STEP Examiner's Report 2014

Mathematics

STEP 9465/9470/9475

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Contents

STEP Mathematics (9465, 9470, 9475)

SI 2014 Report

General Comments

More than 1800 candidates sat this paper, which represents another increase in uptake for this STEP paper. The impression given, however, is that many of these extra candidates are just not sufficiently well prepared for questions which are not structured in the same way as are the A-level questions that they are, perhaps, more accustomed to seeing. Although STEP questions try to give all able candidates "a bit of an intro." into each question, they are not intended to be easy, and (at some point) imagination and real flair (as well as determination) are required if one is to score well on them. In general, it is simply not possible to get very far into a question without making some attempt to think about what is actually going on in the situation presented therein; and those students who expect to be told exactly what to do at each stage of a process are in for a shock. Too many candidates only attempt the first parts of many questions, restricting themselves to 3-6 marks on each, rather than trying to get to grips with substantial portions of work – the readiness to give up and try to find something else that is "easy pickings" seldom allows such candidates to acquire more than 40 marks (as was the case with almost half of this year's candidature, in fact).

Poor preparation was strongly in evidence – curve-sketching skills were weak, inequalities very poorly handled, algebraic capabilities (especially in non-standard settings) were often pretty poor, and the ability to get to grips with extended bits of working lacking in the extreme; also, an unwillingness to be imaginative and creative, allied with a lack of thoroughness and attention to detail, made this a disappointing (and, possibly, very uncomfortable) experience for many of those students who took the paper.

On the other side of the coin, there was a very pleasing number of candidates who produced exceptional pieces of work on 5 or 6 questions, and thus scored very highly indeed on the paper overall. Around 100 of them scored 90+ marks of the 120 available, and they should be very proud of their performance – it is a significant and noteworthy achievement.

Comments on individual questions

[Examiner's note: in order to extract the maximum amount of profit from this report, I would firmly recommend that the reader studies this report alongside the *Hints and Solutions* supplied separately.]

Q1 Traditionally, question 1 is intended to be the most generous and/or helpful question on the paper, in order to permit as many candidates as possible to get started in a reasonably friendly situation, and thereby pick up at least 10 marks on the paper; giving them a positive start to the examination. This year, however, despite the high rate of popularity (over 80% of the candidature attempted Q1), there were several surprises in store for the examiners.

Firstly, it was not nearly so popular as it appears from the proportion of attempts, as it turned out that many of these attempts were either weak or inconsequential, petering out the moment the work became algebraic rather than numerical. The other surprise was how poorly the very simple ideas were handled. Many candidates clearly did not know what constituted a proof in these settings, when little more than (say) a statement such as $2k+1 \equiv (k+1)^2 - k^2$ in (ii) was perfectly sufficient. Quite a few went on to attempt what was clearly intended to be an inductive proof, having already written the correct (and wholly adequate) result, sometimes in each of parts (ii), (iii) and (iv).

Furthermore these sorts of mistakes were often preceded by incorrect numerical work in part (i), including offerings that ignored the initial prompting regarding the use of non-negative integers, such as "12 = $7^2 - \left(\sqrt{37}\right)^2$. In other parts of the question, candidates would resort to providing counterexamples to results that had not been suggested; such as, in part (iv) producing a counterexample (such as "6") to refute the notion that "every number of the form $4k + 2$ can be written as the difference of two squares" when the question actually required them to show that ***no*** number of this form has the proposed property, so offering one example represented a considerable misunderstanding of mathematical ideas and terminology. Part (iv) also suffered from the common misconception that factorising $4k + 2$ as $2(2k + 1)$ immediately meant that $2k + 1$ had to be prime.

Candidates who had seen and used modular arithmetic had a bit of an advantage in (iv) but, in fact, there was very little evidence of such. Partly balancing the widespread lack of (pretty basic) number theoretic appreciation were the few candidates who found this all very straightforward, as had been intended to be the case. Overall, however, this question provided a very disappointing range of responses, and the mean score of under 5/20 underlines this fact.

Q2 This was another very popular question, attempted by around 80% of candidates, and producing much greater success, although it has to be noted that this usually extended to work up to the end of part (iii), after which the integration efforts had become so prolonged and involved that many candidates simply moved on elsewhere rather than plough on into (iv). This all led to a mean score on the question of almost exactly 10/20.

There were two perfectly acceptable approaches to part (i); integrating the LHS by parts , after writing $\ln(2 - x)$ as the product $\ln(2 - x).1$ or, instead, differentiating the RHS in order to verify the result. The first method is probably that which is most "in the spirit of the game", though the second is, perhaps, the shrewder tactic. For those adopting the first approach, some difficulties were encountered when the extra "$2 - x$" failed to appear naturally, indicating a failure to appreciate the nature of arbitrary constants (namely, that "$-x + C$" could equally well be written have been written as "$-x + 2 + C$").

The curve-sketching was handled in the usual mixed way, with many candidates clearly well-prepared and dealing admirably with crossing-points on the axes and asymptotes, while others at the other end of the ability range seemed capable only of plotting points and "joining the dots". There were also many who thought that, towards asymptotes, the graph of a function should only approach positive infinity, and this led to a $\cup$-shaped central portion. However, there were very few sketch-attempts that failed to pick up at least 3 or 4 point-scoring features of the graph at hand.

Following this, attempts at part (iii) again generally picked up quite a few of the available marks by using the correct limits, separating $\ln\left(4 - x^2\right)$ as $\ln(2 - x) + \ln(2 + x)$, and then adapting the given result of (i) to the second term (although this frequently took far longer than should have been the case). However, when it came to part (iv), most candidates decided they'd had enough and went elsewhere. Many who started (iv) were clearly thrown by the extra set of modulus-brackets (even though they were intended to make life easy by rendering every part of the first curve positive). The extra bits of area then came simply from the use of a new pair of limits and the given result for evaluating the integrand in the vicinity of the asymptote.

Q3 This was, by far, the most popular question on the paper, with around 90% of candidates making an attempt at it. The mean score on it was just under 9/20. There was much on this question that made it straightforward, although there were several points at which candidates either overlooked something or were not sufficiently careful in their explanation. Almost all candidates managed part (i) successfully and managed to obtain the quartic equation in (ii). Many of these, however, assumed they had made a mistake since the question gives a cubic instead, and some of them tried, often repeatedly, the same working again rather than try to remove the "obvious" factor of (b – 1). Continuing with the given result again allowed candidates to employ some fairly routine skills, and many did so successfully (though often without important bits of explanation).

Part (iii) proved to be rather less successful for most candidates, as they simply substituted straightaway for p and q and then found themselves in difficulties with the ab term that arose. Finally, it was (once again) clear that the majority of candidates are really not very comfortable with inequalities and very few of them managed to establish both "halves" of the required result.

Q4 This question was very unpopular indeed, almost certainly due to the lack of given structure. It attracted the attention of less than half of all candidates, and many of these attempts got no further than the first two lines of working involving the use of the *Cosine Rule*. This led to a mean score of 4/20 on this question and made it the second lowest scoring question on the paper.

Those candidates who did then differentiate generally overlooked the fact that they should have been differentiating with respect to time; fortunately, with $\frac{\mathrm{d}\theta}{\mathrm{d}t}$ being constant, there was very little penalty in terms of both marks lost and in straying from a profitable path of progress through the working.

As mentioned already, attempts that went significantly beyond this point were few and far between, with relatively few of such candidates realising that they needed to turn the resulting equation into a quadratic in $\cos\theta$, and even fewer managing to factorise it appropriately. For the very final part of the question, quite a few managed to obtain the correct (given) answer legitimately, even though they had been unsuccessful with the bulk of the question's working until then. This, at least, demonstrates a shrewd grasp of examination technique and generally earned them 3 or 4 marks at the end.

Q5 As already indicated in the comments for Q3, candidates generally do not like working with inequalities and this question is riddled with them. Q5 thus turned out to be the second least popular of the pure questions, and scored poorly with a mean score of under 5/20, again largely due to a lack of progress beyond the first part of the question.

Even in (i), there was a tendency to dive straight in to the sketch without having worked out any useful points on the curve, including missing the obvious point (a, 0). Using this would have led easily towards a factorisation of f(x) into three linear factors, though most preferred to find the turning points instead (which approach works equally well). Though not crucial to the following working, the special case $a = 0$ remained almost universally unaddressed.

Each of parts (ii) and (iii) can be approached via the *AM-GM Inequality* though very few did so as we had instructed candidates to use the result of part (i). It was disappointing to see so few serious attempts at part (ii) since all that is required is to set $a = y$ and then the "$x + 2y$" is practically waving at you. Part (iii) required a bit more thought (setting $p = x$ and then $q + r = 2a$) but both imagination and determination seemed in short supply by this stage of the question.

Q6 Around half of the candidates attempted this question, though successful working was (yet again) almost entirely limited to the opening part. Even here, there were far too many candidates who were unable to turn $4\sin^2\theta\cos^2\theta$ into $\sin^2 2\theta$. Many of those who did spot this simplification had difficulties trying to find u_2 in a similar form – thereby completely overlooking the fact that starting with $\sin^2(A)$ **at any stage of the process** clearly had to yield $\sin^2(2A)$ at the next. This also applies to the inductive step, which thus requires almost no further working – a position which was carefully avoided by all those who ploughed on into the standard format of a *proof by induction* without thinking about what they had just established.

Part (ii), was not often attempted. Some candidates substituted for v_n but not v_{n+1}; others thought that u_n and u_n^2 were the same thing and collected their coefficients up together; and, generally, the algebra was clearly found very unappealling. The very last part of the question required a "hence" approach, so those candidates who simply set about the sequence numerically scored only one mark. Even those who played the game according to the "hence" overlooked the need to check that the given condition was satisfied.

Q7 Of the pure maths questions, this was by far the least popular, with attempts from only around a quarter of the candidature. Very few attempts proceeded beyond the opening stages. Surprisingly – despite the fact that the whole question can be done with little more than the knowledge of how to split a line segment in a given ratio, vector equations of lines joining two given points, and the finding of a point of intersection of two lines – most attempts began with incorrect statements of the position vectors **d** and **e** in terms of **b** and **a** (respectively). Most candidates wisely gave up at this point, though some persevered, but with little success. The mean score of under 3/20 on this question reflects the paucity and brevity of efforts.

Geometers amongst the readership may notice that this result follows from a combination of *Menelaus' Theorem* and *Ceva's Theorem*. A handful of candidates noticed it too, and scored most of the marks for relatively little effort.

Q8 In hindsight, this question was a little too straightforward, and could well have been placed earlier on in the paper. Nonetheless, around two-thirds of all candidates attempted it, and marks were generally very high, making it the second highest-scoring question on the paper (and only marginally behind Q2) at just under 10/20. Finding equations of lines and intersections in the coordinate geometry setting was clearly much more in candidates' comfort zone than the vector setting of Q7, although there were problems caused by the surfeit of minus signs, and many repeated their working for L_a when finding L_b rather than simply changing the a's into b's.

Parts (ii) and (iii) were also handled well, though slightly less confidently than (i). Part of this was due to the lack of clear explanations given by candidates as to what had been done or found, or a failure to realise that there was a need to justify that "$\sqrt{c}$" satisfied the same conditions as the a from earlier on. Sadly, some failed to give the x a new label (c here), and persisted to substitute x's as part of a gradient into what then became a non- linear formula. Overall, however, this was a good question for candidates and most managed to make substantial progress most of the way through it.

Qs.9-11 The mechanics questions in section B always seem to prove more popular than those in the probability & statistics section C, and this was again the case this year. Qs. 9 & 11 each drew around 700 attempts – I suspect because they look the more standard settings – while Q10 attracted the attention of almost 550. However, those who persevered with Q10 generally scored more marks (Q9's means score was just under 6½/20; Q11's a mark less; while Q10's was around 9½/20), largely because of the numerical "pay-off" at the end of the question.

The key point in Q9 was to realise that the given expression for T meant that T was the time when the particle "turned round" horizontally. Those candidates who spotted this then had the opportunity to score lots of marks, as the sketches related to the point at which the particle turned back relative to its highest point and its landing-point. Those who approached the problem from a purely algebraic direction usually struggled with the significances of the three (four) cases.

Those candidates who did well on Q10 were generally those who set their working out in a more structured manner. For instance, a diagram to illustrate the assigned (symbols for the) speeds and directions of the objects involved in the collision generally helps prevent mistakes involving signs when applying the principles of *Conservation of Linear Momentum* and *Newton's (Experimental) Law of Restitution*. Indeed, without such a clear indication, it is often very difficult indeed for the markers to follow working involving symbols that just appear from nowhere!

Unfortunately, Q11 suffered particularly from precisely this issue also, and most marks gained on it came from successful attempts at the single-pulley scenario given in part (i) – for which we allocated six marks. Efforts at part (ii) often saw candidates failing to produce diagrams indicating directions for the various accelerations (etc.) and simply resorting to writing down several vague statements based on vague interpretations of "resolving" ideas and/or *N*2*L*. The failure to grasp that there needed to be some notion of relative accelerations involved for the two masses attached to pulley P_1 meant that most efforts were fatally flawed anyhow. Strangely, yet illustrating again the shrewdness of exam. technique amongst some of the candidates, it was possible to attempt the very final part just by taking the two given answers and running with them (although many failed to appreciate that an 'if and only if' proof needed two directions of reasoning).

Qs12 & 13 These questions elicited the least amount of interest from candidates (250 and 320 attempts respectively), though marks were generally in line with those for Qs. 9 & 11 (also respectively) at around 6½/20 and 5½/20.

The big hurdle in Q12 was the modulus function, which many candidates simply ignored. Those who were happy to use it properly generally gained the required result and used it to find that $k = 7$ (though some failed to discount $k = 1$ along the way). A further obstacle arose as most candidates who continued into the second part of the question failed to account for all six outcomes when calculating $P(X > 25)$.

In Q13, apart from the usual sign errors, most candidates correctly found $g(x)$ and $h(x)$. A popular approach for the mean was to throw the word "centroid" at the problem and hope that this sufficed. For the median, around half of attempts failed to consider the easy (symmetric) case when $m = c = \tfrac{1}{2}(a + b)$. The case $c > \tfrac{1}{2}(a + b)$, corresponding to when m lies under the first line-segment, was handled very well; the other case very poorly, since most candidates tried to work from the LHS up rather than from the RHS down. A very few realised that working down from the top actually made this just a "write down" by switching a for b suitably.

S2 2014 Report

General Comments

There were good solutions presented to all of the questions, although there was generally less success in those questions that required explanations of results or the use of diagrams and graphs to reach the solution. Algebraic manipulation was generally well done by many of the candidates although a range of common errors such as confusing differentiation and integration and simple arithmetic slips were evident. Candidates should also be advised to use the methods that are asked for in questions unless it is clear that other methods will be accepted (such as by the use of the phrase “or otherwise”).

Comments on individual questions.

Question 1

While the first part of the question was successfully completed by many of the candidates, there were quite a few diagrams drawn showing the point P further from the line AB than Q. Those who established the expression for $x\cos\theta$ were usually able to find an expression for $x\sin\theta$ and good justifications of the quadratic equation were given. The case where P and Q lie on the lines AC produced and BC produced caused a lot of difficulty for many of the candidates, many of whom tried unsuccessfully to create an argument based on similar triangles.

The condition for (*) to be linear in x did not cause much difficulty, although a number of candidates did not give the value of $\cos^{-1}\left(-\frac{1}{2}\right)$. Many candidates realised that the justification that the roots were distinct would involve the discriminant, although some solutions included the case where the discriminant could be equal to 0 were produced. However, very few solutions were able to give a clear justification that the discriminant must be greater than 0.

In the final part some candidates sketched the graph of the quadratic rather than sketching the triangle in the two cases given. In the second case many candidates did not realise that Q was at the same point as C.

Question 2

This was one of the more popular questions of the paper. Most candidates successfully showed that the first inequality was satisfied, but when producing counterexamples, some failed to show that either $f(x) \neq 0$ or $f(\pi) \neq 0$ for their chosen functions. In the second part many candidates did not attempt to choose values of a, b and c, but substituted the general form of the quadratic function into the inequality instead. In the case where the function involved trigonometric functions, many of those who attempted it were able to deduce that $p = q = -r$, but several candidates made mistakes in the required integration. Those who established two inequalities were able to decide which gives the better estimate for π.

Question 3

Many candidates produced a correct solution to the first part of the question. There were a number of popular methods, such as the use of similar triangles, but an algebraic approach finding the intersection between the line and a perpendicular line through the origin was the most popular. Some candidates however, simply stated a formula for the shortest distance from a point to a line. Establishing the differential equation in the second part of the question was generally done well, but many candidates struggled with the solution of the differential equation. A common error was to ignore the case $y'' = 0$ and simply find the circle solution.

The final part of the question was attempted by only a few of the candidates, many of whom did not produce an example that satisfied all of the conditions stated in the question, in particular the condition that the tangents should not be vertical at any point was often missed.

Question 4

Many candidates were able to perform the given substitution correctly and then correctly explain how this demonstrates that the integral is equal to 1. The second part caused more difficulty, particularly with candidates not able to state the relationship between $\arctan x$ and $\arctan\left(\frac{1}{x}\right)$. Attempts to integrate with the substitution $v = \arctan\left(\frac{1}{u}\right)$ often resulted in an incorrect application of the chain rule when finding $\frac{dv}{du}$.

In the final part of the question many candidates attempted to use integration by parts to reach the given answer.

Question 5

This was the most popular question on the paper and the question which had the highest average score. Most candidates correctly solved the differential equation in the first part of the question, but many then calculated the constant term incorrectly. In the second part of the question most candidates were able to find the appropriate values of a and b, but then did not see how to apply the result from part (i) and so did the integration again or just copied the answer from the first part. Some candidates again struggled to obtain the correct constant for the integration and others did not substitute the correct values for the point on the curve (taking (X, Y) as $(1,1)$ rather than (x, y)).

Question 6

This was one of the less popular of the pure maths questions, but the average mark achieved on this paper was one of the highest for the paper. The first section did not present too much difficulty for the majority of candidates, with a variety of methods being used to show the first result such as proof by induction or use of $e^x = \cos x + i \sin x$. In the second part of the question many of the candidates struggled to explain the reasoning clearly to show the required result. Most candidates who reached the final part of the question realised that the previous part provides the basis for a proof by induction.

Question 7

This was another of the less popular pure maths questions. The nature of this question meant that many solutions involved a series of sketches of graphs with very little written explanation. Most candidates were able to identify that the sloping edges of $y = f(x)$ would have the same gradient as the sloping edges of $y = g(x)$, but many did not have both sloping edges overlapping for the two graphs. In some cases only one sloping edge of $y = g(x)$ was drawn. A large number of candidates who correctly sketched the graphs identified the quadrilateral as a rectangle, rather than a square. In the second part of the question, sketches of the case with one solution often did not have the graph of $y = |x - c|$ meeting the x-axis at one corner of the square identified in part (i), although many candidates were able to identify the different cases that could occur. Unfortunately in the final part of the question very few candidates used the result from the first part of the question and so considered a number of possibilities that do not exist for any values of a, b, c and d.

Question 8

This was the least popular of the pure maths questions and also the one with the lowest average score. Many of the candidates were able to show the required result at the start of the question, although very few candidates explained that m could be either of the two integers when the range included two integers. Parts (i) and (ii) were then quite straightforward for most candidates, although many calculated the range of values but did not justify their choice in the case where there were two possibilities. In the final two parts of the question some candidates mistakenly chose the value 0 when asked for a positive integer.

Question 9

This question was not attempted by a very large number of candidates and the average score achieved was the lowest on the paper. While there were a number of attempts that did not proceed beyond drawing a diagram to represent the situation, the first part of the question was done well by a large number of candidates. Many were also able to adjust the result for the case when the frictional force acts downwards. Unfortunately, in the final part of the question many candidates continued to use $F = \mu R$, not realising that this only applies in the critical case and so there were very few correct solutions to this part of the question.

Question 10

This was the most popular of the mechanics questions and also the one that had the best average score, although candidates did struggle to get very high marks on the question particularly on the final parts. The first part of the question asks for a derivation of the equation for the trajectory which was familiar to many candidates, although in some cases the result was obtained by stating that it is a parabola and knowledge of the maximum value and the range. Many candidates who successfully obtained the Cartesian equation then struggled with the differentiation with respect to λ, instead finding the maximum height for a constant value of λ. Unfortunately, this made the remainder of the question insoluble. Some candidates decided to differentiate with respect to θ instead, which did not cause any serious problems, although it did require more work. A few candidates used the discriminant rather than differentiation, but did not provide any justification of this method.

Candidates were able to draw the graph, but many did not label the area that was asked for in the question. Those who reached the final part of the question and considered the distance function for the position during the flight used differentiation to work out the greatest distance. However, many did not realise that the maximum value of a function can be achieved at an end-point of the domain even with a derivative that is non-zero.

Question 11

Many candidates who attempted this question struggled, particularly due to a difficulty in drawing a diagram to represent the situation. From these incorrect diagrams candidates often reached results where one of the signs did not match that given in the question. The calculation of the acceleration was found to be difficult by many of the candidates, although those who understood that differentiation of the coordinates of P would give the acceleration were then able to complete the rest of the question correctly. Those candidates that attempted the final part of the question were able to solve it correctly.

Question 12

This was the least popular question on the paper. A large number of candidates who attempted this question seemed unable to work out where to start on the first part of the question. Much of the rest of the question requires working with the hazard function defined at the start of the question and so many candidates who attempted these parts were able to do the necessary integration to solve the differential equations that arose. A common error among those who attempted part (iv) was to ignore the "if and only if" statement in the question and only show the result one way round.

Question 13

This was the more popular of the two questions on Probability and Statistics, but as in previous years it still only attracted answers from a very small number of candidates. The average mark for this question was also quite low, often due to a difficulty in explaining the reasoning behind some of the parts of the question. Many candidates were able to find the expression for $P(X = 4)$ and most were then able to obtain the general formula required in part (i) of the question, although a number of candidates did not include the correct number of factors in the answer. Parts (ii) and (iii) did not cause too much difficulty, but the final part required a clear explanation to gain full marks.

STEP 3 2014 Examiners' report

A 10% increase in the number of candidates and the popularity of all questions ensured that all questions had a good number of attempts, though the first two questions were very much the most popular. Every question received at least one absolutely correct solution. In most cases when candidates submitted more than six solutions, the extra ones were rarely substantial attempts. Five sixths gave in at least six attempts.

1. This was the most popular question on the paper, being attempted by approximately 14 out of every 15 candidates. It was the second most successfully attempted with a mean score of half marks. The stem of the question caused no problems, but a common mistake in part (i) was to attempt derivatives to obtain the desired result. Most candidates came unstuck in part (ii), making it much more difficult for themselves by attempting to work with expressions in a, b, and c rather than using the log series working with q and r, and as a result making sign errors, putting part (iii) beyond reach, and although they could find counterexamples for the claim in part (iv), they did so without the clear direction that working with the expressions in q and r would have made obvious.

2. This was only marginally less popular than question 1, but was the most successfully attempted with a mean of two thirds marks. Most that attempted the question were able to do the first two parts easily, but could not find a suitable substitution to do the last part. In about a tenth of the attempts, a helpful substitution was made in part (iii) which then usually resulted in successful completion of the question. Modulus signs were often ignored, or could not be distinguished from usual parentheses, and the arbitrary constant, even though it appeared in the result for part (i), was frequently overlooked. A few did not use the correct formulae for $\cosh 2x$, instead resorting to the trigonometric versions. A handful of candidates attempted partial fractions in the last part having correctly factorised the quartic, but this did not use the previous parts as instructed.

3. About half of the candidates attempted this, but it was the second least successfully attempted with a mean score just below a quarter marks. Most managed the first result, with those not doing so falling foul of various basic algebraic errors. The second result of part (i) was often answered with no justification. The second part was poorly done with a variety of approaches attempted such as obtaining a distance function, and then using completing the square or differentiation, or investigating the intersections of the circle and parabola. Few considered the geometry of the parabola and its normal which would have yielded the results fairly simply.

4. Two thirds of the candidature attempted this but with only moderate success earning just a third of the marks. The very first result was frequently obtained although some fell at the first hurdle through not appreciating that they needed to use $\sec^2 x = 1 + \tan^2 x$, or else that there was then an exact differential. The second result in part (i) was 'only if' whereas many read it, or answered it, as 'if'. In part (ii), most spotted $b = a$. There were many inappropriate functions suggested for the last part of the question, many which ignored the requirement that $y = 0$, $x = 1$.

5. This was a moderately popular question attempted by half the candidates, with some success, scoring a little below half marks. There were some basic problems exposed in this question such as the differences between a vector and its length, the negative of a vector and the vector, and the meaning of 'if and only if' resulting in things being shown in one direction only throughout the question. Part (i) was generally well done, but in part (ii), it was commonly forgotten that there

were two conditions for XYZT to be a square. Approaches using real and imaginary parts (breaking into components) were not very successful.

6. The third most popular question, as well as the third most successful being only marginally behind question one in marks, having been attempted by about 70%. Many did not use the required starting point, instead resorting to monotonicity or drawing pictures (graphs) which were not proofs. In parts (i) especially and (ii) as well, candidates failed to use the result that $f(t) > 0$, cavalierly using $f(t) < 0$, or even $f(t) < 1$ without justification. Many made complicated choices of functions for (i) and (ii), and then got lost in their differentiations, and finally there was frequent lack of care to ensure that quantities dividing inequalities were positive.

7. Roughly two fifths of the candidates attempted this with a mean score of just over three marks making it the least well attempted question on the paper. Most could do part (i), which is GCSE material, but frustratingly quite a few stated that the triangles were similar with no justification. Part (ii) was by far the most poorly attempted part with a lot of hand-waving arguments. Part (iii) was done well by virtue of only the best candidates making it past part (i) with 75% of solutions containing good proofs by contradiction for the first result and the last two parts were pretty well done.

8. Just fewer than half the candidates attempted this scoring just over a third of the marks. Many managed all but part (iii) easily but few managed that last part, and most did not try it. In part (i), having correctly used the result from the stem, there was frequently not enough care taken in extending this to the full sum. A not infrequent error of logic was that $\sum_{r=1}^{2^{N+1}-1} 1/r < N+1$ and $\lim_{N\to\infty} N+1 = \infty$ somehow implies that $\sum_{r=1}^{\infty} 1/r$ does not converge.

9. A fifth attempted this, scoring at the same level as question 8. The first differentiation and the verification of the initial conditions were managed but very few bothered to check that the equation of motion was satisfied. Most obtained the first displayed result but few realised that β was the angle of depression rather than elevation and this generated plenty of sign errors. A few did achieve the very final result.

10. This was attempted by a quarter of the candidates with scores just below those achieved in question 5. Good candidates could obtain full marks in less than a page of working whilst weak ones spent a lot of effort trying to solve differential equations for x and y because they hadn't spotted the change of variables to $x - y$ and $x + y$. The vast majority could obtain the first equation, often using the given result as a guide. However, there was frequent confusion between extension and total length of the springs. In addition, sign errors in $\frac{d^2y}{dt^2}$ prevented the next part from working out. Lots did not realise to work with $x - y$ and $x + y$, but those that saw SHM in one of these, saw it in the other. Likewise, with initial conditions, quite a few overlooked $\frac{dx}{dt} = 0$, $\frac{dy}{dt} = 0$, which prevented them solving for the constants, and also the sign was often overlooked in the condition $y = -\frac{1}{2}a$. In attempting the last result, some used the factor formula, which worked but was unnecessary. Quite often, they stumbled over the final step of logic ending up with apparent contradictions such as $\sqrt{3} = 1$, which is of course false, but did not demonstrate full understanding.

11. Just marginally more popular than question 10, it was attempted with the same level of success. Provided that a correct figure (and it didn't matter whether P was above the level of B or not) was drawn, and that resolving was correctly conducted, then candidates could obtain the two tensions in general, in which case the inequality frequently followed. However, the geometric result stumped many; the few completing it did so via the cosine rule and completing the square. At this point, the final results usually followed for candidates still on track.

12. Less than 8% tried this, scoring just over a quarter of the marks. Very few got the question totally correct, but a number got it mostly right. Nearly all managed the median of Y, but the probability density function of Y caused some to stumble. However the mode result, apart from some poor differentiation, was mostly alright. The explanation in part (iii) eluded some candidates who were otherwise strong. Applying the mode result in part (iv) to obtain λ surprisingly tripped up some merely through inaccurate differentiation. As one would hope, anyone that got as far as part (iv) spotted that the median of X was .

13. Just a handful of candidates more attempted this than question 12, but scoring marginally less with one quarter marks. A small number did just part (i), but otherwise candidates tended to either score zero or nearly all of the marks. There was some very shaky logic in finding the first result of part (iii) and then failing to deduce, as required, the probability result. Quite often, the working for μ in part (iv), whilst usually correct, was extremely convoluted.

Explanation of Results STEP 2014

All STEP questions are marked out of 20. The mark scheme for each question is designed to reward candidates who make good progress towards a solution. A candidate reaching the correct answer will receive full marks, regardless of the method used to answer the question.

All the questions that are attempted by a student are marked. However, only the 6 best answers are used in the calculation of the final grade for the paper.

There are five grades for STEP Mathematics which are:
S – Outstanding
1 – Very Good
2 – Good
3 – Satisfactory
U – Unclassified

The rest of this document presents, for each paper, the grade boundaries (minimum scores required to achieve each grade), cumulative percentage of candidates achieving each grade, and a graph showing the score distribution (percentage of candidates on each mark).

STEP Mathematics I (9465)

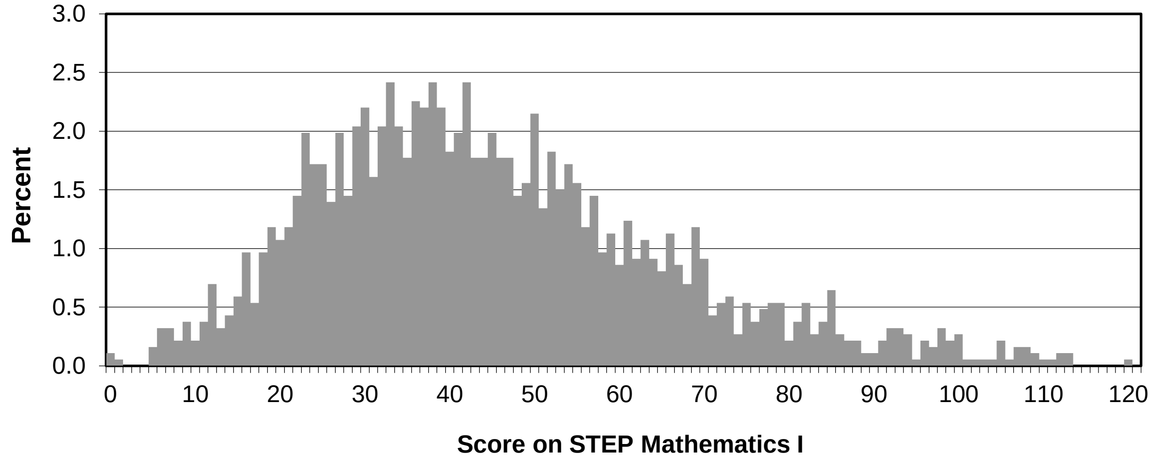
Grade boundaries

Maximum Mark	S	1	2	3	U
120	90	63	43	28	0

Cumulative percentage achieving each grade

Maximum Mark	S	1	2	3	U
120	3.8	18.9	48.8	79.6	100.0

Distribution of scores



STEP Mathematics II (9470)

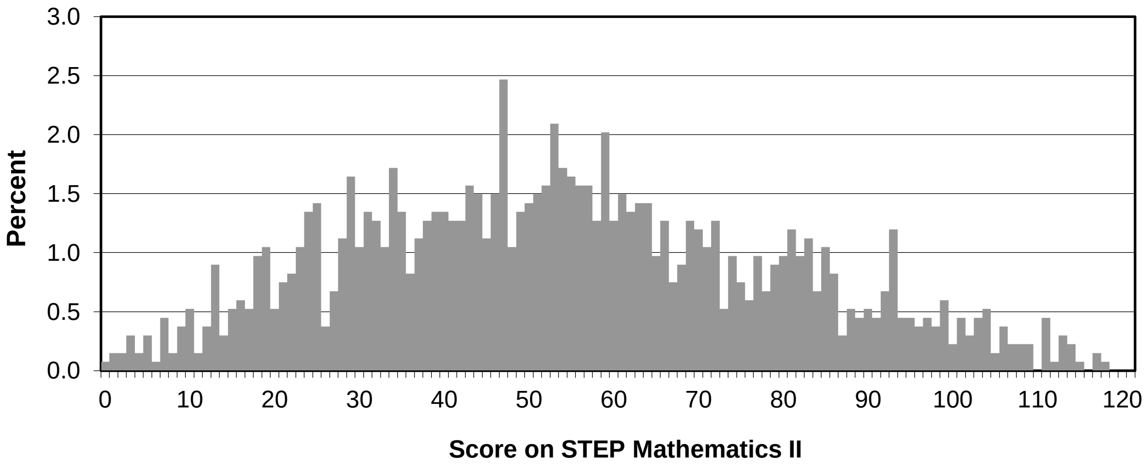
Grade boundaries

Maximum Mark	S	1	2	3	U
120	95	74	64	30	0

Cumulative percentage achieving each grade

Maximum Mark	S	1	2	3	U
120	6.7	22.9	33.6	82.2	100.0

Distribution of scores



STEP Mathematics III (9475)

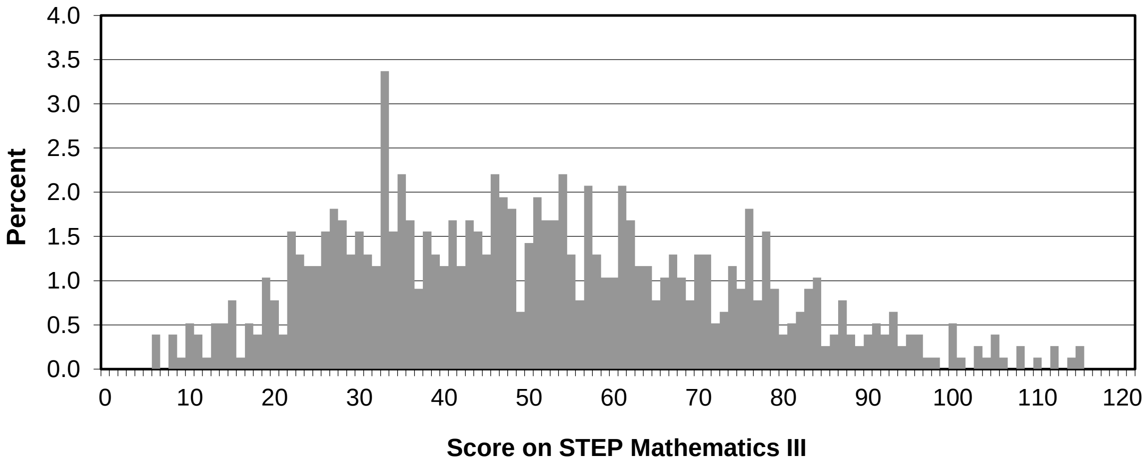
Grade boundaries

Maximum Mark	S	1	2	3	U
120	81	59	48	28	0

Cumulative percentage achieving each grade

Maximum Mark	S	1	2	3	U
120	11.0	35.4	52.2	84.5	100.0

Distribution of scores



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