MATHEMATICS

Paper 9794/01
Pure Mathematics 1

Key Messages

Candidates must ensure that they read the questions thoroughly to understand exactly what they are being requested to do. When asked to prove a result, candidates must plan their response carefully to ensure that they do not assume the truth of what they are attempting to prove. They must also choose words with precision when explaining their answers so as not to state the opposite of what they intend and must ensure that they have a confident and secure understanding of the way requests are conventionally phrased in mathematics.

General Comments

At one end, the paper contained significant challenges for the most able candidates while at the other, weaker candidates were afforded the opportunity to show their ability in more routine requests. Candidates showed that they were able to rise to the challenges presented and the vast majority of candidates showed confidence and accuracy in producing detailed and very clearly presented solutions.

Comments on Specific Questions

Question 1

This was a very straightforward opening question which caused no issues for many candidates. However, this is one place where the importance of observing standard mathematical descriptions should be stressed. Some candidates gave as their answer $-3 > x > 4$ but plainly showed by their working that they did not intend this. Another case in which what was stated was not what was necessarily intended was when candidates just used a comma as in $-3 < x, x < 4$. Finally, candidates would be best advised not to use words like AND and OR unless they are fully familiar with their logical implications.

Answer: $-3 < x < 4$

Question 2

This question caused few problems to most candidates and, perhaps due to the ability of modern calculators to transform many decimals into exact fractions, the roots were most often seen in that form. There was a tendency on the part of a minority, however, to supply both the exact and decimal form of the roots. To present both an exact form followed by an approximate form is a curious decision and one which is best avoided. A very small number of candidates could make no substantial progress with this question but this was attributable almost universally to faulty algebra in squaring $(10 - 2y)$ as $100 + 4y^2$.

Answer: $(2, 4), \left(\frac{14}{8}, \frac{8}{3}\right)$

Question 3

Almost universally, candidates recognised that the Sine Rule provided the method for solving this problem and were successful in correctly substituting the values into the formula. Some very successful attempts were seen at manipulating the equation to obtain the correct value of x but a sizeable minority of the algebraically less secure candidates made errors perhaps caused by the combination of sines and terms involving the variable appearing on both sides of the equation. Some obscure answers to otherwise correct methods could be attributed to candidates using their calculator in radian mode. It may be worth emphasising to candidates the need to check beforehand that their calculator is set correctly.

Answer: 1.52

Question 4

There was a variable response to this question. The idea of assessing the laws of logarithms in the context of reduction to linear form should not have been unexpected, but a sizeable number of candidates did not recognise how a linear form could be achieved and decided that the required form should be $\ln P = bt \ln ae$. Stating the vertical intercept and gradient from their equation thus became impossible. Some candidates seemed to realise this and tried to complete an answer to part **(i)** by resorting to the graph to attempt to find values of the gradient and intercept. This received no credit unless repeated in part **(ii)** where use of the graph provided was indeed requested. On the other hand, those candidates who successfully reduced the equation to the required linear form seemed to have no difficulty in completing the question. Candidates should be aware that using logarithms to reduce an equation to linear form is an essential tool for the mathematician when modelling data from realistic situations.

Answer: **(i)** $\ln P = \ln a + bt$, gradient = b, intercept = $\ln a$ **(ii)** $a = e^2$, $b = 2.5$.

Question 5

This question provided further unexpected difficulties to many candidates. It is important that the distinction between a request to "find" and "show" or "prove" is well understood. Thus, stating $(x - 3)^2 + (y - 2)^2 = 25$ only is sufficient to find the radius but quite insufficient to show that the centre of the circle is (3, 2). For that request, candidates were expected to start from the given equation and manipulate it into the completed square form. There were many valid ways seen of doing this but the most popular was to indicate just the integers that needed subtraction to maintain the same equation:$(x - 3)^2 - 9 + (y - 2)^2 - 4 = 12$. A similar comment might be made about part **(iii)**. In order to show that the second diameter was perpendicular to PQ, a calculation of its gradient was necessary in order to use the well-known result $m_1m_2 = -1$. While all candidates were aware of this result, it was not acceptable to use the result first to find the gradient of the second diameter as this assumed the truth of what candidates were asked to prove. It is perhaps also worth mentioning that the use of diagrams to find gradients needs care. While a diagram can be thoroughly commended to help clarify a situation, it must be followed by an explicit calculation to justify the gradient. For example, of those diagrams seen, none explicitly showed why the gradient had to be negative. In contrast, the gradient of PQ was almost invariably calculated explicitly in part **(ii)**, although some candidates implicitly differentiated the equation of the circle to find the equation of the tangent at the point (−1, −1). It may also be apposite to stress the need for candidates to read the question carefully and give the final answer in the form requested. Some candidates lost credit in this part for providing their answer in alternative forms.

Answer: **(i)** 5 **(ii)** $3x - 4y = 1$

Question 6

In general, the knowledge shown by candidates in forming the composite and inverse of a function and its associated terminology was impressive. Candidates did not, however, display sufficient care in reading the question. If a request for the values of x for which $(gf)^{-1}$ is not defined receives the answer "$x \neq 2$" the candidate is asserting the exact opposite of what they presumably intended. Some candidates were let down by their algebra in that, having obtained the correct expression for gf, they simplified their answer incorrectly and then used this erroneous version for part **(ii)**. Stating the domain for gf posed fewer issues than the range, which only a minority of candidates were able to state correctly. There were also a few candidates who interpreted gf as the product of the two functions g and f rather than their composition.

Answer: **(i)** $y = \dfrac{3}{x-1} + 2$ $x \neq 2$, $y \neq 2$ **(ii)** $y = \dfrac{x+1}{x-2}$, $x = 2$

Question 7

Performance on this question indicated a very good level of understanding by the majority of candidates. However, many other candidates lost marks through a mixture of imperfect knowledge and careless reading of the question. The use in part **(ii)** of the position vector of the point on the line rather than the direction vector to find the angle between the lines was regrettable. Candidates were asked to "show" that the lines intersected before finding the point of intersection. There were many acceptable ways to do this but some candidates ignored the request altogether. It is also worth a comment that when required to find coordinates, it is usually not acceptable to offer these in vector form. On this occasion a column vector was accepted, but answers as a linear scaling of **i**, **j** and **k** were considered too far away from what was actually requested.

Answer: **(i)** (1, 14, 5) **(ii)** 9.0°

Question 8

This question was well done by the majority of candidates who showed a sound knowledge of operations on complex numbers. A few observations may be worth noting however. Many candidates lost the final mark in part **(iv)** because they did not make a proper conclusion to their reasoning and left their answer as 2. This left it to the Examiner to deduce that they were aware that 2 was a real number. Experience has shown that this deduction cannot always be made so proper care has to be taken by candidates to make their conclusions explicit. Also, on this occasion, Examiners were looking for the correct relative positions of the points on the Argand diagram rather than the details of the diagram itself, but it was notable in a few instances that correct labelling of the axes, or sometimes any labelling at all, was absent. The syllabus does not dictate the range in which the values of the argument have to be given so Examiners were prepared to accept both a range from $-\pi$ to $+\pi$ as well as from 0 to 2π but this had to be in radians so, unfortunately, the candidates who gave answers in degrees did not receive credit.

Answer: **(i)** $\frac{1+2i}{5}$ **(iii)** –0.322 or 5.96

Question 9

This question was well done by almost all candidates who recognised the need for the product rule and went on to provide accurate roots in exact form, although a surprising number thought the *y*-coordinate was $-2e^{-1}$ rather than −2e. Only the most able candidates, however, explicitly discarded the factor e^{-x} by implying in some way that $e^{-x} \neq 0$. Most candidates merely let it disappear from their working and so lost the credit available for explaining why it could not provide a root to the equation when the derivative was equated to 0.

Answer : (−1, −2e), (3, $6e^{-3}$)

Question 10

The most able candidates were able to achieve a complete solution to this question, but it was plain that, for others, it provided a significant challenge. In part **(i)** those who saw that *x* could be written as $-(1-t)^{\frac{3}{2}}$ gave themselves a much simpler task to find the derivative than those who had to apply the chain rule at least twice on $-((1-t)^3)^{\frac{1}{2}}$. These candidates often forgot to differentiate (1 – *t*) at the end and so did not deal with the negative sign. For those who arrived at a correct form for $\frac{dy}{dx}$, the move to the given answer was often not justified by any evidence but merely quoted. This could not receive any credit. In part **(ii)** a significant proportion of candidates appeared not to realise the significance of a "series of ascending powers of *t*" and dealt with the quotient form of $\frac{dy}{dx}$ directly. Others substituted $t = 0.5$ prematurely in the expression $(1+t)\left(1+\frac{t^2}{2}+\frac{3t^4}{8}\right)$, not realising that at the stage at which they were doing it, they were including a term in t^5. Perhaps because of a confusion over index laws in the candidates' mind, success in part **(ii)** was limited all too frequently by mistakenly writing $\frac{1+t}{\sqrt{1-t^2}}$ as $(1+t)(1-t)^{\frac{1}{2}}$ from which little valid progress could be made.

Answer : **(ii)** $1+t+\frac{t^2}{2}+\frac{t^3}{2}+\frac{3t^4}{8}$, 1.71

Question 11

This question was designed to challenge the best candidates and it is a tribute to the quality of candidates who attempted this question that so many of them succeeded in producing a complete proof of the result. Even weaker candidates managed to perform the substitution to obtain an integral in *u*, although sometimes with a mixture of variables on the way. Some candidates saw that their work could be reduced by using the result in the formula booklet while others used partial fractions to arrive at the same result. The very best candidates achieved full marks for their explanation of how the constant *A* related to the + *c* of their integration. Previous reports have referred to this aspect of candidates' work as lacking clarity but this has now been successfully addressed in the best solutions and candidates deserve appreciation for their efforts.

MATHEMATICS

Paper 9794/02
Pure Mathematics 2

Key Messages

There were a number of questions on this paper where candidates had to prove a result or justify a given answer. It is essential that sufficient detail is provided, both in words and algebra. Candidates should show every step in their method, even if it may seem trivial to them. Candidates should read the question carefully, to ensure that they fulfil all of the requests in the question, and should consider how early parts of a question could support them in answering later parts.

General Comments

Candidates generally seemed well prepared for the examination and all were able to demonstrate their knowledge on the more straightforward questions, even later on in the paper. There were some very testing aspects to the last two questions, and only the most able candidates were able to provide accurate and well thought out solutions. The standard of presentation was mostly good but candidates should ensure that they delete any working that does not form part of their final solution. This was particularly apparent on the last two questions, where some candidates tried a number of different approaches in their quest for the correct answer. There were two questions where a sketch graph was requested; there is no expectation that graph paper be used. A sketch in the answer booklet can be more than adequate, as long as the general shape of the graph is apparent and any key points are clearly labelled.

When candidates use additional materials, be it a second answer booklet or graph paper, Centres should ensure that these are securely fastened to the main answer booklet to ensure that the candidate's work is marked in its entirety.

Comments on Specific Questions

Question 1

This was a straightforward start to the paper and most candidates provided fully correct solutions. As with all requests to prove a given result, candidates must ensure that they provide sufficient detail in order to be fully convincing. This included clearly evaluating the denominator before cancelling to obtain the given answer.

Question 2

Most candidates appreciated the need to integrate the gradient function, and then use the given point, so as to obtain the equation of the curve and many fully correct solutions were seen. The most common error was to simply find the equation of the straight line, through (1, 3) with gradient 8, without appreciating the need for calculus.

Answer: $y = 2x^3 + 2x - 1$

Question 3

(i) All but a few candidates were able to gain at least the first mark for sketching a V–shaped graph. Some candidates did so through using a table of values, but the majority used their knowledge of transformations to deduce the shape of the requested graph. Whilst a sketch, rather than an accurately plotted graph, was all that was required, candidates should ensure that they include an indication of key points such as the minimum point and the *y*–intercept. Without this information it is impossible to discern a candidate's true intent. A number of candidates did not gain the final mark as they did not produce a graph that extended over the entire given range of *x*–values.

(ii) The most successful candidates provided an explanation that two x-values corresponded to the same y-value, and then reinforced this with a specific example. Some explanations were too vague to be given credit; simply stating that it was not one-one because it was many-one did not give any indication that the candidate had considered this particular function.

Answer: **(ii)** 2 x-values correspond to the same y-value

Question 4

This question was also very well answered, with the vast majority of candidates gaining all of the marks available. The generic formula for a volume of revolution was usually initially quoted, and then applied to the given problem. The integration was invariably correct, and the use of limits was shown explicitly.

Answer: $\frac{127}{7}\pi$

Question 5

(i) Candidates appreciated the need to evaluate f(1.5) and f(2) and most were able to do this accurately, although a few had their calculator in degree mode rather than radian mode. A surprising minority were unable to correctly round the ensuing answers, and a few candidates showed no evidence of actually evaluating their expressions. To gain the second mark, candidates had to conclude appropriately. It was expected that they would explain how they knew that there was a root in the given range, by referring to a sign change or equivalent. Most candidates could express their reasoning clearly, either in words or symbols, but a few candidates omitted to offer any evidence for their conclusion.

(ii) The question specifies that a suitable starting value should be used, and it was expected that candidates would use the information from part **(i)** and pick a starting value between 1.5 and 2 inclusive. However a number of candidates did not do so, and hence lost 1 mark of the 3 available. Most candidates could then use the given iteration to attempt to find the root, and showed evidence of this. Some candidates simply wrote down the answer; with no evidence of using iteration no credit could be awarded. The other common error was to use an alternative process instead, such as the Newton-Raphson method. Candidates should appreciate that iteration is being used to find a root, and conclude accordingly. Statements such as $x_8 = 1.93$ suggest that a candidate has simply stopped iterating as opposed to making a clear conclusion about the value of the root. Candidates who rounded to 3 decimal places throughout their working sometimes made an incorrect final statement; having seen the iteration settle at 1.935, it was relatively common for the final conclusion to then be given as 1.94.

(iii) Candidates were clearly familiar with the graphs of $y = \sin x$ and $y = x - 1$, but a number struggled with ensuring that the two graphs were in proportion to each other. The more successful candidates used a horizontal scale of 1, 2, 3 etc. and used this to locate the correct points of intersection with the x-axis. The most common error was to start with the graph of $y = \sin x$, using a scale of $\frac{1}{2}\pi$ and π, but then draw $y = x - 1$ crossing the x-axis at a point other than $x = 1$. The question requests that the two graphs be drawn for $0 \leqslant x \leqslant \pi$; this was invariably true for $y = \sin x$ but all too often the linear graph stopped short.

(iv) In order to gain this mark, candidates had to refer to the two graphs having a single point of intersection and the majority of candidates duly did so. The better candidates continued with a convincing description of what would happen outside of this range. This level of precision and detail in some candidate responses was admirable.

Answers: **(iv)** only 1 point of intersection

Question 6

(i) Many candidates struggled with providing a suitable explanation about the provenance of the given differential equation, and there were four points that needed to be addressed. Most candidates could identify that $T - 20$ was the difference in temperature and that it was negative due to the temperature decreasing, and this was sufficient to gain one of the two marks available. The second mark proved to be more elusive, and precision in the language used was required. Many candidates simply stated that k was a positive constant, but this was just repeating the information given in the question; candidates had to explicitly link this to the proportionality involved in the relationship. The second point, and the one that was most commonly ignored, was explaining that the left-hand side of the differential equation represented the rate of change of T.

(ii) Most candidates were able to gain the first three marks for separating the variables and integrating, although a few did struggle with the initial step. There was usually then both an attempt at evaluating the constant of integration and also an attempt at rearranging the equation, and candidates were fairly evenly spread across which step was attempted first. In this question the answer was given, and candidates were expected to show sufficient detail of both of these steps. Whilst a number of suitably detailed solutions were seen, too many candidates omitted crucial steps in their method and this was penalised. Going from $\ln(T-20) = -kt + c$ to $T - 20 = Ae^{-kt}$, with no intermediate steps shown, is not sufficiently convincing. Equally, just stating that $A = 60$, with no indication of how this was obtained, will not be given credit when working towards a given answer.

(iii) This final part of the question was generally done very well, and most candidates gained full marks for substituting into the given equation and rearranging to obtain a value for k, either exact or a decimal approximation.

Answers: **(iii)** $k = \frac{1}{2}\ln\left(\frac{3}{2}\right)$

Question 7

(i) The vast majority of candidates gained full credit on this question, usually by making t the subject of the first equation and then substituting into the second to obtain the given equation.

(ii) This part of the question was equally well done, and most candidates gained all six marks with ease. The first step was obtaining an equation in a single variable, and this was invariably x, although a few did decide to work in t instead. Candidates used the information given to deduce that $(x - 3)$ must be a factor and then attempted to find the linked quadratic factor. This was nearly always done correctly, and it was surprising how many candidates worked with the cubic still having a fractional coefficient rather than first multiplying through by 27. The correct roots duly appeared, although a few candidates made errors when finding the y-coordinates. A number of candidates simply wrote down the three roots of the cubic with no evidence of first factorising. Whilst the effective use of a calculator is to be encouraged, it does make it almost impossible to award partial credit if the final answer is incorrect, and candidates would be well-advised to show more detail in their method.

Answer: **(ii)** (30, 1001) and (–6, –7)

Question 8

A number of elegant and concise proofs were seen in this question, with candidates explaining their reasoning clearly and providing evidence to support their conclusions. The first three marks were for differentiating f(x), which was usually done by using the quotient rule, and simplifying their answer. Candidates who attempted differentiation usually gained these marks. Most candidates were aware that, in order to prove it was a decreasing function, they had to show that the gradient was negative. Whilst some did indeed consider the signs of both the numerator and the denominator before concluding that $f'(x)$ was negative, a number of other candidates simply stated that $f'(x)$ was negative with minimal, or no, evidence. An alternative, and equally acceptable, approach was to show that there were no turning points for $x > 1$, test the gradient at a single point and then conclude appropriately. Some candidates seemed unaware of the structure of a rigorous proof and simply evaluated f(x) for several different values of x. There were also some attempts to draw the graph of the function; this could be an appropriate approach but is not sufficient without supporting algebraic justification.

Question 9

This question was generally very well answered, with many candidates gaining at least 7 of the 8 marks available. Only the most astute candidates gained the final mark, by using both the positive and negative square roots to give all four tangents. The most common approach was to differentiate implicitly and this was invariably correct. Some candidates decided to rewrite the function in the form $y = f(x)$, and then use the chain rule. This was a more complicated approach, and incorrect derivatives were more prevalent. A surprisingly common error was for the attempt at square rooting to go one step further, resulting in $y = x^2 - 2x^{1.5} + 6$, which limited the subsequent marks available.

Answers: $y = 3$, $y = -3$, $y = 6$, $y = -6$

Question 10

(i) Only a few candidates did not expand the given expression using the relevant identity, and most were able to then provide sufficient evidence to justify the appearance of the given answer.

(ii) Candidates were expected to use the identity from part **(i)**, as indicated by the use of 'hence' in the question. Having done this, a number of candidates could identify $\frac{1}{2}\pi$ as a solution, but only the most able candidates were able to generate further solutions by considering the periodicity of the function. The most successful approach was to use the identity for $\sin A - \sin B$ and equate each part of the ensuing product to 0.

(iii) Most candidates gained the first three marks by providing a convincing proof for the given identity. The solutions were generally well structured and provided clear evidence for each stage of the proof, although a few candidates did not gain the third mark due to missing out several essential lines of working. The majority of candidates also gained the next mark for attempting to obtain a cubic in terms of $\sin\theta$, and could identify how it was related to the given cubic in terms of x. The final step was for candidates to use their answer(s) to part **(ii)** to solve the given cubic. A number of candidates had $\frac{1}{2}\pi$ as their only answer from the previous part, and could use this to deduce that $x = 1$ must be a root and hence solve the cubic. Candidates who had found further roots in part **(ii)** were able to simply write down the solutions to the cubic. However, the question did ask candidates to use their previous answer so there was no credit available for those who simply solved the cubic with no reference to any trigonometric substitution.

Answers: **(ii)** $\theta = \frac{1}{10}\pi,\ \frac{1}{2}\pi,\ \frac{9}{10}\pi,\ \frac{13}{10}\pi,\ \frac{17}{10}\pi$ **(iii)** $x = -0.809, 0.309, 1$

Question 11

(i) There were a pleasing number of fully correct solutions seen to this question, and most candidates were able to at least make an attempt at finding the perimeter and area. The arc length was usually correctly stated, as was the area of a sector. There were a variety of approaches to finding lengths within the triangle, with some methods significantly more efficient than others. The most successful approach was to use basic trigonometry as it is a right-angled triangle. A more convoluted approach involved the use of the sine rule; whilst this was often correct it rarely resulted in an expression that was suitably simplified. Having found the shaded area by subtracting the area of the sector from the area of the triangle, a number of candidates attempted to replicate this method to find the perimeter without considering whether this was a suitable strategy.

(ii) This proved to be a suitably challenging finish to the paper and only the most able candidates were able to provide a complete and convincing proof. Most candidates gained the first mark for substituting their answers from the first part into $A = rP$, but then struggled to make any further progress. Of the correct solutions seen, there were a variety of creative and thoughtful approaches. Some considered the range of values for the functions involved, others differentiated to show that it was an increasing function and there were also some successful graphical approaches.

Answers: **(i)** $P = r\sec\theta - r + r\theta + r\tan\theta$, $A = \frac{1}{2}r^2\left(\tan\theta - \theta\right)$

MATHEMATICS

Paper 9794/03

Applications of Mathematics

Key Messages

Questions that ask candidates to obtain or show a given result place the onus on the candidates to ensure that their work leading to that result is clear and unequivocal and that it is reached in a thoroughly complete and convincing manner. In questions where a sketch is asked for, it is assumed that candidates will draw it in the body of the script, and not use graph paper. Sketches should be drawn neatly using a ruler for straight lines and should be appropriately labelled; they are not expected to be accurate or 'to scale'.

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. Once again, 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. When a question asks for a probability distribution to be stated, it is not unreasonable to expect candidates to use the correct, conventional notation, including any relevant parameters.

Comments on Specific Questions

Section A Probability

Question 1

This question was well answered by the vast majority of candidates. Candidates either could recall the appropriate formula to use or were able to locate it in the formula booklet. When an incorrect answer appeared it was almost always preceded by the correct method and so was the result of mistakes made in the use of the calculator.

Answer: $r = 0.692$

Question 2

(a) In this part of the question candidates needed to realise that the order in which the set of cards is obtained does not matter. Many candidates did not appreciate this and consequently the (incorrect) answer 0.2^5 was much more common than the correct answer.

(b) (i) As well as naming the type of distribution (Geometric) candidates needed to specify the value of the parameter in order to score the mark. In general it is not helpful to try to list the sequence of probabilities (especially since, in this case, it is potentially infinite). Even when providing the correct information, candidates' use of the standard notation $X \sim \text{Geo}(p)$ was poor.

(ii) This part was answered easily by most candidates, even when they had not managed to score the mark for part **(b)(i)**.

(iii) There were many correct answers to this part. Some candidates managed to make it more difficult than it needed to be. The best answers used the fact that, for the Geometric distribution, $\mathrm{P}(X \geqslant r) = q^{r-1}$.

Answers: **(a)** 0.0384 **(b)(i)** $\mathrm{Geo}\left(\frac{1}{5}\right)$ **(ii)** 5 **(iii)** $\frac{16}{25}$

Question 3

(i) This part was answered easily by almost all candidates. There were a few issues to do with premature approximation of the *z*-value prior to looking up the probability in the tables. Candidates should normally expect to have to use the difference columns in the tables, and if it is clear that they have not done so then they might not earn full credit.

(ii) There were very many correct answers to this part too. On the rare occasions when full marks were not awarded the reason was either due to an error in the calculation or the use of 1.64 or 1.65 instead of 1.645 (which is clearly shown in the list of critical values on page 18 of the formula booklet).

Answers: **(i)** 0.8598 **(ii)** 08 06

Question 4

(i) There were many ways of approaching this part of the question, although they all amounted to the same thing in the end, i.e. counting the number of ways of choosing 2 males or 2 females from the group of 16. The crucial thing for candidates to remember is that the second member of each pair is chosen from a reduced pool. On the whole it was well answered.

(ii) The same is true of this part of the question, but this time it was necessary to consider and count the number of ways in 4 cases instead of 2. A number of candidates tried to answer it by first finding P(the same year) and then treating (incorrectly) ‘sex’ and ‘year’ as independent.

(iii) Many candidates knew the relationship between $\mathrm{P}(A \mid B)$ and $\mathrm{P}(A \cap B)$ and so had little difficulty with this part. There were a number of candidates who attempted to count the number of ways but this approach turned out to be too complicated and beyond them.

Answers: **(i)** $\frac{19}{40}$ **(ii)** $\frac{9}{40}$ **(iii)** $\frac{9}{19}$

Question 5

(i) Many candidates scored full marks here. As with **Question 2(b)(i)**, what was required was the name of the type of distribution and the values of its parameters rather than a list of the probabilities. Also, as with **Question 2 (b)(i)**, the correct use of the notation $X \sim \mathrm{Bin}(n, p)$ was not as well understood as it should be.

(ii) (a) This part was answered easily by most candidates.

(b) This part was also answered easily by most candidates.

(iii) In this part candidates needed to consider the second phase of the context, i.e. the removal of some of the seedlings and, more importantly, how many seedlings remained in each pot, and to notice the connection with part **(ii)(b)**. Success in answering the question seemed to rely on how well they had done that. This time the instruction ‘Write out…’ allowed them to list or tabulate the probabilities of the two events, though an answer in the form $X \sim \mathrm{Bin}(1, \ldots)$ was equally acceptable.

(iv) Candidates who were successful in part **(iii)** were likely to be successful with this part too, and there were many others who also appreciated what was required.

Answers: **(i)** Bin(3, 0.7) **(ii)(a)** 0.441 **(b)** 0.973 **(iii)** $\mathrm{P}(X = 0) = 0.027$, $\mathrm{P}(X = 1) = 0.973$ **(iv)** 0.8485

Section B Mechanics

Question 6

(i) This part was answered easily by most candidates.

(ii) This part was also answered easily by most candidates. Answers were usually well-organised and direct, demonstrating a clear application of Newton's Second Law.

Answers: **(i)** 101.4 N **(ii)** 0.1068 ms^{-2}

Question 7

(i) In this part the standard model for projectile motion seemed to be well known, and candidates were usually able to write down the simultaneous equations for u and θ correctly. A little care was then needed to establish the given value of $\tan\theta$ in a convincing manner. Rather messy presentation sometimes gave the impression that the result was taken for granted. The value of u usually followed fairly easily. At this level candidates really should be so familiar with the 3–4–5 triangle that they can state the exact values of $\sin\theta$ and $\cos\theta$ without resorting to their calculator to first find θ.

(ii) By far the most common (and successful) strategy here was to find the time of flight and then use it to work out the range of the projectile. This was in preference to using the formula for the range; perhaps candidates have decided not to memorise it or felt that the effort of deriving it was not justified on this occasion.

Answers: **(i)** 15 ms^{-1} **(ii)** 21.6 m

Question 8

(i) Full marks were obtained for this part by almost all candidates. Many candidates chose to use graph paper and set about drawing a detailed graph, not a sketch, of the journey. They ended up doing far more than was required at this point, duplicating much of the work that they then needed in parts **(ii)** and **(iii)**. Many others drew a sketch but all too often it was a very poorly presented affair; the use of a ruler and a little care to produce a neat drawing should not be too much to ask.

(ii) This part was answered easily by most candidates.

(iii) This part was also answered easily by most candidates. In this part, and in part **(ii)**, many candidates obtained the answers by interpreting the geometry of the velocity-time graph, as intended. A little care was needed to organise the information required to show the total journey time given in the question.

Answers: **(ii)** 8 ms^{-1}, 64 m

Question 9

(i) This part was answered easily by most candidates. The Principle of the Conservation of Momentum seemed to be well known and its application here posed little problem.

(ii) This part was also answered easily by many candidates. The use of Newton's Experimental Law, together with the expression obtained in part **(i)** proved to be straightforward enough for most.

(iii) The best answers to this part started with the condition '$e \le 1$', replaced e with the expression found in part **(ii)** and then rearranged the inequality to make k the subject. Many candidates adopted this approach successfully. Many more attempted to explain the result in a much more wordy fashion and were usually unable to put together a sufficiently rigorous argument for a variety of reasons which included an apparent inability or reluctance to work with inequalities.

Answers: **(i)** $v = \dfrac{u}{2k}$ **(ii)** $e = \dfrac{1}{2k}$

Question 10

In this question the particle is sliding on a smooth slope and so the usual projectile model of separate horizontal and vertical equations is not appropriate and should not be used. The key to success in the question lies with being able to state the correct acceleration of the particle on the slope. After that the various times and distances needed to describe the complete journey back to the mark can be obtained using the standard '*suvat*' equations. There were many candidates who understood which model to apply and they usually went on to provide a complete, or nearly complete, solution to the question (though not always by the most efficient route). Candidates who start out with the wrong model (and many did) can end up losing most, if not all, of the marks. When an exact value of sinθ is given in the question it seems a little odd if a candidate first chooses to find the angle using their calculator in order then to use its sine.

Answers: 10.5 s, 11.425 m