MATHEMATICS

Paper 9794/01
Pure Mathematics 1

Key messages

A key message which seems to need reiterating each year is the need for care and accuracy in the sketching of graphs. It may be worth making expectations clear at this point. For linear graphs the intersections with the axes are required. Scales on the axes should be numbered; it is not sufficient for scales to be indicated only by marks on axes. There were instances of this on **Question 7** this year and candidates could receive no credit because it was not clear that the correct graph had been drawn. For graphs similar to the graph of $y = \ln x$ the asymptote must be clearly indicated and labelled. For simple quadratic graphs the coordinates of the stationary points and possibly intersection points with the axes may be expected but, for more complex quadratics and graphs of higher polynomials some indication of the requirements will normally be provided to guide candidates. It may again be stressed however that graph paper is not required for a sketch.

A second key message from this year's paper is to stress the need for candidates to read questions carefully and answer the question asked. This year a volume of revolution was required about the *y*-axis but large numbers of candidates read this as the *x*-axis and gave themselves a considerable amount of unnecessary work as well as losing most of the marks for the question.

General comments

The standard of presentation was high, and most candidates had taken care to provide fully argued and detailed responses to the questions asked. It was also apparent that many candidates have achieved over the years an easy command of the style and content of the paper and found few challenges in the early part of the paper. Very few full marks were seen however and the latter part of the paper provided a challenge to even the best candidates.

Comments on specific questions

Question 1

The easy opening questions caused most candidates little difficulty. This is assuredly true of the first question which attracted almost universally correct responses, although a few candidates were inaccurate in what they wrote down, quoting the radius rather than the diameter in **part (ii)** or not indicating their values as coordinates in **part (i)**.

Answers: **(i)** (3, 2) **(ii)** 6

Question 2

Most candidates again achieved full marks on this question although insecurity in the use of logarithms was sometimes apparent in **part (i)** with log 6 achieved via $\frac{\log 12}{\log 2}$ and more apparent in **part (ii)** where an incorrect grouping of terms led to a false conclusion.

Answers: **(i)** log 6 **(ii)** $\log\frac{x^2z^2}{y^3}$

Question 3

The majority of candidates were able to apply the cosine rule correctly to the data in the question. There seems doubt in some candidates' minds, however, how much evidence to supply in questions where they have to show the result. This is understandable but it may be helpful for candidates to bear in mind that Examiners look for evidence that the given answer has not been simply quoted. Thus, from writing $8^2 = 7^2 + 6^2 - 2(7)(6)\cos ABC$, Examiners were reluctant to believe that a candidate could simply go straight to the answer because of the operations involved in making the trigonometric term the subject and they therefore required some sign of intermediate evaluation. On the other hand, they were prepared to believe that the calculator alone was perfectly sufficient to achieve the answer from the $\cos ABC = \dfrac{6^2 + 7^2 - 8^2}{2(7)(6)}$ form.

Success was notable in **part (ii)**. Although this was not penalised, Examiners did question the appropriateness of giving an exact form in a practical application like the area of a triangle, although most candidates gave a decimal for their answer. Some confusion was observed over whether $\dfrac{\sqrt{15}}{4}$ was the sine of an angle or the angle itself. A few candidates felt the need to use the base and height of the triangle to achieve their answer.

Answer: **(ii)** 20.3

Question 4

The modal mark for this question was three marks out of four. Candidates easily recognised the identity required and found the angles of 60° and 120° but then made the usual error of dividing by $\cos x$ rather than factorising the term, thus losing the two angles of 90° and. 270° and the final mark as a result.

Answer: 60°, 120°, 90°, 270°.

Question 5

This is the first time a request has been made involving an inequality with two moduli and the majority of candidates handled it well by squaring both sides and solving the resulting inequality. Some candidates attempted a graphical approach and provided the graphs were adorned with sufficient detail and a correct inequality chosen to find the point of intersection of the two graphs, this worked well. The approach which caused candidates substantial difficulty was the one which amounted to finding a piecewise function. Sometimes it worked well, with candidates finding the critical values, evaluating whether each of the three intervals would yield a valid solution and concluding correctly from finding the right interval. Unfortunately, most candidates who tried this approach gave the impression that they were completely lost by trying every possible sign combination for the two expressions and they could receive only two marks.

Answer: $x > \dfrac{-\sqrt{3}}{2}$

Question 6

Performance on this question was predictably excellent with most candidates achieving full marks on both parts.

Answer: **(i)** $1 + \dfrac{1}{2}x - \dfrac{1}{8}x^2 + \dfrac{1}{16}x^3$ **(ii)** –7

Question 7

Reference has been made in the Key messages to the problems seen in sketching graphs for this question. Since the final mark, requiring the deduction to be made about the number of roots, depended on the correct graphs being drawn, one inadequate or incompletely specified graph entailed the loss of two marks. Credit was, however, extended to candidates who realised that a root could only occur in the positive quadrant and so drew graphs only in the positive quadrant.

The first part of the question attracted a poor response with a lack of precision in the terms used. Candidates must appreciate that mastery of technical vocabulary is an essential part of learning mathematics and everyday words like 'move' or 'shift' are not acceptable. Translation is the only acceptable word in the context of this question. There was also a lack of precision is describing the translation itself. The only accurate description of the translation is that it is parallel to the *x*-axis. It is not a translation 'in', 'on' or 'along' just the *x*–axis. Those who specified the translation by means of a vector avoided these pitfalls of course.

The final part was better done and the root was usually specified as requested and not just left hanging in a list of iterates. A few candidates did not read the question carefully enough to see that the Newton-Raphson process was specifically requested and a few also found a function to use which suggested that they had in mind some other iterative process. However, those who used an alternative form, e.g. $f(x) = e^{4-x} - x - 1$ received full credit if the process was correctly carried out although it was unclear why such candidates would wish to give themselves extra work in this way rather than use the function given to them.

Answer: **(iii)** 2.693

Question 8

This question was answered well by almost all candidates. Some displayed a somewhat less than convincing treatment of the implicit differentiation itself but were not sufficiently adrift in notation that penalty was incurred. Knowledge of gradients and straight line forms was particularly impressive.

Answer: $8y + 13x - 21 = 0$

Question 9

The initial parts of the question caused more issues than expected. Examiners expected the use of the factor theorem to locate the real root followed by long division or its equivalent to isolate a quadratic factor which would then yield complex roots via the formula. Most candidates did indeed follow this path but with a troubling lack of precision which lost credit. Thus for example, it was not sufficient to show that $8+12-20=0$ without also indicating what this calculation showed. Credit was lost also for asserting that $z-2$ was a root or that $z = 2$ was a factor. The unstructured nature of the request for roots did lead some candidates astray by substituting (a + ib) into the cubic and attempting to equate real and imaginary parts. This not only led to an immense amount of algebra but was very rarely successful.

Once the roots were achieved, candidates showed a good knowledge of finding moduli and arguments and illustrating these on an Argand diagram. Examiners were not prepared to accept what amounted to a Cartesian graph when an Argand diagram had been specified in the question. A few candidates forgot to include their real root in their diagram and calculation of modulus and argument which was unfortunate.

Answer: 2 with modulus 2 and argument 0, $-1 - 3i$, with modulus $\sqrt{10}$ and argument –1.89 or 4.39, $-1 + 3i$ with modulus, $\sqrt{10}$ and argument 1.89

Question 10

This was perhaps the most poorly answered question on the paper, largely because so many candidates chose to interpret the request as a revolution about the *x*-axis. Since this involved a considerable amount of extra effort of a by no means easy nature, some credit was given to these candidates. It should be emphasised to candidates the need to read questions carefully to avoid errors such as this.

Other more successful candidates usually chose to evaluate separate integrals of the form $\pi\int x^2 \mathrm{d}y$ although of these, a few found difficulties in selecting the correct limits. A significant number of candidates chose to form a single integral however. Those who did so by subtracting (9 – 5y) from (9 − 3y) could receive no further credit but on this occasion it was possible to subtract $\frac{1}{5}(9-x^2)$ from $\frac{1}{3}(9-x^2)$ to form a single integral and some candidates continued this through to a successful conclusion, although again some fell by the wayside by choosing the wrong limits.

Answer: **(i)** $\frac{27\pi}{5}$

Question 11

Perhaps because candidates felt on more familiar ground, solutions given to this question were very satisfactory with a secure knowledge shown of vector equations of lines, finding their points of intersection and using the scalar product to find an angle between lines. Occasionally, some very innovative approaches to finding the point of intersection of the lines were seen, all of which received full credit. Again however, candidates need to observe carefully the form of the requests made. The coordinates of the point of intersection were specifically requested and it was not acceptable to give these in vector form. Many candidates lost a mark at this point.

Answer: **(i)** $\left(\frac{18}{5}, -1, -\frac{13}{5}\right)$ **(ii)** 70.9°

Question 12

Many candidates achieved success in this challenging question. Candidates adopted different approaches in dealing with the relation between pressure and volume. Most used the obvious form $P = \frac{k}{V}$ but a few chose to use the form $P = \frac{V}{k}$. Although this rather unusual form gave k = 16, the solution was carried through in this rather upside down way validly to arrive at the same result and so full credit was given. Weaker candidates managed to achieve the first three marks without too much difficulty but thereafter, the more able candidates diverged in their approach. Most used the chain rule to obtain an expression in V, whereas others obtained an expression in P but a significant proportion chose to integrate $\frac{\mathrm{d}V}{\mathrm{d}t}$ at this stage, apply the initial condition that at t = 0, V = 80, and to incorporate this expression in t in the chain rule. However, the same message that candidates should take care to respond to the request exactly as asked applies here as in the request for coordinates earlier. The correct answer to the rate at which the pressure is decreasing is 0.625 but many candidates lost a mark by giving the answer as –0.625 which implies of course an increasing pressure.

Answer: 0.625

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. When multiple attempts are made at a question, candidates would be well advised to make clear which attempt they wish to be marked.

General Comments

Candidates generally seemed well prepared for the examination and all were able to demonstrate their knowledge throughout the paper. They seemed familiar with the syllabus content being tested, and could attempt to apply their knowledge to questions that were not entirely routine. The standard of presentation was mostly good and most candidates were able to produce solutions that were detailed and easy to follow. However, 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. This should include showing each step clearly rather than combining a number of steps in one line of working.

Comments on Specific Questions

Question 1

This was a straightforward start to the paper, and the majority of candidates gained full marks. Candidates were nearly always able to find the correct gradient, with only a few instances of the reciprocal being used instead. Candidates were then able to give an equation of the line in an acceptable format, and this was then usually used to demonstrate that the given point was also on the line. An alternative, equally acceptable, method was to show that the equation of the line joining the given point to one of the other two was the same as the equation already found. A few candidates gave the equation of the line in vector form instead; whilst this was not the form expected, it was still condoned.

Answer: $y + x = 7$

Question 2

(a) (i) This question was invariably correct, with candidates able to quote and then evaluate an expression for the discriminant. A few candidates included the square root as part of their discriminant, which gained no credit.

(ii) The majority of the candidates were able to state that there would be no real roots, and provide a justification for this answer. A few candidates instead stated the number of complex roots, or even found these complex roots, which did not answer the question posed.

(b) The final part of this question was also done very well, with nearly all candidates gaining full marks.

Answers: **(a)(i)** -11 **(ii)** 0 roots, as $-11 < 0$ **(b)** 0.45

Question 3

Most candidates were able to apply the correct order of operations to find an angle in the given range, and many were able to produce a correct second angle as well. Some candidates spoiled an otherwise correct answer by not adhering to the instruction that angles should be given to 1 decimal place. Rather than use the more efficient method, some candidates instead used the relevant addition formula. Some correct solutions were seen using this approach, but the algebraic manipulation required proved problematical for most.

Answer: 175.7°, 355.7°

Question 4

(i) The majority of candidates recognised this as an inductive sequence and were able to successfully generate the first six terms, although some stopped on the fifth term. There were some sign errors when simplifying the terms, and others made no attempt at simplification instead leaving the terms as powers of i.

(ii) There were a variety of acceptable descriptions of the sequence's behaviour and most candidates were able to state one of them. Some focused on the periodic nature of the sequence, whereas others identified it as being a geometric sequence. Some candidates commented on the pattern made when the points were plotted in an Argand diagram.

(iii) Most candidates used the periodic nature of the sequence to evaluate the sum of the first 73 terms, most commonly using the fact that the total of four consecutive terms would be 0 but other approaches were also seen. Another reasonably common approach was to use the formula for the sum of a geometric progression, and this was usually done correctly as well.

Answers: **(i)** $-1 + \mathrm{i}, -1 - \mathrm{i}, 1 - \mathrm{i}, 1 + \mathrm{i}, -1 + \mathrm{i}$ **(ii)** periodic **(iii)** $1 + \mathrm{i}$

Question 5

(i) There were many fully correct solutions seen to this question, using either the product rule or the quotient rule. The most successful candidates stated clearly which functions they were using as u and v, and also used the chain rule explicitly to find v' before substituting into the relevant rule. The less successful approach was to attempt the entire derivative in one go. If correct then full credit can be awarded, but it can be difficult to discern how partial credit can be awarded when there is no clear use of the chain rule or a differentiation technique. Some candidates were unable to correctly identify u and v in the rule that they were trying to use; a common error was to have $(1 + x^2)^{-0.5}$ being used as v in the quotient rule. In this part of the question full credit was awarded once a correct derivative was seen; this favoured some candidates who could correctly carry out the differentiation but then struggled with the subsequent algebraic manipulation when simplifying.

(ii) This part of the question proved to be more challenging. Candidates were expected to rearrange their derivative to useable form, justify why it was always positive and conclude that it was an increasing function. Whilst a number of mathematically elegant and precise solutions were seen, others lacked clarity. Some simply referred to the presence of x^2 meaning that it was always positive, without considering the rest of the function, and others attempted a numerical justification. Too many candidates claimed that it would always be positive, but were referring to a function where this was not apparent.

Answers: **(i)** $(1 + x^2)^{-0.5} - x^2(1 + x^2)^{-1.5}$

Question 6

Most candidates appreciated the need to separate the variables, and were able to do so successfully. The most effective technique for integrating the function of x was to write it as two terms, and then integrate these terms. Some candidates attempted to employ a longer method using integration by parts, but this was rarely successful. A significant minority of candidates differentiated the y term rather than integrating it. Candidates were then able to attempt c using the information given, and rearrange to the required form. There were many fully correct solutions to this question.

Answer: $y = \sqrt[3]{3x + 3\ln x + 24}$

Question 7

(i) The majority of candidates were able to attempt the parametric differentiation, and this was invariably correct with only the occasional sign error being seen.

(ii) This proved to be a challenging question, and a number of candidates struggled to make any progress. The most common error was to find the points where the curve intersected with the axes, rather than the points where the tangent intersected with the axes. The most successful candidates took a logical approach to the question by first finding the equation of the tangent, and then considering how to use this to find the points of intersection. A number of trigonometric identities had to be employed, and some candidates decided to simplify the equation of the tangent before using it whereas others simplified after substituting 0 for one of the coordinates. The former approach tended to be slightly more successful. Candidates should appreciate that, when demonstrating a given result, their work must be detailed and convincing. In some cases, a number of steps were run together resulting in a solution that lacked the clarity required.

(iii) Candidates who used the midpoint were nearly always able to show that this point was on the given curve, either by substituting both coordinates into the equation or by substituting one coordinate and rearranging to obtain the other one. However, there were a number of candidates who assumed that the question was asking for the Cartesian equation that corresponded to the given parametric equation and thus gained no credit.

Question 8

(i) Candidates were able to set up an identity and use this in an attempt to find the numerators of the two fractions. Some candidates used the more efficient method of substituting values of x, along with coefficient matching, whereas others solved a set of simultaneous equations. Both methods tended to be equally successful.

(ii) Most candidates were able to make a good attempt at this part of the question, with many gaining the majority of the marks available. They were usually able to simply state the integral of the fraction with the linear denominator. However, the integral of the other term was not so easily recognised as also being a natural logarithm, and a number of candidates used substitution to integrate this fraction. Most candidates could then use limits correctly in their integral, and attempt to simplify the resulting expression. To obtain full credit candidates were expected to correctly use the modulus in the relevant logarithms, and using laws of logarithms with negative values was penalised. Some candidates simply ignored the terms involving negative values, clearly unsure as to how to proceed with them. There were a number of fully correct solutions seen that made correct use of the modulus throughout. Other candidates used brackets in the method shown, but did correctly deal with the modulus of the negative numbers. However, in many solutions no modulus sign was ever seen or implied.

Answers: **(i)** $A = 6$, $B = 0$, $C = 1$ **(ii)** $\ln 4$

Question 9

(i) The vast majority of candidates were able to identify an appropriate strategy and make a good attempt at this question, mostly gaining at least the first 4 marks for a correct integration. Integration by parts was the most common approach, but a number did attempt to use substitution. Of those using the latter method, a number carried out the substitution but then did not appreciate that they could now expand the brackets and continued by using integration by parts. Having obtained a correct integral, many candidates were unsure as to how to further proceed. Whilst a number could identify and use a common denominator of 35, it was a minority that could identify the algebraic common factor and hence simplify to the given answer.

(ii) The majority of candidates could find the correct derivative, hence gaining the first two marks with ease, and could then equate it to 0. Attempting to solve this equation proved to be challenging for many, with the most common error being to square term by term. The most common approach was to either factorise or cancel through by x, rearrange and square both sides of the equation. The result of this should be a cubic equation that yielded both of the non-zero roots. However, cancelling rather than factorising often resulted in only one non-zero root being found. When solving the equation, many candidates never even considered the possibility of $x = 0$ and simply cancelled through by x. Some candidates gave a reason why it could not be a solution, whereas other candidates managed to find a real y-coordinate to go with $x = 0$. The most mathematically elegant solution was to factorise the derivative into three factors, one of which still involved the square root of $(x - 2)$, and hence deduce the three required x values.

Answers: **(ii)** $\left(2, \frac{4}{3}\right)$, $\left(3, \frac{38}{35}\right)$, $x = 0$ not valid

Question 10

(i) Many candidates were able to gain at least 5 marks on this question, by setting up two relevant equations and solving them simultaneously. Eliminating a and d to obtain a quadratic in r was the most common approach, and this was usually successful. Only the more astute candidates considered the possibility of $r = 1$, and justified why this was not a valid solution. The majority of candidates glossed over this aspect, simply offering $r = 3$ as the only solution and thus not gaining full credit. The other common approach was to equate two expressions for r in terms of a and d, solve for d and then substitute back to find r and this tended to be equally successful. Candidates who used this method very rarely considered the possibility of $d = 0$, and instead just cancelled by this variable thus losing a mark. There were also some other, more long-winded, methods but it was not always easy to follow the candidate's reasoning. As $r = 3$ is a given answer, the method shown had to be complete and convincing.

(ii) Most candidates were able to deduce an expression for d in terms of a_1. The most common errors were to not simplify an expression in terms of a_1 or to omit the subscript.

(iii)(a) Nearly all candidates were able to generate the first three terms of the two sequences with ease.

(iii)(b) Most candidates could make some attempt at this question, but there was a lack of precision in the explanations. Candidates had to demonstrate, with some reasoning, that the terms of the geometric sequence were odd multiples of 5, and the terms of the arithmetic sequence were all of the odd multiples of 5 thus the terms of the geometric sequence must be contained within the terms of the arithmetic sequence. A common error was to refer to just multiples of 5, rather than identifying that they also had to be odd. Only the most astute candidates used 'all' in their description of the terms of the arithmetic progression. A minority of candidates found nth term expressions for the two sequences, and then attempted to demonstrate that 3^{m-1} was contained within $2n - 1$. Once again, precision was required in the solutions and this was not always present. A number of fully correct solutions were seen, but these were certainly not in the majority.

Answers: **(ii)** $d = 2a_1$ **(iii)(a)** AP: 5, 15, 25; GP: 5, 15, 45

MATHEMATICS

Paper 9794/03
Applications of Mathematics

Key messages

Candidates need to be aware that, when an answer is given in the question, it places an additional onus on them to provide sufficient working to show clearly how the answer has been reached. In particular, for numerical answers the working ought to include intermediate steps to demonstrate that the calculations really have been carried out by the candidate. It is not wise to rely on the assumption that a calculation shown or implied will produce the required answer.

In the Statistics section, when the question calls for the calculation of summary statistics for a set of data, it is assumed that candidates will make the fullest possible use of the functions built in to their calculators. This includes, for example, quoting summaries such as Σx and Σx^2 as well as the values of the statistics themselves. There should be no need for candidates to actually perform any of these calculations 'by hand', especially if it involves using a rounded value of one en route to the other.

General comments

This paper appears to have been well received by most candidates. There was no evidence to suggest that candidates were short of time. On the whole the Probability and Mechanics Sections appear to have been equally accessible to most candidates. At all times, candidates should be mindful of the instruction to 'Give non-exact numerical answers correct to 3 significant figures …', even when the third figure is a zero coming after the decimal point, as, for example, 2.10 in **Question 2(i)**.

Comments on specific questions

Section A: Probability

Question 1

(i) In this question it was expected that, by using their calculators properly, candidates would be able to write down the mean and standard deviation with no more than a minimal amount of 'working'. While almost all candidates gave a correct answer for the mean, the value of the standard deviation was not always as accurate as it could have been.

(ii) In the syllabus, two methods of identifying outliers are specified: '$1.5 \times$ IQR' and '± 2 standard deviation'. From the wording of this question, 'Hence …', candidates should realise that the latter is required on this occasion. By far the majority of candidates chose to use quartiles and the IQR, and furthermore, whichever approach they adopted, the details were poorly recalled.

Answers: **(i)** Mean 75.8, Standard Deviation 20.9 **(ii)** 19

Question 2

(i) The equation of the regression line was usually obtained correctly. As in **Question 1(i)**, it is assumed that candidates will be able to use the statistics mode on their calculator to enter the data and retrieve accurate values of the coefficients for the regression line. Any working shown should be to indicate that the correct method is understood by using summaries also retrieved from the calculator.

(ii) Candidates need to appreciate that the residual is 'observed value – calculated value' and is therefore a signed quantity.

(iii) A correct estimate for the turnover in 2024 was found by most candidates. The crucial point to be made when evaluating the reliability of this estimate is that it involves extrapolation; any other form of comment is likely to be mere speculation.

Answers: **(i)** $y = 2.10 + 0.245x$ **(ii)** -0.337 **(iii)** 7.98 (£ millions)

Question 3

(i) This question was well answered by most candidates.

(ii) Apart from some errors and uncertainties among the weakest candidates this question was also well answered.

(iii) There were many correct answers here. When candidates were unable to get the right answer it was usually because they had not appreciated that the events $X = 4$ and $X > 0$ are not independent and that $P(X = 4 \cap X > 0) = P(X = 4)$.

Answers: **(ii)** 1.68 **(iii)** 0.15

Question 4

(i) Most attempts at this question were set up correctly and incorrect answers were quite rare.

(ii) There were many correct answers to this question. Some candidates needed to realise that, once one S has been placed at the start and another at the end, the problem is reduced to finding the number of arrangements of 'TATISTIC'.

(iii) The number of arrangements here turns out to be the same as in **part (ii)**. This time there needed to be an attempt to find a probability in order to score any marks.

Answers: **(i)** 50 400 **(ii)** 3360 **(iii)** $\frac{1}{15}$

Question 5

(i) Relatively few candidates were able to score full marks here, and many could not see how to get started. A variety of approaches were possible. Attempts to list and sum the first n probabilities often needed more care and attention to detail than they received. A number of candidates impressed by offering an argument along the lines that for $X > n$ the first n trials must all have resulted in 'failure'.

(ii) There were many correct answers to this question. If candidates got into difficulty it was usually because they had not been able to interpret correctly $X \geqslant 4$ and/or $X \leqslant 8$ in terms of $X > n$.

(iii) Candidates who had obtained a value of p in **part (ii)** could usually be relied on to answer this part correctly. The relevant expressions are given in the formula booklet.

Answers: **(ii)** 0.4, 0.983 **(iii)** 2.5, 3.75

Section B: Mechanics

Question 6

(i) The vast majority of candidates were able to draw a suitable diagram to show the forces on the crate.

(ii) Compared with last year, candidates were *much* better at writing down a coherent application of Newton's Second Law which they could then apply successfully to each of the three stages of the downward motion of the crate. Only occasionally were there problems, usually involving the signs/directions in Stage 3.

(iii) The sketches of the velocity-time graph were usually acceptable. Candidates are reminded that unless instructed otherwise it is assumed that they will not feel the need to use graph paper.

(iv) Most candidates approached this part by considering the motion of the crate one stage at a time, and this was almost always successful, if rather disorganised-looking. Unsuccessful attempts were usually the result of careless errors. It is worth considering that, by looking at the area of the trapezium in the velocity-time graph as a whole, candidates can save themselves work and thereby reduce the risk of making mistakes.

Answers: **(ii)** 1870, 2200, 2365 N **(iv)** 8 sec

Question 7

(i) There were many correct answers to this question. The usual strategy involved using the vertical component to find the time of flight and then using it for the horizontal component. Unsuccessful candidates seemed to adopt an 'autopilot' approach to projectile motion. They would have been better off reading the question more carefully in order to understand the details of the situation posed and then considering how to adapt the standard projectile model to suit the circumstances.

(ii) Candidates with a clear and structured approach as advocated for **part (i)** had little difficulty answering this part correctly too. There was one issue requiring more care: that the direction on hitting the ground should be referred to the horizontal in a clear and unequivocal manner. Many candidates tried to express this direction as a bearing which is hardly appropriate.

Answers: **(i)** 12 ms^{-1} **(ii)** 28.6 ms^{-1}, 65.2° below the horizontal

Question 8

(i) On the whole, this question was not well answered. A correct triangle, which involves forces represented as directed line segments, has all sides and angles labelled to show the information given in the question. Arrows are also needed to indicate the directions of the forces and to show that the forces are in equilibrium.

(ii) Having drawn the triangle in **part (i)** candidates were expected to answer this question by solving the triangle. A direct approach involves the sine rule and the results can be obtained quickly with only a minimal amount of manipulation. However, most candidates preferred to resolve vertically and horizontally and then set about solving a pair of non-trivial simultaneous equations. It is very much to the credit of many of them that they persevered with this, obtaining an equation of the form $a\sin\theta + b\cos\theta = c$ which they solved using, for example, $R\sin(\theta+\alpha)$, and eventually arriving at the correct set of answers. This approach involves a considerable amount of manipulation, is fraught with difficulties and often proved too much. Other strategies, which involve first finding the values of *P*, can risk the added complication of a spurious value of θ which is not easily seen as such.

Answers: **(ii)** 23.1°, 96.9°, 7.86, 19.9 N

Question 9

(i) There were many correct answers to this question. As with so many '*suvat*' questions there is an easy, one-step approach to this one which was often missed. Candidates stand to benefit if they know how to select the most suitable formula for a given situation.

(ii) (a) The correct values of t were found by just about all candidates.

(b) Most candidates knew that they were expected to integrate the velocity function, and the integration itself was almost always correct. The next steps, towards obtaining the numerical value given in the question, require considerable care. The constant of integration should be handled explicitly and rigorously, and the substitution of $t = 18$ should be done in such a way that it is clear beyond a shadow of a doubt that the calculations have actually been carried out by the candidate. It is all too tempting to assume that the value of the expression written down equals the answer given in the question.

(iii) From the preceding parts of the question it can be seen that the two models take the same time to move from P to Q. Model 2 may be regarded as more appropriate because, on arrival at Q, the particle/instrument comes to rest. When answering questions such as this, candidates should be encouraged to confine themselves to what is known about the situation or can be deduced from the information given.

Answers: **(i)** $0.4\,\text{ms}^{-1}$ **(ii)(a)** 0, 18

Question 10

Many candidates answered this question successfully. The best strategy was to define t as the time from when the bus starts moving and then to equate the expressions, in terms of t, for the distances travelled by the bus and the cyclist respectively. A relatively straightforward quadratic equation for t then quickly leads to the correct answers. Various incorrect versions were seen, usually involving the omission of one of the terms in the expression for the distance travelled by the cyclist.

Answers: 20 sec, $10\,\text{ms}^{-1}$