MATHEMATICS

Paper 9794/01
Pure Mathematics 1

Key messages

Candidates would be most advised to take great care to present fully labelled graph sketches which show all the essential features of the curve: asymptotes, crossing points on the axes and, but only if appropriate, co-ordinates of stationary points.

General comments

Candidates showed a confident understanding of all aspects of the syllabus examined in this paper. An excellent standard of presentation was observed. The paper provided weaker candidates with the opportunity to show their ability to produce fully detailed, well-argued and accurate solutions, whilst at the same time containing challenges which defeated all but the most able candidates.

Comments on specific questions

Question 1

This was a very straightforward question and obviously gave candidates confidence to tackle the rest of the paper. Any lack of success was due to arithmetic slips.

Answer: **(i)** $(x-4)^2-6$ **(ii)** -6 at $x = 4$

Question 2

This question caused many candidates considerable problems. The general features of the tan curve were known but those of the inverse were much less known so that many versions seen by Examiners were reminiscent of the reciprocal of x. However, the main problem remains the lack of clarity in the minds of many candidates over what constitutes a sketch. While the asymptotes of the tan curve were shown, there seemed little appreciation that there was an equal need to show the asymptotes of the inverse. Even if these were not shown, it was important to show at least that $\tan^{-1}\left(\frac{\pi}{2}\right)=1$. In general, for any sketch, the salient points of a curve must be shown and indicated clearly, perhaps by a scale on the axes. A curve should also be carefully drawn and labelled. Thus, for example, some tan curves were so drawn that they appeared to cut the asymptotes. Those candidates who drew two unlabelled curves received no credit at all as it was not clear to Examiners which curve was which.

Question 3

This question proved one of the most accessible on the paper with very few incorrect responses seen. Squaring both sides was by far the preferred approach by candidates although it is, arguably, the one which involves more work. Solutions which considered $\pm(2x-1)<3$ and a graphical approach were also successful. The answer was given as a single expression almost universally, but those candidates who prefer to offer two separate inequalities must always ensure that they are joined correctly by the appropriate term. Thus, the very small minority who did not join their inequalities lost a mark.

Answer: $-1 < x < 2$

Question 4

There was a high degree of success with this question, although some candidates did show difficulties in interpreting the factor of $-\frac{1}{2}$ in the second part. A point which deserves mention, however, is that when asked to draw transformations of this type, a scale on both axes is essential. The use of graph paper is, of course, perfectly acceptable and indeed, probably a more efficient choice than having to sketch out axes in the examination booklet, but a scale must still be included. A sketch with no scale can only attract limited credit and many candidates lost marks for this reason.

Question 5

This question provided unexpected difficulties for many candidates. It was envisaged that candidates would consider expanding the factors $\left(x-\left(3+\mathrm{i}\right)\right)\left(x-\left(3-\mathrm{i}\right)\right)$ and comparing the coefficients. Although the conjugate was recognised by almost all, many candidates preferred other approaches. One of the more unexpected was to use the quadratic formula itself with $\frac{-p}{2}=3$ and $\frac{\sqrt{36-4q}}{2}=\mathrm{i}$. Attempts to work with only the product of the roots, however, did not receive credit unless it was clear that candidates were considering also the sum of the roots. This is not a technique within the specification for this paper but some candidates showed that they had mastered it well. Substituting the two roots into the equation to form two simultaneous equations and equating real and imaginary parts was also seen and was a successful approach for those candidates who used it.

Answer: $p = -6$, $q = 10$.

Question 6

The performance of candidates on this question was impressive and it proved to be one of the most accessible in the paper. Very few candidates fell into the trap of integrating the difference between the curve and the line over an interval in which the curve fell below the x-axis but instead, correctly found the area of the triangle involved. There was only one point which Examiners felt was worth reiterating which was the interpretation of the word "exact" in the question. Many candidates seem unhappy with the idea of an answer like $\frac{5}{6}$ and feel impelled to supply a decimal approximation. The point cannot be made too strongly that they will incur a penalty by doing so as it is no longer apparent that they have answered the question as set nor know the meaning of "exact". It is also unwise in such questions to use decimal approximations in the intermediate working.

Answer: **(ii)** $y = x - 1$ **(iii)** $\frac{5}{6}$

Question 7

Performance on this type of question has improved over recent sessions. Candidates now tend to state the root separately from the iterates rather than expecting the Examiner to interpret the underlining of an iterate as implying the answer and, almost universally, the root was stated to the correct degree of accuracy. However, a few candidates relied on trial and error and an equally small number did not appear to know the formula correctly, and should be reminded that it is in the formula booklet, but a much larger number made an error in finding the derivative. A remaining and significant problem, however, is an appreciation by candidates that if an answer is required correct to three significant figures, then the iterates should be stated to four. Moreover, these should be rounded and not truncated. This question did not require any proof that the value obtained by the process was indeed a root other than by observing when two or more iterates agreed to 3 significant figures. This however, did require evidence that sufficient iterates were attempted so just stating two, or indeed in one case, no iterates, was hardly a strategy which would be expected to receive credit.

Answer: 2.47

Question 8

This question was accessible to the majority of candidates. The chain rule was well recognised and candidates were able to reduce their equation to $e^t = 0.5$ and apply a log law to achieve the given result with little difficulty. Some candidates tried to approach the problem from a different perspective by substituting $t = -\ln 2$ into the derivative and deducing that the result was 3. This approach was allowed on this occasion but it is a nice question whether this amounted to rewriting the question to show that the gradient was 3 at the point on the curve when $t = -\ln 2$. Candidates must be very careful in their reading of a question before deciding on a strategy for answering it.
There was, however, a sizeable minority of candidates who were unable to differentiate the original functions correctly, arriving at $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{te^t - 5}{te^t - 2}$ which effectively prevented them from achieving the given answer in the second part. It is always of value to point out to candidates that when they are unable to obtain the given answer to a question with a reasonable amount of work, they should always check back to ensure that their previous work does not contain an error. Assuming that the question is wrong or attempting to manipulate the mathematics to achieve the desired end is never a helpful strategy.

Answer: **(i)** $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{e^t - 5}{e^t - 2}$

Question 9

This question proved challenging to a large number of candidates. It was expected that candidates would be able to recall and apply properties of geometric progressions readily but this was often not the case. This was particularly so in the last part where, having obtained values of r successfully as $-\frac{2}{3}$ and $\frac{3}{2}$, calculations of sums to infinity were made with both values of r and no choice made between them. Such candidates merited very little credit and those who rejected the correct value and used only $\frac{3}{2}$ received none at all. It cannot be stressed enough that candidates should know standard results fully and correctly, and know which ones are provided in the formula booklet. Statements that sums to infinity depended on $r < 1$ did not gain credit. It was also surprising that a large proportion of candidates were unable to formulate clearly expressions for r in the first part, of which the given quadratic equation was the result.

Answer: **(i)** 4, − 9 **(ii)** $-\frac{2}{3}, \frac{3}{2}$ **(iii)** 13.5, 8.1

Question 10

Most candidates showed a good grasp of the integration tested in this question. The first part was particularly successful with many correct answers seen. Some candidates showed some confusion in the handling of the constant, producing $\frac{1}{2}\ln(2x^2 + 10)$ as their integral. They gained credit for obtaining an expression of the form $\ln(f(x))$ though and for using correctly a log law at least once on their expression.

Candidates in the second part were almost equally divided between those who used integration by parts and those who chose a substitution method. A few candidates went on to further simplify their answer correctly and are to be commended for this. Many candidates, though, lost a mark for not observing that an indefinite integral should include a constant of integration.

Answer: **(b)** $\frac{2}{15}(x-2)^{\frac{3}{2}}(3x-4)+c$

Question 11

Completing this question successfully proved challenging to even the best candidates. All were able to gain marks by dealing with the partial fractions in the first part and most made a very sensible attempt at the second part. The separation of variables technique was well recognised but some candidates lost marks in the second part by not retaining the idea of an equation throughout and dealt only with the integration of one side. There was also a lack of clarity in how the constant *A* was obtained. The value of *A* was found successfully in part **(iii)** by almost all candidates but only the most able were sufficiently secure in their understanding of the problem to select the correct root. Most chose the positive root without checking that this did not satisfy the initial conditions. It was noted that, even with the wrong choice of root, algebraic insecurity prevented a majority of candidates from validly expressing *y* in terms of *x*.

Answer: **(i)** $\frac{2}{y}+\frac{2}{1-y}$ **(iii)** $A = 4$, $y=\frac{2e^{\frac{x}{2}}}{2e^{\frac{x}{2}}-1}$

Question 12

Candidates found the second part of this question particularly challenging, although most gained credit for a correct start to the first part, reaching the expression $\dfrac{\dfrac{4\tan x}{1-\tan^2 x}}{1-\left(\dfrac{2\tan x}{1-\tan^2 x}\right)^2}$. However, only the most able candidates with secure algebraic skills were able to deal successfully with the denominator and so achieve the given result correctly.

The essence of the proof required in the second part was to link the identity to the equation by observing that if $x=\frac{\pi}{16}$ was a root of the equation then $\tan\left(\frac{4\pi}{16}\right)=\tan\left(\frac{\pi}{4}\right)=1$. A consequent rearrangement of the identity using $x=\frac{\pi}{16}$ immediately gave the value of *p*. Very many impressive attempts were observed to come to this conclusion, but candidates often lost credit by not quoting directly that they were relying on the fact that $\tan\left(\frac{\pi}{4}\right)=1$. The value of *p* was often given without any justification and this did not receive credit, nor did attempts to work a decimal solution. It may be worth pointing out to candidates that at this stage in the paper, they are expected to be able to produce fully argued solutions.

Answer: $p = 4$

MATHEMATICS

Paper 9794/02

Pure Mathematics 2

Key Messages

In order to be successful, candidates need to have a good understanding of the entire content of the syllabus. Candidates should be able to use mathematical conventions to express themselves clearly, including the use of brackets and a clear indication of where a fraction line is intended to finish. In questions that involve a proof it is essential that sufficient justification and detail are provided, both in words and algebra, in order to be convincing.

General Comments

Candidates generally seemed well prepared for the examination and all were able to demonstrate their knowledge on the more straightforward questions. The better candidates then produced some accurate and well reasoned solutions to some testing questions. The standard of presentation was mostly good and candidates were able to produce solutions that were detailed and easy to follow. Candidates are reminded that they should heed any advice given about the accuracy of final answers, especially if an exact solution has been requested. When a sketch graph is requested there is no expectation that graph paper should be used and attempting to plot points accurately is often not the most effective way to convey intent. All that is required is a sketch that shows the salient features of the curve, including the general shape and points of intersection with the axes, which can be adequately executed in the answer booklet.

Comments on Specific Questions

Question 1

Both parts of this question were very well attempted, and nearly all candidates gained all of the marks available. Candidates could quote the relevant formulae, substitute in and then correctly evaluate each expression. Only a few candidates omitted to check that their calculator was in the correct mode before attempting evaluation. Some candidates opted to employ longer methods using right-angled triangles; this was usually successful but premature approximation sometimes resulted in a loss of accuracy in the final answer.

Answers: **(i)** 13.2 **(ii)** 34.5

Question 2

This should have been a straightforward early question, and many candidates did indeed gain full marks, but it proved problematical for a minority of candidates.

(i) Most candidates could quote the correct expression for the discriminant and gained both of the available marks with ease, although a few spoiled their answer by also including the square root. The most common error was to instead find $f'(x)$, possibly confusing discriminant and derivative.

(ii) The better candidates quoted the required inequality at the start of their solution, and then attempted to solve it. Some candidates lost a mark by only considering the positive square root and others by using incorrect notation such as $k > \pm 4$ or $-4 > k > 4$. Other solutions were not so well presented and, whilst 4 and –4 did appear, it was not clear whether the correct inequality sign was being considered.

Answers: **(i)** $k^2 - 16$ **(ii)** $k > 4$, $k < -4$

Question 3

This is a standard specification request and most candidates did at least seem aware of the required process. However, for such a standard question it was disappointing not to see more fully correct solutions. Most candidates could attempt the correct structure for the gradient of the chord, then expand and simplify. Some errors occurred due to too many steps being attempted in a single line; when a convincing proof is required candidates should ensure that each step is carefully detailed. Minor errors in notation were condoned, such as stating $h = 0$ rather than showing it tending to 0, but candidates should aim to be precise with their notation. A number of candidates did not gain the final mark in an otherwise correct solution, as there was never any sight of $f'(x)$.

Question 4

(i) The overwhelming majority of candidates were able to use the scalar product to attempt a relevant angle, but many did not give enough consideration to the direction of vectors which resulted in the obtuse angle being found. This could still gain two of the four marks available. A quick sketch may have proved helpful in determining the vectors to be used. Some candidates opted to use the cosine rule instead; this was usually done correctly and also ensured that the required acute angle was found.

(ii) This part of the question was very well done, and a pleasing number of fully correct solutions were seen. The most successful approach was to find the two parallel vectors, deduce the scalar multiple required and hence find a and b, although more informal methods were equally successful.

Answers: **(i)** 47.1 **(ii)** $a = -13$, $b = -22$

Question 5

(i) The tenth term was found correctly by all but a few candidates.

(ii) The vast majority of candidates could quote the correct formula, substitute in and find the required sum to gain both of the marks available. There were a few errors made when evaluating the expression, but only a handful of candidates had to resort to manually summing the fifteen terms.

(iii) This final part of the question proved to be much more challenging, and a number of candidates struggled to identify the new terms to be summed. The most common error was to treat the definition of the new progression as a recursive one rather than an nth term definition. The more able candidates appreciated the link with the previous part of the question and simply doubled their previous answer, but there was some uncertainty as to whether to then add 1 or 15. Others managed to generate the terms of the new sequence, deduce the values for a and d (or possibly l) and then use the sum formula again.

Answers: **(i)** 68 **(ii)** 810 **(iii)** 1635

Question 6

Most candidates were able to make a good attempt at finding the requested exact values, with very few resorting to using their calculator and giving decimal answers. The vast majority of candidates could quote the required identity for $\sin 2\theta$ and the definition for $\cot\theta$, and most could then make an attempt at finding relevant trigonometric ratios. The most common approach was to draw a right-angled triangle using the given ratio, attempt the missing side and hence the requested ratios. Upon seeing sides of 3 and 4, a few candidates assumed that the final side must be 5 despite this not being commensurate with their diagram. The other approach was to square the given ratio and then use relevant identities. Both approaches tended to be equally successful, although the first was more efficient.

Answers: $\sin 2\theta = \dfrac{3\sqrt{7}}{8}$, $\cot\theta = \dfrac{3}{\sqrt{7}}$

Question 7

(i) This question should have been a simple factorisation of a disguised quadratic in z^2, and many candidates were able to simply write down the correct answer. A few used more long-winded methods, seemingly based on the sum and product of roots, but most did get there in the end.

(ii) Most candidates correctly found the roots of ± 2, but a number then only produced a further single root of i forgetting that $z^2 = -1$ should also give two solutions. Candidates were clearly familiar with the concept of an Argand diagram, and many could correctly plot the roots that they had found. Some candidates did not appreciate that the points should be on the axes and instead attempted to combine the roots and plotted points such as 2 + i.

Answer: **(i)** $(z^2 + 4)(z^2 - 1)$

Question 8

This question was generally very well done, with most candidates gaining at least three of the marks available. The differentiation was invariably correct, and this was then equated to zero with an attempt to solve. Done correctly, this gained the first four marks although a surprising minority found the square root of 0.5 to be 0.25. In order to make further progress candidates had to consider both the positive and negative roots, discard the latter with a convincing explanation and finally find the coordinates of the stationary point in an exact form. It was disappointing that some candidates spoiled an otherwise correct solution by resorting to decimals.

Answer: $\left(\frac{1}{\sqrt{2}}, \frac{1}{2} - \ln\frac{1}{\sqrt{2}}\right)$

Question 9

(i) Candidates seemed familiar with this topic and were able to use the given recurrence relations to evaluate the predicted population for each of the two models. Rounding answers to the nearest integer, rounding down to an integer value and leaving the final answer as a decimal were all condoned.

(ii) Most candidates were able to identify that Model 1 would predict a stable population with some minimally acceptable reasoning, usually referring to deceasing differences, and this gained one mark. To get both marks, candidates had to also demonstrate that they had considered what would happen in the long term, in that it converged to a specific value.

(iii) Only the best candidates were able to provide a convincing solution for this question. They were expected to evidence their answer by identifying that, in the long term, the model became periodic. They could either identify the four values involved or refer to a period of 4, but many simply referred to the behaviour being unstable without showing that they had considered values beyond the initial ones.

Answers: **(i)** 687, 927 **(ii)** Model 1 as it converges to 693 **(iii)** periodic with 926, 561, 980, 429

Question 10

This question was very well done by the full range of candidates.

(i) All candidates substituted $x = 1$ and evaluated the expression, although a number did not then make a relevant conclusion.

(ii) A few candidates first used the remainder theorem to find the remainder and then attempted to find the quotient, although most used a single method to find both. A variety of methods were seen, including long division, coefficient matching and inspection and these all proved to be equally successful, with many fully correct solutions being seen.

(iii) Many candidates could identify the link to the first two parts of the question, and it was then reasonably straightforward to find the quadratic factor and hence fully factorise the function. If the division had gone wrong in part **(ii)**, candidates could still either use $(x - 1)$ as a factor, or identify one of their own, and proceed to find a fully correct factorisation. Sketching the graph proved to be more challenging; a number assumed that the three roots meant that it had to be a cubic rather than looking at the given equation or appreciating the significance of the repeated root. Of those who did manage to identify the salient features, many did not take sufficient care when sketching the graph. A common error was to assume that $(0, -15)$ was a turning point, which was condoned as long as the general shape was still roughly correct, and other graphs showed the incorrect curvature as y increased. Some candidates did more work than was necessary by calculating the coordinates of the turning point, even though the phrasing of the question indicated that only the roots needed to be considered for the sketch.

Answers: **(ii)** quotient is $(x^3 + x^2 - 5x + 3)$, remainder is 0 **(iii)** $(x - 5)(x - 1)^2(x + 3)$

Question 11

Whilst the first part of this question was done well, the second and third parts proved to be the most challenging aspect of the paper. This seemed to be an area of the specification that many candidates were not overly familiar with.

(i) Candidates seemed generally proficient with all of the required differentiation techniques, and full marks were relatively common. Full credit was given at the first point where a fully correct expression was seen which meant that subsequent errors when attempting simplification were ignored. These errors, which were reasonably common, did then have an impact on the values obtained in the latter parts of this question. It was disappointing to see some candidates lose marks through not using brackets to accurately convey their intentions.

(ii) Only the most able candidates even considered the gradients of the three functions at $x = 1.9$. Candidates were then required to explain the reasoning for any choices made, and these were often only partially correct or no reason at all was given. When asked to show a given result it is essential that candidates can provide an accurate and complete proof. Whilst some fully correct solutions were seen, too many candidates simply considered the value of the function itself at $x = 1.9$ and thus gained no credit.

(iii) Even fewer fully correct solutions were seen to this final part of the question. Despite the sequence of errors being defined, most candidates were unclear on how to proceed. The most efficient method was to set up an inequality or equation in terms of e_1 and then cancel, but some candidates instead evaluated e_1 and continued with this numerical value, which could still gain full marks.

Answers: **(i)** $x - \frac{3}{4}x^2$, $\frac{1}{3}\left(2x^2 - 4x + 7\right)^{-\frac{2}{3}}(4x - 4)$, $\dfrac{-4\left(x^2 - 2x\right) - (7 - 4x)(2x - 2)}{\left(x^2 - 2x\right)^2}$

(ii) $F_1(x)$ and $F_2(x)$ will converge, and $F_2(x)$ will do so more rapidly **(iii)** 22 iterations

Question 12

This question proved to be a challenging end to the paper, particularly the second part.

(i) The majority of candidates appreciated the need to solve $x = 0$, although some did not treat the expression as the product of two terms in t, and others expanded and cancelled thus losing solutions. A minority expended a lot of time and energy in finding the gradient function, and equating this to zero, without considering whether this was an appropriate strategy. However a good number of candidates did equate the two terms to zero and attempt their solution. Candidates could usually obtain $t = \frac{1}{2}\pi$ but the second solution was often omitted. Whilst both solutions to $1 - 2\sin t = 0$ were more often seen, only the most able candidates appreciated that these both gave the same point, which was required to confirm the three points of intersection.

(ii) Most candidates were able to make some attempt to find the range of values for which *y* was positive, and a number of partially correct solutions were seen. The better candidates were able to identify the second range of values as well. Only the most astute candidates also considered whether the two factors could both be negative. Despite being given the equation in factorised form, a number of candidates decided to first expand it and then attempt the solution. This usually resulted in the inequality signs now being incorrect.

Answers: **(i)** $y = -2$ when $t = \frac{1}{2}\pi$, $y = -4$ when $t = \frac{3}{2}\pi$, $y = -\frac{1}{4}$ when $t = \pi$ and $\frac{5}{6}\pi$

(ii) $t \in \left(0, \sin^{-1}\frac{1}{3}\right) \cup \left(\pi - \sin^{-1}\frac{1}{3}, \pi\right)$

MATHEMATICS

Paper 9794/03
Applications of Mathematics

Key Messages

When tackling questions involving permutations and combinations (such as **Question 5**), candidates should make sure that they fully understand the terms of the question and any constraints that apply to the situation posed before commencing their answer. In Mechanics questions involving integration (such as **Question 10**) candidates should be mindful of the need always to address the initial conditions either by including "+*c*", which is then evaluated explicitly, or by including and applying limits, as appropriate to the circumstances of the question.

General Comments

This paper appeared to have been well received by candidates and there were many high scoring scripts. There was no evidence to suggest that candidates were short of time. On the whole the Probability and Mechanics Sections appeared to be equally accessible to most candidates. Candidates are reminded that they should take heed of the instruction about the accuracy of final answers, while at the same time bearing in mind the consequences of premature approximation.

Comments on Specific Questions

Section A Probability

Question 1

This question was answered correctly by most candidates. Compared to previous years candidates seemed better able to make sensible and efficient use of the built-in statistics functions of their calculator. Apart from anything else this avoids getting the wrong answer for the standard deviation as a result of premature approximation of the mean. It is appropriate to show a certain amount of working in order to demonstrate an understanding of the method but there should be no need for candidates to do the calculations manually.

Answers: Mean 2.062, Standard deviation 0.244

Question 2

(i) This part was generally well answered. Only a few candidates made the mistake of working out $P(A) \times P(B)$; this assumes that A and B are independent, which is the point of part **(iii)**.

(ii) This part was also well answered.

(iii) It was apparent that candidates did not know the meaning of independence and the conditions for two events to be independent. Many confused "independent" with "mutually exclusive" and/or "exhaustive". Candidates were asked to "Explain …" so they were expected to quote the numerical evidence on which they based their conclusion.

Answers: **(i)** 0.3 **(ii)** 0.5

Question 3

All parts of this question were very well answered by almost all candidates.

Answers: **(i)** 0.2 **(ii)** 4 **(iii)** 3.45

Question 4

(i) This part was answered easily by almost all candidates.

(ii) Most candidates chose to calculate the probability of exactly 8 people using the formula for a binomial probability. While this is a perfectly good approach, it was anticipated that many more candidates would use the cumulative binomial tables provided in the formula booklet than turned out to be the case.

(iii) In this part, use of the tables to find $1 - P(X \leq 7)$ was by far the quickest and easiest approach. Many candidates did it this way, but there seemed to be a widespread reluctance to do so by many others who preferred to use the formula for a binomial probability (as in part **(ii)**) and sum over several terms. These candidates created considerable extra work for themselves along with an increased risk of making mistakes. It is, perhaps, to their credit that many of them persevered to a successful conclusion.

Answers: **(i)** 8 **(ii)** 0.1797 **(iii)** 0.5841

Question 5

(i) This part was usually answered correctly, with candidates recognising it as a combinations problem.

(ii) Most candidates struggled to make suitable progress with this part. Because part **(i)** involved combinations (of 4 from 15), many candidates assumed that this part would involve permutations (of 4 from 15), missing the point about there being no restrictions on how the medals could be allocated. There were quite a few other candidates who picked up on the absence of restrictions, most of whom tried to enumerate the different cases that could arise, which made the question far more difficult than necessary, and their methods were usually incomplete. Relatively few candidates appreciated that each medal can be awarded in 15 ways and that overall there are 15^4 ways.

(iii) This is where permutations (of 4 from 15) comes into the question. Candidates who had managed to sort out part **(ii)** were usually able to complete the question successfully, but they were in the minority. Most other attempts involved the answer to part **(i)** divided by the answer to part **(ii)**.

Answers: **(i)** 1365 **(ii)** 50625 **(iii)** 0.647

Question 6

(i) There were many successful attempts at this part of the question. Unsuccessful attempts were usually the consequence of not knowing how to handle probabilities in the left-hand tail of the normal distribution.

(ii) It was clear that most candidates had met this sort of question before and so knew what was expected in terms of setting up and solving simultaneous equations for the mean and standard deviation. As in part **(i)** the most common errors were to do with handling the left-hand tail of the distribution. Candidates needed to obtain "*z*-values" by reading the normal tables in reverse, and this involves using the difference columns to get as close to the correct values as they reasonably can. Care was also needed in solving their simultaneous equations: premature approximation at any stage was likely affect the accuracy of their final answers.

Answers: **(i)** 0.6826 **(ii)** Mean 8.308 Standard deviation 0.1628

Section B Mechanics

Question 7

There were very many correct solutions to this question. It was interesting to note that the approaches adopted were not always the most efficient. Many candidates did not seem to realise the symmetry of the situation and so, typically, they would find the times for the ascent and descent separately and using different (albeit correct) "*suvat*" formulae. There were a few candidates who found the time for the ascent only.

Answers: Height 45m, Time 6s

Question 8

(i) This part was usually answered correctly.

(ii) Candidates usually found the magnitude of the force $\mathbf{F}_4$ very easily. Having used an appropriate inverse trigonometric function, many candidates made heavy weather of describing the direction. It seemed that they were not confident about using the convention that angles are measured anticlockwise from the positive **i** direction and so resorted to various alternative means, including the use of bearings.

Answers: **(i)** $-8\mathbf{i} + 6\mathbf{j}$ **(ii)** Magnitude 10N, Direction 143°

Question 9

(i) Candidates need to be careful that a force diagram includes only the relevant forces (i.e. the weight, the friction and the normal contact force in this question) and that none are duplicated. For instance it is not appropriate to include the components of the weight as well as the weight itself or to include the resultant force (down the slope in this case).

(ii) Many candidates answered this part of the question well.

(iii) In the situation described in this question, a particle released from rest on a slope that is so rough ($\mu > \tan\theta$) simply will not move. Many of the responses may have been intended to say that but in reality they said something different (e.g. "It will not accelerate down the slope"). There were quite a few who said that the particle will accelerate up the slope.

Answers: **(ii)** $a = g(\sin\theta - \mu\cos\theta)$

Question 10

In this question the acceleration is variable (with time) and so "*suvat*" equations should not be used. Candidates who do not appreciate this can end up losing all the marks.

(i) Integration of the expression for the acceleration rarely posed difficulties. Unfortunately, many candidates omitted the constant of integration, either because they realised it would be zero or through negligence. Either way it is important to include it and to show how its value is determined.

(ii) As in part **(i)**, the integration was usually carried out successfully, but, also as in part **(i)**, the constant of integration was often missing. In this part it would have been quite acceptable to use a definite integral with limits of 0 and 4 (properly applied).

(iii) On the whole candidates answered this part well.

Answers: **(i)** $0\ \text{ms}^{-1}$ **(ii)** 32 m **(iii)** $-36\ \text{ms}^{-1}$

Question 11

(i) There were many good, well-organised solutions to this question. Solutions that were not successful usually exhibited a lack of clarity and organisation, especially in relation to which direction is positive for the application of Newton's Second Law to each particle.

(ii) Almost all candidates used their acceleration from the previous part to find the speed of the heavier particle as it hit the ground. Occasionally some used g instead.

(iii) Most candidates knew that 'Impulse = change of momentum'. There was some degree of uncertainty over the units of impulse: Ns is usual but kg ms^{-1} is an acceptable alternative.

(iv) In this part many candidates made extra work for themselves by using Newton's Second Law and "*suvat*" to find the force required. The much more direct method is to use 'Impulse = force $\times$ time'.

Answers: **(i)** $a = 2\text{ms}^{-2}$, $T = 2.4\text{N}$ **(ii)** 3ms^{-1} **(iii)** 0.9Ns **(iv)** 180N