candidates were able to do completely correctly. Most candidates obtained accurate answers in part (a). However, in part (b), the limits for integrals were frequently either omitted or incorrect. In part (b)(ii), it was necessary to 'use integration' as the question required and not merely to quote a formula. Too many candidates did not multiply by 24 to get answers in hours in part (c).

Question 4

This question was extremely well answered by many candidates. The necessary theory was well known and applied accurately. One point to note was that, as the larger value of s^2 was in the numerator, the variance ratio can only be significantly different from 1 by being in the upper tail of the distribution curve. A number of candidates wasted time by working out the lower critical value correctly. This showed impressive knowledge of the distribution but was not required. Again a few candidates made errors with degrees of freedom. It should be noted that, for the final mark, the conclusion had to be in the context of the question and not merely a statement indicating acceptance of the null hypothesis.

Question 5

The theory for parts (a) and (b) was well known and most candidates could handle the necessary algebra to obtain correct derivations. There were some surprising errors with the differentiation in part (c). Indeed, some candidates did not realise that differentiation (or completing the square) was needed to establish a minimum variance. Only the better candidates knew what to do in part (d).

Question 6

There were many completely correct answers to this question. The work was accurate and the theory well known. Part (c)(i) only carried 1 mark for adding the probabilities of the first two terms, in order to **verify** 0.2. A number of candidates obtained a quadratic equation but then did not demonstrate how to solve it. There were some arithmetic errors in part (c), usually by omitting a square root or working it out incorrectly.

MM1A/W Mechanics 1

General

The paper proved accessible to the majority of candidates, who were able to attempt all the questions within the time allowed. Candidates had the opportunity to demonstrate their knowledge of mechanics and to show the necessary skills in providing clear solutions. Presentation of work was good, with mostly accurate working, and diagrams were clear. Understanding of mechanical principles was mostly good, but the reasoning behind fully correct solutions in 3(d), 4(b) and 6(c) was not always sound.

Question 1

A popular question with high marks awarded. It was pleasing that many scored full marks although some assumed the speed to be constant in part (b).

Question 2

A straightforward question, but not always yielding the marks it should. In part (a) many were careless with working, often confusing values of u and v, and altering or ignoring incorrect signs in subsequent working. Candidates should be aware that 'show that' requests require convincing correct working leading to the printed result. In part (b) sketches were usually good but sometimes marred by incomplete labelling. Part (c) was done well. Responses in part (d) sometimes referred to irrelevant factors rather than the model of the motion given in the question.

Question 3

Diagrams in part (a) were clear and mostly correct, with occasional marks lost due to missing arrows or an additional or incorrect force; the reaction force being vertical and the weight being given as 'g' were the most frequent errors. Part (b) was mostly done correctly, but part (c) was less successful, with extra forces sometimes present in equilibrium equations. The friction law was usually applied in part (d) but marks were lost through missing or incorrect inequality signs and rounding of answers to 2 significant figures.

Question 4

It was pleasing that most candidates formed, as requested in part (a), equations of motion for the two particles. Pleasingly very few used the 'whole approach instead of forming equations of motion for the two particles as requested. Most then proceeded to find the tension in the string. In part (b), rather than answer the question set, with a very small minority realising the necessity to consider the stone or the can in isolation.

Question 5

This was found to be the most difficult question on the paper. While the most able were able to score full marks, others showed confusion between vectors and scalars, or simply showed misunderstanding of vector quantities. Many found the vector $\overrightarrow{AB}$ in part (a) but could not then proceed correctly, with ratios of vectors often leading to vector expressions for the time. The most successful methods included the application of the equations of motion with constant acceleration, and the use of diagrams with explained steps in motion. Part (b) often began with the assumption of a zero initial velocity, some only considered the **j** component of the motion, and many failed to add the position vector of the particle at B. Part (c) often began well with the vector $\overrightarrow{AC}$ found, but with no attempt to find its magnitude to give the distance requested.

Question 6

This question proved quite challenging, with the least successful candidates confusing the horizontal and vertical components of motion, and in some cases trying to incorporate expressions for the greatest height, horizontal range, and time of flight, thereby making the question harder. Part (a) was mostly done well, but some assumed vertical motion was involved. Part (b) was sometimes omitted, while a significant number did not realise that the calculation could be done in one stage and wasted time in carrying out a series of calculations often losing an accuracy mark due to rounding values within their working. In part (c)(i) common errors included finding the vertical component of velocity only, using '24' as the initial velocity with no component, and mixing horizontal/vertical motions or velocity/displacement in calculations. Those successful in part (c)(i) usually completed part (c)(ii).

Question 7

Despite being unusual this question was completed well by many candidates. Some candidates who struggled with algebraic expressions were subsequently very comfortable when able to substitute a numerical value for '*rn*'. Overall the handling of vectors was much better here than in Question 5. The most frequent errors included giving the final mass as 'O.2m', including '*g*' in momentum terms, and assuming the initial total momentum to equal zero. Confusion with scalar quantities was pleasingly rare.

MMIB Mechanics 1B

General

The paper proved accessible to the majority of candidates, who were able to attempt all the questions within the time allowed and had the opportunity to demonstrate their knowledge of mechanics and the necessary skills to provide clear solutions. Presentation of work was good, with accurate working, and diagrams were clear. Verbal responses were usually clear even though not always relevant to the point under consideration. Strong candidates showed good analytical skills in questions 4(d), 6(b) and 7(c) in particular.

Question 1

A popular question with high marks awarded. It was pleasing that many found the average speed as requested although some found the final speed instead.

Question 2

Again, this was answered very well, often scoring full marks.

Question 3

A straightforward question, but not always yielding the marks it should. In part (a) many candidates were careless with working, often confusing values of u and v, and altering or ignoring incorrect signs in subsequent working. Candidates should be aware that 'show that' requests require convincing correct working leading to the printed result. In part (b) sketches were usually good but sometimes marred by incomplete labelling. Part (c) was done well. Responses in part (d) sometimes referred to irrelevant factors rather than the model of the motion given in the question.

Question 4

Diagrams in part (a) were clear and mostly correct, with occasional marks lost due to missing arrows or a missing or incorrect force, with the weight being given as 'g' as the most frequent. Parts (b) and parts (c) were also good, but few scored well in part (d), with one or even two forces missing from the equation of motion, the weight component being the most frequent omission.

Question 5

Again diagrams were mostly good, and parts (a)(ii) and (c) usually gained full marks. Part (b) was successfully completed by most candidates with the main error being the inclusion of the weight of P instead of the frictional force in the equation of motion of P. Pleasingly very few candidates used a 'whole string' approach instead of forming equations of motion for the two particles as requested. In part (d) the intended response focussed on the remaining force acting on each particle and the subsequent change in speed. Many candidates were successful here but others focussed on forces no longer present.

Question 6

This was found to be the most difficult question on the paper. While the most able candidates were able to score full marks, others showed confusion between vectors and scalars, or simply showed misunderstanding of vector quantities. Many found the vector $\overline{\text{AB}}$ in part (a) but could not then proceed correctly, with ratios of vectors often leading to vector expressions for the time. The most successful methods included the application of the equations of motion with constant acceleration, and the use of diagrams with explained steps in motion. Part (b) often began with the assumption of a zero initial velocity, some only considered the **j** component of the motion, and many failed to add the position vector of the particle at B. Part (c) often began well with the vector $\overline{\text{AC}}$ found, but with no attempt to find its magnitude to give the distance requested.

Question 7

This question proved quite challenging, with the least successful candidates confusing the horizontal and vertical components of motion, and in some cases trying to incorporate expressions for the greatest height, horizontal range, and time of flight, thereby making the question harder. Part (a) was mostly done well, but some assumed vertical motion was involved. Part (b) was sometimes omitted, while a significant number did not realise that the calculation could be done in one stage and wasted time in carrying out a series of calculations often losing an accuracy mark due to rounding values within their working. In part (c)(i) common errors included finding the vertical component of velocity only, using '24' as the initial velocity with no component, and mixing horizontal/vertical motions or velocity/displacement in calculations. Those successful in part (c)(i) usually completed (c)(ii).

Question 8

Despite being unusual this question was completed well by many candidates. Some candidates who struggled with algebraic expressions were subsequently very comfortable when able to substitute a numerical value for 'm'. Overall the handling of vectors was much better here then in Question 6. The most frequent errors included giving the final mass as 'O.2m', including '*g*' in momentum terms, and assuming the initial total momentum to equal zero. Confusion with scalar quantities was pleasingly rare.

MM2A Mechanics 2A

General

As in summer 2005, there was a smaller entry for this paper than for the non-coursework version. The entry was however, much higher than in summer 2005. For this reason the comments below for the common questions are based on the MM2B scripts as well.

Question 1

There were very many good solutions to this question and a good number of candidates scored full marks. Some candidates did however make errors. In part (a) there were some cases where the candidates made some minor errors when differentiating one or both of the components. In part (b) a few candidates had difficulties substituting $t = \frac{1}{3}$ correctly, but the biggest problem in this part of the question was the description of the direction. While a number did state that the direction was south, some stated that it was north, even though they had calculated the velocity correctly. Others did not use either north or south, but gave answers that implied that **j** was a vertical unit vector.

Parts (c) and (d) were generally done well, but a few candidates experienced difficulties with the differentiation and very occasionally with the substitution of $t = 4$.

Question 2

Parts (a) and (b) of this question were done well by many candidates. They were probably helped by the printed answer in part (a) to select the correct method and were able to apply this again in part (b). Some candidates did use some unconventional methods, such as working relative to a point outside the framework, to obtain correct solutions.

Part (c) was found to be more demanding. Candidates made a number of errors including;

- Using sine or cosine instead of tangent functions,
- Not using the correct distances,
- Using the correct distances, but with the fraction inverted.

Question 3

Part (a) was done very well, with very few incorrect responses. Part (b) of the question was also done fairly well, with the printed answer helping some candidates. The main issue here was that some candidates did not use the correct distances to find the elastic potential energies. Part (c) was much more demanding. Many candidates were able to calculate the magnitude of the friction force correctly, but far fewer were able to incorporate this correctly into an energy equation.

Question 4

This question proved to be more challenging and only a relatively small number of candidates gained full marks. Part (a) was done well by those candidates who could form the correct energy equation. Some candidates only included one kinetic energy term.

A number of candidates obtained a correct expression for v^2, but simplified it incorrectly.

In part (b), there were a variety of responses. For example, some simply assumed that the tension would be the product of the mass and the acceleration.

For those candidates who formed a three term equation of motion, there were a number of problems with resolving, for example using $T\cos 60°$ instead of *T*. Some students who had formed correct equations were unable to carry out the simplification correctly and so gave an incorrect final answer.

Part (c) was often done well. The most common error was to substitute the value of *v* obtained in part (a) instead of simply substituting *U*.

Question 5

Part (a) was done very well by the vast majority of the candidates. The printed answer probably helped some of them. In part (b), many candidates were able to obtain the value of 0.4, but far fewer were able to deal correctly with the inequality. When attempting questions like this candidates should start with $F \leq \mu R$ and preserve the inequality through out their working. Typically no attempt was made to start with an inequality, which some candidates did then try to introduce at the end of their solution.

Question 6

Part (a) of this question was often done well. Many candidates seemed to take the question in their stride, but others made limited progress or did not know how to approach the question. There were some who lost accuracy marks. The four main causes of this were;

- Omission of the negative sign in the differential equation,
- Algebraic errors,
- Incorrect integration,
- Not finding the value of the constant of integration.

Part (b) was done very well, with many candidates gaining the available mark without doing part (a).

MM2B – Mechanics 2B

General

There were many good scripts and it appeared that the majority of candidates were well prepared for the examination. There were very few very weak scripts. Most of the candidates presented their solutions well, but there were some scripts where the working was difficult to follow.

Question 1

There were very many good solutions to this question and a good number of candidates scored full marks. Some candidates did however make errors. In part (a) there were some cases where the candidates made minor errors when differentiating one or both of the components. In part (b) a few candidates had difficulties substituting $t = \frac{1}{3}$ correctly, but the biggest problem in this part of the question was the description of the direction. While a number did state that the direction was south, some stated that it was north, even though they had calculated the velocity correctly.

Others did not use either north or south, but gave answers that implied that **j** was a vertical unit vector. Parts (c) and (d) were generally done well, but a few candidates experienced difficulties with the differentiation and very occasionally with the substitution of $t = 4$.

Question 2

Parts (a) and (b) of this question were done very well by the vast majority of candidates. The number of candidates using constant acceleration equations instead of energy was quite small.

Part (c) was found more difficult. There were some candidates who did not really know how to proceed with the question, and others who were confused about how to calculate the work done against the air resistance. One of the most common incorrect responses was to produce the answer 47.04 J.

Part (d) was answered well by some candidates, but some gave fairly poor and very brief answers.

Question 3

There were some very good answers to this question, but a number of areas of difficulty were evident on some scripts. In part (a) a common error was to show the tension acting in an upward direction. Another error that appeared was to omit the normal reaction force. The vast majority of the candidates were able to produce the correct answer in part (b). Some candidates not find the tension directly, but found the reaction force first and then used this to find the tension. The fact that the tension was given helped some candidates, but there were a few solutions where not enough working was shown.

In part (c), one of the most common errors was to omit g from the moment equation, so that one of the terms was the product of a distance and a mass, rather than a distance and a force. This often had an implication for the next stage when the candidates were finding the reaction force. Interestingly, some candidates took moments about the end of the rod, so that having an incorrect mass did not have an impact on their answer. Part (d) was generally done well.

Question 4

This question proved to be more challenging and only a relatively small number of candidates gained full marks. Part (a) was done well by those candidates who could form the correct energy equation. Some candidates only included one kinetic energy term. A number of candidates obtained a correct expression for v^2, but simplified it incorrectly.

In part (b), there were a variety of responses. For example, some simply assumed that the tension would be the product of the mass and the acceleration.

For those candidates who formed a three term equation of motion, there were a number of problems with resolving, for example using $T\cos 60°$ instead of T. Some students who had formed correct equations were unable to carry out the simplification correctly and so gave an incorrect final answer.

Part (c) was often done well. The most common error was to substitute the value of v obtained in part (a) instead of simply substituting U.

Question 5

The candidates generally found part (a) of this question very difficult. Some of the more able candidates found an expression for F in terms of t and then applied Newton's second law. A few effectively reversed this process, by changing the graph into one for acceleration and then finding the equation of the line. Due to the fact that the answer was given, there were a large number of partial or very unconvincing arguments. Some candidates simply omitted this part of the question and went straight on to part (b).

There were many good responses to part (b), but a common error was to ignore the constant of integration. Candidates do need to include a constant of integration and find its value, even if it is zero, in order to gain full marks.

There was a similar problem in part (c), with many candidates again ignoring the constant of integration. Those candidates who included limits of integration, experienced less difficulty, because they wrote down the values of 0 and 200 and substituted both of them.

A few candidates used constant acceleration equations, but the number doing this was fairly small.

Part (d) produced some very mixed responses. There were some very good explanations, but some were very confused. Some candidates wrote about the acceleration instead of the velocity. In some cases the candidates seemed to have some idea of how to respond, but did not express this clearly. Quite a few candidates said that the constant would change, which seemed to imply that they were thinking about the intercept of the graph, but this did not lead to any marks as the velocity does not contain a constant term.

Question 6

Part (a) was done very well by the vast majority of the candidates. The printed answer probably helped some of them. In part (b), many candidates were able to obtain the value of 0.4, but far fewer were able to deal correctly with the inequality. When attempting questions like this, candidates must start with $F \le \mu R$ and preserve the inequality through out their working. Typically no attempt was made to start with an inequality, which some candidates did then try to introduce at the end of their solution.

Question 7

Part (a) of this question was often done well. Many candidates seemed to take the question in their stride, but others made limited progress or did not know how to approach the question. There were some who lost accuracy marks. The four main causes of this were;

- Omission of the negative sign in the differential equation,
- Algebraic errors,
- Incorrect integration,
- Not finding the value of the constant of integration.

Part (b) was done very well, with many candidates gaining the available mark without doing part (a).

MM03 Mechanics 3

General

Many candidates were well prepared for this paper and they showed good understanding. However, there was a minority who had little knowledge of most of the topics and responded correctly to a few questions. A significant number of candidates did not answer question 1 correctly. The attempts at projectile questions were good. There was some confusion over the signs in the application of Newton's experimental law and in the application of Impulse-Momentum principle. Most candidates showed competence in algebraic methods and calculus.

Question 1

The response to this question was quite variable. Too often, candidates were unable to answer this question correctly. Evidently, these candidates were not prepared for questions based on dimensional analysis. Some candidates' response to this question was flawed as these candidates started with the formula $T = 2\pi\sqrt{\frac{l}{g}}$ and showed that $T = T$.

Question 2

Part (a) This part was answered well by the great majority of candidates. However, a small number of candidates committed sign errors in using Newton's experimental law.

Part (b) Most candidates were able to apply the principle of conservation of the linear momentum and Newton's experimental law correctly but a significant number could not arrive at the correct quadratic equation in *e*. Most candidates solved the quadratic equation by using the formula and others by completing the square.

Question 3

Part (a) A large number of candidates substituted 0.1 for *t* in $1.4\times10^5(t^2-10t^3)$, instead of integrating to find the magnitude of the impulse exerted by the bat on the ball.

In part (b) many candidates could not use the principle of conservation of linear momentum correctly and accurately. These candidates overlooked the change in the direction of the ball due to the rebound.

Part (c) Most candidates stated that the ball is not perfectly elastic, or $e \neq 1$, or some of the kinetic energy of the ball is transferred into heat and sound energies.

Question 4

Part (a) Very few candidates did not answer this part correctly. These candidates found the velocity of Aazar relative to Ben or they did not express the relative velocity in terms of **i** and **j**.

In part (b) the vast majority of the candidates answered this part correctly. About half of the candidates used the relationship ${}_B\mathbf{r}_A = {}_B\mathbf{r}_{0A} + {}_B\mathbf{v}_A t$ and their answer to part (a) to obtain the required answer. The other candidates found r_A and r_B at time *t* and used subtraction to show the required result.

In part (c) There were many correct responses to this part. The most common approach was finding $\frac{\mathrm{d}\left|{}_B\mathbf{r}_A\right|^2}{\mathrm{d}t}$ and setting it to zero to find the time for the closest approach. The use of the chain rule was the most popular method of integration. Alternatively, the expansion and simplification of $s^2=(13+6t)^2+(6-20t)^2$ before integration were sometimes not free from errors. A small number of candidates efficiently used the scalar product ${}_B\mathbf{r}_A \cdot {}_B\mathbf{v}_A$ to find the closest approach time. A number of candidates obtained the required time by completing the square for s^2 and satisfying the condition for minimising it. Some candidates gave their result to two significant figures.

Part (d) The method mark for this part was dependent on the method marks for part (c). The majority of the candidates were able to use their result from part (c) to correctly answer this part.

Question 5

Part (a) The vast majority of candidates were familiar with the equations of motion for a projectile. They were able to eliminate t and arrive at the required equation of the trajectory.

Part (b) The algebraic manipulation and 'tidying up' of the quadratic equation in x and the subsequent task of solving it were prone to errors for some candidates. Some candidates who solved the equation correctly did not identify the required answer from their two solutions.

Part (c) Most candidates stated the two assumptions; no air resistance and the ball is a particle. A small minority of the candidates mistakenly stated that the ball was a particle without that mass.

Question 6

Part (a) Many candidates were able to apply the principle of conservation of linear momentum and Newton's experimental law along the line of centres. Some candidates had difficulty finding the components of the velocities along the line centres. This question requested the speed of B immediately after the collision. However, some candidates only found the component of the velocity of B after the collision along the line of centres. Some candidates found the velocity of B after the collision in terms of **i** and **j** and did not work out the speed as requested. Some candidates truncated rather than round their final result of calculation.

Part (b) Invariably, the candidates who correctly found the component of the velocity of B along the line of centres after the collision in part (a), were also able to answer this part correctly.

Question 7

Part (a)(i) Many candidates were able to answer this part correctly. A small number of candidates used $U\cos\theta$ and $g\sin\alpha$ as the components of initial velocity and acceleration respectively. In part (ii) there were many correct answers to this part. Many candidates found this part too difficult and gained no marks or only one method mark for this part. Some candidates found the inverse of the requested ratio.

MMO4 Mechanics 4

General

A very encouraging response from the vast majority of candidates. Some clear solutions evident. All questions succeeded in differentiating between candidates. The vast majority of candidates attempted all of the questions. There was evidence to suggest that some candidates had targeted particular topics for revision, often rotational dynamics. The paper appeared to be the correct length.

The best response was received for Question 3, Frameworks, and Question 4, Toppling/Sliding. The most challenging questions for candidates were Question 5, Rotation of a cylinder/attached to a string, and Question 7, Rotation of a framework/particles.

Question 1

Most candidates knew that the result must be zero and used it to find (a) and (b). In part (b) minor slips in the calculation of the determinant lost candidates marks. The best solutions showed clear calculation of each determinant before adding them together. Calculation of $\mathbf{F}\times\mathbf{r}$ r resulted in a 1 mark penalty.

Question 2

Part (a) was very well done. In part (b) some candidates again used $\mathbf{r}\times\mathbf{F}$, although when candidates chose to do this they often made errors. The most successful candidates calculated the moments from a clear diagram. Candidates did clearly distinguish between clockwise and anticlockwise moments. In part (b) the most common error was to use the total resultant instead of the x component. A number of correct solutions were seen which used the equation of the line of action.

Question 3

A good response to this question, although many candidates were not aware of the idea of using moments or resolving for the whole system. The most successful solutions included clear labelling of tensions in the framework, using T_{AB}. When candidates insisted on mixing compressions with tensions this only led to confusion in the solution. The weakest solutions resolved everywhere to get to the solutions, which were then not always correct.

Question 4

Only a few candidates correctly drew the force diagram, many not realising the **three** forces must go through the same point for the second mark. Many candidates found that the structure here did not help them with many answering part (b) in part (c). Full marks were awarded for this, of course. When errors did occur it was often due to an inverted ratio in part (b) – 3 instead of $\frac{1}{3}$.

Question 5

This was the question that proved to be most challenging. The best solutions correctly identified energy terms clearly – KE for cylinder, KE for particle, PE for particle before forming the equation. Alternatively they used F = ma for the particle and $C = \text{I} \times \text{angular}$ acceleration for the cylinder. Many candidates did not know how to start. A significant number used an invalid method which resulted in apparently the correct answer. This involved adding the moment of inertia of the cylinder to $2mr^2$ for the particle giving 6mr^2. This was invalid because the particle is moving in a straight, line and not rotating.

Question 6

Candidate performed better than expected here. In part (a)(i) two methods were credited. The standard 'book' method using elemental strips was rarely seen, although this is a useful skill for candidates to develop. Candidates who quoted the standard formula could gain full credit but the final A1 was for explaining from where the '2' had originated. Part (a)(ii) proved more problematic – the integration being beyond many candidates. The best solutions used inspection of substitution with a variety of successful substitutions used including use of trigonometry. Many candidates scored full marks on part (b)(i) and part (b)(ii) although not all candidates were aware of the significance of part a) or the standard result for a triangle. Careless errors were seen in part (b)(iii) with the area of the semicircle being stated as $\pi/2$ or $\pi/4$. The best solutions started with a table giving clear values for areas and distances. Almost all of the candidates scored either 2 or 3 marks in part (c) and this is clearly well understood by candidates.

Question 7

A challenging question with part (a) often stated incorrectly with many candidates not realising that I_G meant that the moment of inertia at the centre of mass was required in order to use the parallel axis theorem. Part (b) was well answered although some candidates confused themselves using standard rod results for particles. Particle C caused most difficulty. Several methods were seen for part (c) with candidates either splitting into particle and framework or combining all and then considering the movement of the centre of mass. Best solutions clearly calculated the position of the centre of mass before using it with potential energy calculations. Where candidates had sketched the relative positions, they had clearly calculated the relevant PE and therefore obtained the correct answer. This is to be encouraged.

MMO5 Mechanics 5

General

This paper was the first MMO5 under the new specification. The entry was small and the success of candidates varied. Total marks for the paper ranged from 4 to 75. Although a few candidates found the paper long, the majority had time to address those questions which they had not been able to finish at their first attempt. Questions 1 and 2 were found, as anticipated, to be straightforward, giving the candidates confidence. Question 3, using a different approach to test polar co-ordinates proved to be challenging. Candidates regularly obtained the printed results by inventing terms or numbers for which, clearly, they obtained no credit. In general the algebraic skills shown by candidates were good.

Question 1

This question was answered well.

Question 2

Except for a minority of candidates who did not find 0.24m, the distance of the particle from the centre of oscillation, candidates found this question straightforward and answered it correctly.

Question 3

The latter parts of this question were found challenging. Even in part (a), some candidates did not appreciate that the minimum value of $\dfrac{a}{1+5\cos\theta}$ occurred when the value of $1+5\cos\theta$ was a maximum, which was 6. In part (b), most candidates realised that to find $\dot{r}$ they needed to find $\dfrac{\mathrm{d}r}{\mathrm{d}\theta}.\dfrac{\mathrm{d}\theta}{\mathrm{d}t}$; but in part (c), the necessity to find $\ddot{r}$ was often ignored. In part (d), many candidates did not notice that, at A, $\dot{r} = 0$.

Question 4

The majority of candidates answered the question well. A small number failed to find the correct extension of the string and seemed to simply invented the answer. In parts (b) and (c), most candidates used the appropriate method with only a few having difficulty, usually in differentiating $\cos^2\theta$.

Question 5

Most candidates made good attempts at parts (a) and (b). The common difficulty occurred in part (b) where in particular problems were caused in their attempts at the removal of logs in the equation $\dfrac{1}{k}\ln\dfrac{\lambda V - kv}{\lambda V} = \dfrac{1}{\lambda}\ln\dfrac{M-\lambda t}{M}$, with terms such as $e^{\frac{1}{k}}$ appearing rather than $\left(\dfrac{\lambda V - kv}{\lambda V}\right)^{\frac{1}{k}}$.

Question 6

Part (a) was answered well, although again some candidates were clearly working back from the printed result to obtain the initial equation of motion. Part (b) was attempted well while the common error was in using $x = a$ when $t = 0$, not noticing that x was the distance below A, and initially the particle was released at A; thus $\alpha = 0$ when $t = 0$. Relatively few candidates were totally accurate in finding the velocity of the particle in part (c) and only these successful candidates could notice that the terms in $\cos\sqrt{3}nt$ cancelled out, leaving only the terms containing $\sin\sqrt{3}nt$.

MD01 Decision 1

General

Overall the paper discriminated well, providing a wide range of marks. Although there were many high marks, maximum marks were very difficult to achieve. There was an increase in the number of candidates who were ill-prepared for the demands of the paper. Some candidates appeared to have specific weaknesses on some topic areas. Candidates did not appear to have a problem with time and most scripts were presentable in appearance. It was disappointing to see a weakness in basic arithmetic, with even candidates who scored 60+ on the paper making very elementary mistakes. It is of concern that an increasing number of candidates do not complete the administration on the inserts and fail to **attach** the insert to their script.

Question 1

Part (a) was well answered and usually scored full marks. In part (b) some candidates are still not following the previous advice about writing down their alternating paths. Candidates who used numbers on a diagram quite often did not show their paths distinctively and lost marks as it is impossible to distinguish between using the required algorithm and trial and improvement.

Question 2

The majority of candidates used the correct sorting algorithm and most candidates identified the ‘no-change’ fourth pass. A significant number of candidates were unsure as to what constituted a pass. These candidates were not penalised in part (a) but obviously lost the marks in part (b). In this part many candidates scored full marks, but a number gave a total for the first 3 passes without any justification.

Question 3

Part (a) was a good source of marks for virtually all candidates, with few scripts using the wrong algorithm. A significant number of candidates merely drew the correct spanning tree, with no working. These candidates were rewarded, but not with full marks. It is essential that **all** working is shown if a candidate is to score full marks. Some diagrams of minimum spanning trees were not labelled at the vertices. Part (b) showed that Dijkstra’s algorithm is now well known and solutions were well presented with diagrams clearly labelled. Part (b)(ii) was a good discriminator.

Question 4

This question proved to be a good discriminator. In part (a) candidates realised that the method involved pairing odd vertices, however many candidates failed to find the minimum pairing connecting the odd vertices. Candidates must realise that they must consider the shortest distances connecting vertices when solving a Chinese postman problem. Parts (b) and (c) were poorly answered. Many candidates produced what appeared to be a random selection of numbers, with little thought as to the requirements of the question. These responses showed a lack of an in-depth understanding of the theory relating to Chinese postman problems.

Question 5

Part (a) of the question was poorly answered, again showing a general lack of understanding of the theory of upper and lower bounds. There were a surprising number of candidates who failed to complete the table correctly in part (b)(i). The rest of the question was well answered by the majority of candidates reflecting their ability to apply the relative algorithms.

Question 6

In part (a) candidates realised that they had set up the inequalities and this part was well answered, but drawing the two diagonal inequalities proved too difficult for many. Centres must ensure that candidates do not always rely on equating x and then y to zero to draw the graphs, as the scale may prevent this. Many students omitted drawing an objective line even though this is clearly mentioned in the specification. Candidates could still consider extreme points on the feasible region for the final two parts of the question, but many failed to find the correct vertices.

Question 7

This question discriminated between candidates, with many showing little understanding of graph theory. Part (a)(ii) was beyond nearly all candidates and in the final part a significant number of candidates stated that all vertices needed to be of even order and then drew a graph with odd vertices. Candidates should expect to be tested on all different aspects of graph theory in the specification.

MD02 Decision 2

General

The general performance on this paper was very good. Some topics such as Critical Path Analysis, Linear Programming using the Simplex Method and Game Theory seemed to be well understood and many candidates presented their solutions showing all the key steps in their working. Network Flows continue to prove difficult for many candidates who do not understand the flow augmentation technique.

Candidates need to distinguish between the different types of Gantt chart. When each activity starts as late as possible the slack needs to be shown in front of each activity bar. It is wise to start with the critical path where there is no slack.

When using the Hungarian algorithm, separate matrices should be used at each stage rather than crossing numbers out and replacing their values in a single tableau. If the numbers are not clear for each stage of the tableau examiners cannot award marks. The lines required to cover the zeros should be drawn and the minimum value, m, of the uncovered numbers should be stated before the matrix is adjusted by adding m to the entries covered by two lines and subtracting m from the uncovered entries.

When using flow augmentation, the labelling procedure requires that both the potential increase and decrease of flow be indicated on each edge. This is best done using forward and backward arrows (or a repeated edge, one showing forward potential increase and the other showing backward decrease). The individual routes augmenting the flow and the values of the extra flows should be recorded in the table provided.

Question 1

The network diagram and the critical path were answered very well by all candidates. A few were unable to identify float times for the non-critical activities. The major problem in the Gantt chart was a failure to show slack time. When this was indicated it was usually shown after the various activities even though the question asked to show activities starting as **late** as possible. Some indication should have been made on the diagram to indicate that G needed to start after F and also after C but this was not penalised this time.

Question 2

Part (a) A minority did not realise that the extra row needed to have equal entries. Those who chose a row of zeros had at least two stages of adjustment and made life difficult for themselves. **In future, a question may ask for a row of non-zero values to be added**.

Part (b) The main problem again was presentation rather than content. It was quite common for candidates to modify one matrix by crossing out entries and replacing them. There were far fewer errors when a new matrix represented each stage of reduction. **In future if candidates simply cross out numbers from one tableau to the next examiners may be instructed to give no marks for the crossed out stages**. Once again, many performed the column and row reductions, but then made no attempt at adjustment omitting an essential part of the Hungarian algorithm. Those who merely guessed at an appropriate matching were usually unsuccessful.

Question 3

A similar question to this had appeared on the specimen paper and most candidates found the minimum cost to be 14. It was answered equally well by those who used stage and state as by those who gave an indication on the network that the value was 16, say, after two successive 'journeys'. It was necessary to indicate that the cost of 14 could be obtained on two different routes. The question was marked generously this year, and **in future guidance may be given to centres indicating what is expected in the form of working in a question of this type so as to convince the examiner that the problem has been solved using dynamic programming**.

Question 4

Part (a) was usually correctly answered but a number made errors in calculating the value of the cut in part (b). The values of the initial maximum flows in part (c) were usually correct also. The insert **Figure 4** was intended to help candidates to set out their solution to part (d) in a logical manner. Some candidates failed to show potential forward **and** backward flows on their network. Candidates are advised to use the table to show what new flows have been introduced and to modify both the forward and backward flows in their network. It should be clear to the examiner what the previous values were when such modification is made and the final backward flows should be the values transferred onto **Figure 5** to give a possible maximum flow. Very few were successful in finding a cut of the same value as the maximum flow. The final part (e) was well answered by most of those who had found the correct maximum flow.

Question 5

A small number of candidates seemed unprepared for the Simplex method. However, apart from a few who made numerical slips, most candidates scored high marks on this question. A few candidates did not seem to realise how a pivot is selected from a given column and all candidates need to be encouraged to state the value of the pivot at each stage.

Question 6

The idea of dominance seems to be well understood but only the best candidates could explain the term 'zero-sum game'. In order to show that the game has no stable solution, it is expected that the minimum values in the rows and maximum values in the columns be indicated before finding the maximum of the minima and the minimum of the maxima. Some statement should then be made indicating that these two values are not equal and hence the game has no stable solution. To find the optimal mixed strategy, when a letter such as p is introduced, there should be an indication that this is the probability that Rowan is choosing R_2 for example. Three expressions in p were often written down with no indication as to what they represented. When three linear graphs had been drawn, many candidates made mistakes in choosing the appropriate highest point of the feasible region. Again, this gave the impression that many were following a recipe rather than understanding what this selection meant. Those who obtained the correct optimal strategy were able to find the value of the game.

Coursework

General

There was a significant reduction in the number of candidates submitting coursework at this session. There was evidence that a number of Centres switched to Specification B at a late stage; it is unclear why this was so. The standard of the AS coursework continues to please, with most candidates able to tackle the given tasks in appropriate fashion producing good analysis.

As mentioned in previous reports, there were a number of cases where errors on scripts were missed. Some of these were simple numerical or arithmetic errors from calculations which had not been checked, but there were some cases of incorrect fundamental statements of theory which were ticked as correct. Centres are reminded that if errors are not highlighted on scripts (or even worse ticked) then moderators will assume that these errors have not been accounted for in the marks awarded unless this is clearly indicated in written statements in the body of the script or on any accompanying paperwork.

There were still a number of Centres where an adjustment to the marks was suggested. This usually occurred when candidates had not addressed all of the strands. It is important that scripts are not just looked at as a whole, but that the specific skills in the strands are identified and applied to the work. In some cases the pieces were not sufficiently differentiated using the full range of marks.

It is a requirement that Centres undertake some form of Internal Moderation to ensure consistent standards are being applied within Centres. It is pleasing to see, in many cases, clear evidence of this identified on accompanying paperwork. Any issues identified by the moderation team will be on the Centre Feedback Form. Any advice or comments made, particularly if a continuation form is completed, should be viewed in a positive, constructive way rather than a criticism of the Centre.

A great deal of discussion has taken place about plagiarism in coursework. Centres need to be constantly vigilant, particularly when candidates have discussed the tasks in groups prior to their write-ups. In marking the work, any concern about the origin of a piece of work must be identified with the candidate before the Candidate Record Form is signed by the candidate. The other issue that candidates need to be careful about here is the use of ‘book-work’ proofs or development of results from texts; in particular it is not appropriate for ‘chunks’ of a text-book to be copied out verbatim.

Administration

It is a requirement that ***all candidates sign*** their Candidate Record Forms as well as the teacher. Failure to do so will lead to moderators sending for these signatures. No candidate signature could lead to candidates receiving no marks for their coursework.

It is a requirement to send a Centre Declaration sheet ***for all*** units in a session signed ***clearly*** by the staff responsible for the assessment. A number of Centres missed the Board – set deadline for the submission of their scripts (although fewer than in previous years). Centres should mark scripts in ***red pen*** and candidates should only use pencil for diagrams.

There were a significant number of errors made in completing the totals on the Candidate Record Forms. Many candidates were awarded an incorrect mark due to incorrect addition of the strands. Please double-check the scores entered which are eventually transferred to the Centre Mark Sheets.

Mechanics

At AS level there were many correct and appropriate calculations based on a good understanding of mechanical principles together with details of experiments and tables of results. There were more attempts at the ‘Basketball’ task this session and this was, in general, very well done. It is important that in this task candidates discuss whether the ball is on the downward path to ensure a basket is scored.

Some candidates did not use the opportunity to draw graphs to aid their generalisation, interpretation and prediction. Candidates should be encouraged to check their mathematical model for realism by comparison with 'real-life' data e.g. Check the reality of possible solutions in a child's slide by referring either to real slides or data on slides from appropriate web sites to aid discussion. Some reports over-relied on extensive, repetitive numerical work, done on a "trial and improvement" basis, which was less successful in the main.

In M2 there were some really excellent scripts seen, from a range of tasks, illustrating a thorough mastery of the mechanical principles in this unit. It was disappointing to see a reduction in the number of scripts seen as these tasks clearly help candidates when tackling the appropriate techniques in the examination.

Statistics

The work seen was generally of a good standard with a range of interesting individual responses to the tasks set. Many candidates generally showed sound understanding of the content of the unit (with perhaps the exception of the Central Limit Theorem). Ample data was collected and there were many correct and appropriate calculations. In the task involving Confidence intervals, diagrams were usefully used to consider the overlap or not of Confidence Intervals and most candidates appropriately used more than one level of confidence. This is still an area though that most candidates find hard to analyse and interpret and where guidance and explanation by the centres is needed. ***Candidates need to discuss how their samples were collected and should also be encouraged to explain in careful detail how it is random and is likely to be representative.*** This section is worth 6 marks and some clear discussion is expected for full marks (related if necessary to any particular difficulties in any method chosen; as in many cases it is simply not feasible to get a random sample). Good use, for sampling purposes, can be made of secondary data found on the internet, but sampling needs discussion as well here. Candidates should take care that they are actually sampling; there were a number of cases where the whole population was used.

The new task on correlation and regression continues to be a popular and successful task for candidates. It is important that candidates think carefully about which is the 'dependent' and 'independent' variable for their data. It may be advisable for Centres who have found difficulty with the Confidence Interval task to consider this option.

There were very few S2 scripts seen in this session and the standard of work seen was good. Candidates attempting the contingency tables task usually produced a sound piece of work if a little laboured at times. The division into categories is an important issue and should be discussed clearly in the write-up. The very best pieces of work seen in S2 were cleverly designed so that not only was a hypothesis test done, but then an appropriate contingency table followed.

Centres are reminded that they must use one of the new tasks approved by the Board for S2.

Mark Range and Award of Grades

Unit/Component	Maximum Mark (Raw)	Maximum Mark (Scaled)	Mean Mark (Scaled)	Standard Deviation (Scaled)
MPC1: Pure Core 1	75	75	46.6	18.1
MPC2: Pure Core 2	75	75	43.1	18.2
MPC3: Pure Core 3	75	75	45.6	16.7
MPC4: Pure Core 4	75	75	43.4	17.5
MFP1: Further Pure 1	75	75	49.0	18.5
MFP2: Further Pure 2	75	75	44.0	16.3
MFP3: Further Pure 3	75	75	53.7	17.5
MFP4: Further Pure 4	75	75	43.6	15.6
MS1A: Statistics 1A	-	100	62.6	18.5
MS1A/W: Statistics 1A Written	60	75	45.0	16.4
MS1A/C: Statistics 1A Coursework	80	25	17.4	4.0
MS1B: Statistics 1B	75	75	45.7	17.6
MS2A: Statistics 2A	-	100	64.2	12.3
MS2A/W: Statistics 2A Written	60	75	45.7	11.0
MS2A/C: Statistics 2A Coursework	80	25	18.2	2.6
MS2B: Statistics 2B Written	75	75	48.6	15.3
MS03: Statistics 3	75	75	50.4	18.2
MS04: Statistics 4	75	75	61.1	11.3

Mark Range and Award of Grades

Unit/Component	Maximum Mark (Raw)	Maximum Mark (Scaled)	Mean Mark (Scaled)	Standard Deviation (Scaled)
MM1A: Mechanics 1A	-	100	60.0	20.5
MM1A/W: Mechanics 1A Written	60	75	43.1	17.8
MM1A/C: Mechanics 1A Coursework	80	25	16.7	4.5
MM1B: Mechanics 1B	75	75	49.0	17.4
MM2A: Mechanics 2A	-	100	73.8	14.9
MM2A/W: Mechanics 2A Written	60	75	54.8	14.2
MM2A/C: Mechanics 2A Coursework	80	25	18.9	2.8
MM2B: Mechanics 2B	75	75	52.0	16.0
MM03: Mechanics 3	75	75	51.4	16.9
MM04: Mechanics 4	75	75	44.3	19.1
MM05: Mechanics 5	75	75	44.2	19.7
MD01: Decision 1	75	75	47.9	15.9
MD02: Decision 2	75	75	55.0	14.2

Unit MPC1: Pure Core 1 (10491 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	61	53	45	38	31
Uniform Boundary Mark	100	80	70	60	50	40

Unit MPC2: Pure Core 2 (17880 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	60	53	46	39	33
Uniform Boundary Mark	100	80	70	60	50	40

Unit MPC3: Pure Core 3 (6669 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	60	53	46	39	32
Uniform Boundary Mark	100	80	70	60	50	40

Unit MPC4: Pure Core 4 (9259 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	61	54	47	40	33
Uniform Boundary Mark	100	80	70	60	50	40

Unit MFP1: Further Pure 1 (1859 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	60	52	44	36	29
Uniform Boundary Mark	100	80	70	60	50	40

Unit MFP2: Further Pure 2 (1265 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	58	51	44	37	30
Uniform Boundary Mark	100	80	70	60	50	40

Unit MFP3: Further Pure 3 (952 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	62	54	46	39	32
Uniform Boundary Mark	100	80	70	60	50	40

Unit MFP4: Further Pure 4 (856 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	59	51	44	37	30
Uniform Boundary Mark	100	80	70	60	50	40

Unit MS1A: Statistics 1A (618 candidates)

		Max. mark	A	B	C	D	E
Writ0ten Boundary Mark	raw	60	48	42	36	30	25
	scaled	75	60	53	45	38	31
Coursework Boundary Mark	raw	80	64	56	48	40	32
	scaled	25	20	18	15	13	10
Unit Scaled Boundary Mark		100	80	70	60	50	41
Uniform Boundary Mark		100	80	70	60	50	40

MS1B: Statistics 1B (8764 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	60	52	44	37	30
Uniform Boundary Mark	100	80	70	60	50	40

Unit MS2A: Statistics 2A (18 candidates)

		Max. mark	A	B	C	D	E
0Written Boundary Mark	raw	60	46	40	34	29	24
	scaled	75	58	50	43	36	30
Coursework Boundary Mark	raw	80	64	56	48	40	32
	scaled	25	20	18	15	13	10
Unit Scaled Boundary Mark		100	78	68	58	49	40
Uniform Boundary Mark		100	80	70	60	50	40

MS2B: Statistics 2B (1656 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	60	52	44	37	30
Uniform Boundary Mark	100	80	70	60	50	40

MS03: Statistics 2B (65 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	61	53	45	38	31
Uniform Boundary Mark	100	80	70	60	50	40

MS04: Statistics 2B (35 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	61	53	45	38	31
Uniform Boundary Mark	100	80	70	60	50	40

Unit MM1A: Mechanics 1A (523 candidates)

		Max. mark	A	B	C	D	E
Written Boundary Mark	raw	60	47	41	35	29	24
	scaled	75	59	51	44	36	30
Coursework Boundary Mark	raw	80	64	56	48	40	32
	scaled	25	20	18	15	13	10
Unit Scaled Boundary Mark		100	79	69	59	49	40
Uniform Boundary Mark		100	80	70	60	50	40

Unit MM1B: Mechanics 1B (6251 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	61	53	45	37	30
Uniform Boundary Mark	100	80	70	60	50	40

Unit MM2A: Mechanics 2A (50 candidates)

		Max. mark	A	B	C	D	E
Written Boundary Mark	raw	60	49	43	37	31	25
	scaled	75	61	54	46	39	31
Coursework Boundary Mark	raw	80	64	56	48	40	32
	scaled	25	20	18	15	13	10
Unit Scaled Boundary Mark		100	81	71	61	51	41
Uniform Boundary Mark		100	80	70	60	50	40

Unit MM2B: Mechanics 2B (2128 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	62	54	46	38	31
Uniform Boundary Mark	100	80	70	60	50	40

Unit MM03: Mechanics 3 (302 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	59	51	44	37	30
Uniform Boundary Mark	100	80	70	60	50	40

Unit MM04: Mechanics 4 (84 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	59	51	43	36	29
Uniform Boundary Mark	100	80	70	60	50	40

Unit MM05: Mechanics 5 (32 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	57	49	41	33	26
Uniform Boundary Mark	100	80	70	60	50	40

Unit MD01: Decision 1 (4829 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	61	54	47	40	33
Uniform Boundary Mark	100	80	70	60	50	40

Unit MD02: Decision 2 (788 candidates)

Grade	Max. mark	A	B	C	D	E
Scaled Boundary Mark	75	64	56	48	41	34
Uniform Boundary Mark	100	80	70	60	50	40

Advanced Subsidiary Awards

Mathematics

Provisional statistics for the award (13363 candidates)

	A	B	C	D	E
Cumulative %	26.2	42.6	58.6	71.2	82.3

Pure Mathematics

Provisional statistics for the award (83 candidates)

	A	B	C	D	E
Cumulative %	26.5	42.2	54.2	66.3	78.3

Further Mathematics

Provisional statistics for the award (1609 candidates)

	A	B	C	D	E
Cumulative %	46.7	66.6	80.1	88.2	94.7

Advanced Awards

Mathematics

Provisional statistics for the award (9137 candidates)

	A	B	C	D	E
Cumulative %	35.3	56.6	75.1	87.9	96.6

Pure Mathematics

Provisional statistics for the award (126 candidates)

	A	B	C	D	E
Cumulative %	34.1	58.7	74.6	81.7	88.1

Further Mathematics

Provisional statistics for the award (1127 candidates)

	A	B	C	D	E
Cumulative %	51.6	73.4	88.1	94.9	98.0

Definitions

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

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

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

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

Further information on how a candidate's raw marks are converted to uniform marks can be found in the AQA booklet *Uniform Marks in GCE, VCE, GNVQ and GCSE Examinations*.