# STEP 2011 Paper I: Principal Examiner's Report

## Introductory comments

There were again significantly more candidates attempting this paper than last year (just over 1100), but the scores were significantly lower than last year: fewer than 2% of candidates scored above 100 marks, and the median mark was only 44, compared to 61 last year. It is not clear why this was the case. One possibility is that Questions 2 and 3, which superficially looked straightforward, turned out to be both popular and far harder than candidates anticipated. The only popular and well-answered questions were 1 and 4.

The pure questions were the most popular as usual, though there was noticeable variation: questions 1–4 were the most popular, while question 7 (on differential equations) was fairly unpopular. Just over half of all candidates attempted at least one mechanics question, which one-third attempted at least one probability question, an increase on last year. The marks were surprising, though: the two best-answered questions were the pure questions 1 and 4, but the next best were statistics question 12 and mechanics question 9. The remainder of the questions were fairly similar in their marks.

A number of candidates ignored the advice on the front cover and attempted more than six questions, with a fifth of candidates trying eight or more questions. A good number of those extra attempts were little more than failed starts, but still suggest that some candidates are not very effective at question-picking. This is an important skill to develop during STEP preparation. Nevertheless, the good marks and the paucity of candidates who attempted the questions in numerical order does suggest that the majority are being wise in their choices. Because of the abortive starts, I have generally restricted my attention to those attempts which counted as one of the six highest-scoring answers in the detailed comments.

On occasions, candidates spent far longer on some questions than was wise. Often, this was due to an algebraic slip early on, and they then used time which could have been far better spent tackling another question. It is important to balance the desire to finish a question with an appreciation of when it is better to stop and move on.

Many candidates realised that for some questions, it was possible to attempt a later part without a complete (or any) solution to an earlier part. An awareness of this could have helped some of the weaker students to gain vital marks when they were stuck; it is generally better to do more of one question than to start another question, in particular if one has already attempted six questions. It is also fine to write "continued later" at the end of a partial attempt and then to continue the answer later in the answer booklet.

As usual, though, some candidates ignored explicit instructions to use the previous work, such as "Hence", or "Deduce". They will get no credit if they do not do what they are asked to! (Of course, a question which has the phrase "or otherwise" gives them the freedom to use any method of their choosing; often the "hence" will be the easiest, though.)

It is wise to remember that STEP questions do require a greater facility with mathematics and algebraic manipulation than the A-level examinations, as well as a depth of understanding which goes beyond that expected in a typical sixth-form classroom. STEP candidates are therefore recommended to heed the sage advice on the STEP Mathematics website, `http://www.admissionstests.cambridgeassessment.org.uk/adt/step`:

> From the point of view of admissions to a university mathematics course, STEP has three purposes. ... Thirdly, it tests motivation. It is important to prepare for STEP (by working through old papers, for example), which can require considerable dedication. Those who are not willing to make the effort are unlikely to thrive on a difficult mathematics course.

Students will also benefit from reading the detailed STEP I solutions which I have written over the previous few years after attempting the papers; these are available from the "Test Preparation" section of the above website.

## Common issues

There were a number of common errors and issues which appeared across the whole paper.

The first was a lack of fluency in algebraic manipulations. STEP questions often use more variables than A-level questions (which tend to be more numerical), and therefore require candidates to be comfortable engaging in extended sequences of algebraic manipulations with determination and, crucially, accuracy. This is a skill which requires plenty of practice to master.

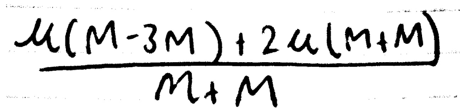
Another area of weakness is logic. The first section of the STEP Specification specifically lists: "Mathematical vocabulary and notation: including: 'equivalent to'; 'necessary and sufficient'; 'if and only if'; '$\Rightarrow$'; '$\iff$'; '$\equiv$'". A lack of confidence in this area showed up several times. In particular, a candidate cannot possibly gain full marks on a question which reads "Show that X if and only if Y" unless they provide an argument which shows that Y follows from X *and vice versa*.

Along with this comes the need for explanations in English: a sequence of formulæ or equations with no explicit connections between them can leave the reader (and writer) confused as to the meaning: Does one statement follow from the other? Are they equivalent statements? Or are they perhaps simultaneous equations? For example, writing $x = 2$ followed by $x^2 = 4$ is not the same as writing $x = 2$ followed by $2x = 4$, and both are different from writing $x = 2$ followed by $y = 3$. Brief connectives or explanations ("thus", "so", "$\therefore$", "$\Rightarrow$" or "$\iff$") would help, and sometimes longer sentences are necessary. The solutions booklet is more verbose than candidates' solutions need to be, but gives an idea of how English can be used.

In some cases, the need for explanations is even greater. Where a question instructs the candidate to prove a statement, writing down an equation without justification is likely to gain the candidate few (if any) marks. For example, it may well suffice to write "Taking moments around $A$" or even just "$\mathscr{M}(A)$" to indicate the source of the following equation. In a pure mathematics question, something like "Substituting (1) into (2):" may well be adequate.

Another related issue continues to be legibility. Many candidates at some point in the paper lost marks through misreading *their own writing*. Common confusions include muddling their symbols, the most common being: $M$ and $m$; $V$ and $v$; $u$ and $n$; $u$ and $N$;

$x$ and $n$; $\alpha$ and 2; $a$ and 9; $s$, $S$ and 5; and occasionally $z$ and 2. It is sad that, at this stage, candidates are still wasting marks because of bad writing habits. A particularly striking example is shown in this candidate's work:



This apparently reads

$$\frac{u(M-3m)+2u(M+m)}{M+m}$$

One frequent error was dividing by zero. On several occasions, an equation of the form $xy = xz$ appeared, and candidates blithely divided by $x$ to reach the conclusion $y = z$. This may or may not be true, depending upon whether or not $x$ could be zero. A better approach in general is to rearrange to get $x(y - z) = 0$ and to deduce that either $x = 0$ or $y = z$. Alternatively, if it is known with certainty that $x \neq 0$, it is fine to divide by $x$, but one must *explicitly* indicate that $x \neq 0$.

Again, I give a strong reminder that it is vital to draw appropriate, clear, accurate diagrams when attempting some questions, mechanics questions in particular: it was shocking how many candidates attempted to solve a collision question without a diagram or a moments question with a tiny, rough sketch!

## Question 1

This was an easy and very popular first question, attempted by almost all of the candidates. It was also the most successfully answered, with a median mark of 14.

(i) Most candidates differentiated the equation implicitly, reaching the specified gradient with ease. Some decided to rearrange the equation into the form $y = \cdots$ before differentiating; this was frequently unsuccessful as the final manipulations required were relatively tricky.

The next step, showing that $p = \pm q$, was also generally answered well, even by candidates who had become stuck on the first part of the question. It was surprising to see many solutions using implicit differentiation to find the gradient of the straight line $ax + by = 1$, rather than rearranging the equation to get $y = mx + c$ and then reading off the answer.

The final step was also generally answered well, though a number of candidates could not see how to use the previous result ($p = \pm q$) to progress. Furthermore, there were a few candidates who managed to deduce one of the possibilities but not the other; this was a little strange, as the argument was essentially identical.

(ii) While the majority of candidates used the result that the products of normal gradients is $-1$, relatively few paid enough attention to notice that the equation of the curve was different to that of part (i). This led them to conclude that $a^2q^2 = -b^2p^2$, from which they were not able to make any progress. (Note here that the left hand side is always positive and the right hand side is always negative.)

Of those who overcame this hurdle and attempted the question posed, some succeeded in reaching the specified conclusion, while most deduced that $a^2q^2 = b^2p^2$ and then became stuck, unable to see how to progress. This is presumably because this equations were more complex than in the first part of the question. Also, some candidates who gave otherwise good answers did not consider both possible cases $aq = +bp$ and $aq = -bp$.

## Question 2

This was a very popular question which was answered spectacularly poorly: almost half of candidates scored 0. Of the other half, the median score was 8, with them succeeding on the first part but getting no further.

For the first part, most candidates (presumably familiar with examples such as $\int x\mathrm{e}^x\,\mathrm{d}x$) attempted to integrate by parts, even though that was not the most appropriate method in this case. Those who did use parts frequently tried to integrate $x/(1+x)$ and tended to get nowhere. Very few understood that a second integration by parts was necessary to finish the job. Nevertheless, most of those who did attempt to use parts showed that they did have a reasonable working knowledge of the technique.

There were a number of shocking errors which recurred frequently. The first was to use the erroneous "rule" that $\int \mathrm{f}(x)\mathrm{g}(x)\,\mathrm{d}x = \int \mathrm{f}(x)\,\mathrm{d}x.\int \mathrm{g}(x)\,\mathrm{d}x$, so there were a number of candidates who wrote $\int \frac{\mathrm{e}^x}{1+x}\,\mathrm{d}x = \mathrm{e}^x \int \frac{1}{1+x}\,\mathrm{d}x$ or similar. Another common error was that $E$, a definite integral, would appear inside integrals or evaluations, giving statements or expressions such as $[xE]_0^1 = E(1) - E(0)$ or $\int E\,\mathrm{d}x$. There were also a number of candidates who applied parts and ended up with integrals inside integrals or integrals inside evaluations ($[\cdots]_0^1$).

A number of candidates also failed to distinguish between indefinite and definite integrals.

*Parts (i) and (ii)*

There were relatively few attempts at these later parts, though some who had been stumped by the first part of the question did succeed with this part.

Some candidates tried to apply the techniques of the first part to this integral, but many realised that a substitution was necessary and successfully executed it.

Most candidates who were successful with part (i) went on to complete the whole question.

## Question 3

This was another very popular but poorly answered question. While most candidates were able to gain some marks, few proceeded beyond the initial part of the question, giving a median mark of 5 and an upper quartile of 7.

Candidates generally did well at the first part of this question, with the majority using the compound angle formulæ to expand the sines on the left hand side of the identity.

A number got stuck at this point, either because they did not know $\sin \frac{1}{3}\pi$ or $\cos \frac{1}{3}\pi$ or because they made algebraic errors. About a quarter of candidates were unable to complete the proof as they did not show that $\sin 3\theta$ is identical to $3\sin\theta - 4\sin^3\theta$ or equivalent; some simply stated the result with no justification. On the other hand, a number of candidates offered very nice arguments using de Moivre's theorem, which was very nice to see.

Some candidates used the factor formulæ, but these were in the minority.

(i) Many candidates who reached this point were able to differentiate the identity correctly, which was pleasing. A significant number failed at this hurdle, though. Of those who did differentiate correctly, though, the majority failed to realise that they could divide their new identity involving cosines by the original identity to reach the stated result. Since the rest of the question depended upon this idea, barely a quarter of candidates made any further progress. There was a strong hint though: the presence of $\cot\theta$ should suggest thinking about $\cos\theta/\sin\theta$.

(ii) Of those who had become stuck earlier, very few attempted this part, even though the first half was totally independent of part (i). Of those who did, a significant number became stuck after performing the given substitution, not realising that they could then use the identity $\sin(\frac{\pi}{2} - x) = \cos x$. There were also a number of candidates who successfully derived the result from scratch using the compound angle formula for tan.

Few candidates made it as far as the cosec equation. Of those who did, and realised that they needed to perform another division or equivalent, few were comfortable enough with the trigonometric manipulations involved to reach an expression involving $\operatorname{cosec} 2\theta$ and thence to reach the stated result.

## Question 4

This was a popular question, attempted by two-thirds of candidates. It was also one of the most successfully answered, with a median mark of 11.

Candidates were very good at differentiating to find the coordinates of $T$, though there were some issues. Those who rearranged to find $y = \sqrt{4ax}$ generally did not handle the possibility that $y$ could be negative. There were also a number of candidates who are still confused when trying to find the equation of a tangent: they used the *general expression* for $\mathrm{d}y/\mathrm{d}x$ rather than substituting in the values of $x$ and $y$ at the point of tangency. This gave them a "straight line" with equation $y - 2ap = \frac{2a}{y}(x - ap^2)$ which was then sometimes rearranged to give a quadratic.

The vast majority were fine with this step, though, and went on to successfully find the coordinates of $T$. Some used the symmetry of the situation to simply write down the equation of the second tangent, while others determined it from scratch.

There was one sticking point, though: at this level of work, candidates are expected to take care when dividing to ensure that they are not dividing by zero. A mark was therefore awarded for stating that $p - q \neq 0$ or $p \neq q$ when dividing by it, but very few candidates did so.

When it came to deducing the given formula for $\cos\phi$, most candidates made a good start, with the dot-product approach more popular than the cosine rule. However, there was a need for some fluent algebraic manipulations, in particular the ability to factorise. This should have been made a little easier by knowing the desired final result, but most candidates became bogged down at this point and were unable to deduce the given expression. The dot-product approach, with its slightly simpler algebra, was generally more successful.

The final part of the question, requiring candidates to deduce that the line $FT$ bisects the angle $PFQ$, produced many spurious attempts. Few candidates appreciated the symmetry of the situation, and so went on to calculate $\cos(\angle TFQ)$ from scratch. Others attempted to find $\cos(\angle PFQ)$, presumably hoping to use a double angle formula or similar. These approaches were sometimes successful.

There were also candidates who attempted to answer this part by using right-angled trigonometry in one of the triangles, or by identifying similar or congruent triangles, even though none of these approaches made sense in this situation.

## Question 5

This was a moderately popular question, attempted by half of the candidates. Most made a reasonably good start, but became stuck after deducing the value of $I$; only half of the candidates gained more than 7 marks.

The first part was answered fairly poorly. Most were able to correctly sketch the graph of $y = \sin x$ (though there were a few who could not) and $y = kx$, but very few made any attempt to justify from their sketch the required result. The most common mark for this part was 1 out of 4.

A handful of candidates decided to rewrite the equation as $\sin x/x = k$ and went on to draw a graph of $y = \sin x/x$, a far more challenging task which was successfully performed by some of the candidates.

The integration part (deducing the formula for $I$) was generally answered very well. There were some who did not understand how to split up the integral or the significance of $x = \alpha$ to this part, but the majority correctly handled the absolute value and the necessity to change the signs of the integrand in the integral from $\alpha$ to $\pi$.

Quite a number used geometrical arguments, considering a triangle from $x = 0$ to $x = \alpha$, a trapezium from $x = \alpha$ to $x = \pi$ and two regions under the curve; most of these also reached the given result.

Determining the stationary points of the function was found to be very challenging. While the differentiation was generally performed correctly, many struggled to factorise the resulting expression. Even among those who did, it was very common to divide by one of the factors, ignoring the possibility that it might be zero. Those who were lucky enough to divide by $\sin\alpha - \alpha\cos\alpha$ deduced the correct value for $\alpha$ at the minimum. Though they gained no immediate credit for this, they were able to continue attempting the rest of the question. Others, though, were less fortunate and asserted that the minimum occurred where $\sin\alpha = \alpha\cos\alpha$; they were unable to make any further progress.

It was very unusual to see any sort of decent justification that $\sin\alpha = \alpha\cos\alpha$ has no solutions in the required range.

Most of the students who reached this point correctly evaluated $I$ at the stationary point to reach the given value.

Finally, students were required to show that the stationary point is a minimum, which few attempted. A significant amount of care was required for each of the approaches, and a small number did so successfully. A few only evaluated $I$ or $\mathrm{d}I/\mathrm{d}\alpha$ on one side of the stationary point rather than on both. Students would do well to remember that there are at least three different general approaches to determining the nature of a stationary point, and that different methods might be more or less successful in different situations.

## Question 6

This was another fairly popular question, but there were many very weak attempts; the median mark was 5.

The first part was answered very poorly. A significant number of candidates only worked out the first few terms and showed that they satisfied the given formula, without making any attempt to justify the formula in general. The majority attempted to write down the general term, with varying degrees of success: many forgot to take account of the minus sign, and so did not include $(-x)^r$. Another common error was to write expressions involving $(-n)!$. Few candidates gave any justification for removal of the minus signs, and solutions which correctly dealt with the case $r < 2$ were rare indeed.

(i) This part was answered very well by the majority of candidates. A number attempted to factorise the numerator as $1 - x + 2x^2 = (1 + x)(1 - 2x)$ or other incorrect ways. Very few answers were careful about the boundary cases, namely where $r = 0$ and $r = 1$, and so most candidates only achieved 4/5 on this part.

(ii) Only a minority of candidates made any progress on this part: most candidates were unable to correctly identify the rule $r^2/2^{r-1}$ for the terms of the sequence. Of those who did, the most common approach was to relate the sequence to that of part (i) as in the first approach described above. Some candidates were able to do the manipulations correctly, but there were a significant number who made slips along the way (for example, using $r^2/2^r$ or leaving out the initial term). Some used the second approach or a variant of it.

It was very pleasing to see some students use the third approach described, many of whom were successful.

## Question 7

This was by far the least popular Pure Mathematics question, attempted by only one-third of candidates. The marks achieved were poor; the median mark was 3.

(i) For this first part of the question, very few candidates were able to justify the form of differential equation given. Many candidates talked about the water level decreasing until it reached $\alpha^2 H$, which is not what actually happens (it continually increases until it reaches that point). This lack of understanding had a knock-on effect later on, too, in that they were unable to generate the required differential equation in part (ii).

Nevertheless, from the given DE, a good number were able to separate the variables and at least make progress towards a solution, though only a minority were able to complete the task.

A number of candidates muddled $H$ and $h$; this sloppiness prevented them from getting the right answer. It was also unfortunate that the symbols for proportionality and the Greek letter alpha are similar; students had to take extra care to keep those distinct as well.

Many candidates used the given result and approximation for $\ln(1+x)$ to deduce the stated approximation.

(ii) Few candidates were able to generate the correct differential equation for this part, with the offering of $\mathrm{d}h/\mathrm{d}t = c(\alpha^2 H - \sqrt{h})$ being far more common. (We were generous and only deducted a few marks if they made progress with this incorrect equation.) Of those who attempted to solve either the correct or this variant differential equation, very few could work out how to integrate the resulting expression. Even when they used the substitution $u = \sqrt{h}$, they were usually unable to integrate the fractional linear expression resulting from it. Some were more successful, especially when they used the substitution $v = \alpha\sqrt{H} - \sqrt{h}$.

A number of students wisely picked up a couple of marks by demonstrating the validity of the final approximation on the basis of the solution given in the question.

## Question 8

This was a moderately popular pure mathematics question, attempted by about half of the candidates. There were a number of good solutions, though the median mark was only 6.

(i) (a) Most realised that $n^2 + 1 > 0$ and deduced that $m^3 > n^3$, though few gave any sort of explanation of how $m > n$ follows from this. A number of students split into four cases depending on the signs of $m$ and $n$; this was frequently a laborious but correct approach.

The next part, requiring the expansion of $(n+1)^3$, was well answered, though few understood the significance of "if and only if": most only provided an argument for one of the two directions.

Most were able to combine the two conditions, and were also comfortable with solving quadratic inequalities.

(b) Few candidates understood the significance of the condition $n < m < n + 1$ where both $n$ and $m$ are supposed to be integers, leaving most unable to do this part. This also led them to struggle with part (ii).

(ii) Relatively few candidates understood what they were trying to do in this part. Many tried to replicate the approach given in part (i) with varying degrees of success.

There were a few concerning errors which occurred in a number of scripts. One was the arithmetic *faux pas* $\sqrt{\frac{1}{2}} = \frac{1}{4}$, the other was the belief that $\mathrm{f}(x) = \mathrm{f}(y)$ is equivalent to or implied by $\mathrm{f}'(x) = \mathrm{f}'(y)$.

Nonetheless, there were also a variety of other correct approaches, for example, some showed that $q - 2 \leqslant p \leqslant q + 2$ for all $q$, and then checked the five possible cases $p = q - 2$, etc., to ascertain all possible solutions.

## Question 9

This was the most popular Mechanics question, attempted by about 40% of the candidates. It was well-answered overall; though the median mark was only 7, over a quarter of candidates achieved 14 or more.

In attempting to find $\tan\theta$, most candidates confidently drew a sketch of the situation and correctly wrote down the equations of motion. Some did not clearly indicate the meanings of their symbols, and this sometimes led to confusion later; some used $x$ for time, which was bizarre.

The greatest stumbling block for the majority of candidates was the algebraic manipulations. Once they had reached the equation $gd_1^2/2v^2\cos^2\theta = d_1\tan\theta - d_2$, many seemed unsure how to proceed. And of those who did, a significant number were unfamiliar with the factorisation of $a^3 - b^3$, leaving them unable to complete this part despite being given the answer.

As a general rule, when using the "suvat" equations, it is worth indicating which equation is being used, and specifying the direction (horizontal or vertical) which is being considered.

A significant number of candidates did not even attempt the final part of the question (finding the range of the particle); it is unclear why this was the case.

Of those who did, many were successfully able to use their earlier work to determine the range. A number became stuck because of algebraic errors, but about 10% of attempts scored full marks.

It was also delightful to see the quadratic equation approach being successfully used at least once; there are often significantly different ways of approaching a problem in Mathematics, and this was a wonderful example.

## Question 10

This Mechanics question was attempted by about one-quarter of candidates, but it was found to be fairly difficult with almost half of candidates scoring 5 or fewer marks.

The first part of this question led to many wordy solutions which did not reach the nub of the problem. Perhaps the wording "Explain why" rather than "Show that" or "Prove that" was part of the cause of this.

Many candidates realised that no energy is lost in the bounce, but few went on to make correct deductions from this. An easy and frequent mistake was to say that both $A$ and $B$ have the same kinetic energy when they collide; this is only true if they have the same mass.

The next part begins as a standard collision question, and many candidates were very comfortable with it. Many, however, had sign errors in their conservation of momentum or equation of restitution equation, preventing any significant further progress. This was particularly frequent among those candidates who did not draw a diagram with the velocities (and their directions) before and after the collision clearly marked. Of those who did, many were able to show that at least one of the particles moved upwards after the collision. Surprisingly few were able to show that both moved upward, in spite of this being a standard type of STEP question.

As mentioned in the overview, another frequent cause of difficulty in this question was a confusion between '$M$' and '$m$'; at this level, it is crucial that students have developed a mathematical writing style which is clear and avoids such errors.

A number of candidates made good attempts to find the maximum height of $B$. Many, however, simply wrote down a series of calculations with no indication of what they were attempting to calculate. As the answer was given, full marks could only be awarded if the argument was clearly correct. It also turned out to be possible to reach the given answer through a straightforward, yet incorrect, calculation; such solutions received very few marks.

## Question 11

This question was attempted by about one-third of candidates, but was fairly poorly answered. About one-third of attempts scored 0 or 1, and the median mark was therefore only 4. Nevertheless, there were many good solutions, reaching about two-thirds of the way through, including a number of perfect scores.

An overall comment for this question is again that candidates need to explain their work. Particularly in questions where the answer is given, little credit will be given for simply writing down an equation which leads to the required answer in one step unless a justification can be seen.

For the first part of the question, most candidates drew decent diagrams, allowing them to proceed, but a fair number drew something which was either inaccurate (placing $A$ below $B$ or drawing the rod horizontally, for example), severely incomplete (no forces) or too small and scribbly to be useful. These led to subsequent difficulties when attempting to resolve forces or take moments.

About 20% of candidates stopped after drawing the diagram, gaining them either 0 or 1 (the modal score).

A number of candidates did not appreciate that the tensions in the two parts of the string were equal, and were therefore unable to proceed.

A common error seen when taking moments was something like $3d(mg) = 7d(T \sin \beta)$; this could be made to give the 'correct' answer, but received little credit. Another common error was to forget to include any forces in the moments equation.

Of those candidates who proceeded further than the diagram, most made good progress towards finding the length of the string.

A common assumption was that $\angle APB$ was a right angle, without giving any justification of this. A similar, though far less common, assertion was that $AP/PB = AG/GB$. Both of these happen to be true, but candidates are required to prove them to gain any credit for their argument.

Many different approaches were seen; the more common ones are described in the solutions above, and there were many variants of these.

When it came to finding the angle of inclination, a small number of candidates successfully did so. There were many attempts which fudged their working to reach the stated conclusion. A number stated that the angle $APB$ is bisected by the line $PG$ without giving any justification; such attempts gained few marks.

## Question 12

Generally, Statistics questions are generally the least popular on STEP papers, and this year was no exception; this question was answered by fewer than one-quarter of candidates. In spite of this (or perhaps because of it), it was one of the most successfully answered on the paper, with a median mark of 11 and an upper quartile of 16.

(i) A few candidates failed to get started and scored no marks at all, or misread the question and gave the probability of failure instead, but the majority gained full marks on this part.

(ii) Most candidates were able to enumerate the possible cases of success or the cases of failure. However, a significant proportion did not provide any justification that they had considered *all* possible cases, and so lost at least 2 marks. In part (iii), this lack led a significant number to overlook one or more cases, and so get the wrong answer.

Several candidates failed to realise that the probability of the second person having a £2 coin depends upon the first person's coin.

(iii) Those who succeeded on part (ii) generally made good progress on this part as well; see the comments above.

## Question 13

This question was attempted by around 20% of candidates, but was only counted as one of the best six questions for about three-quarters of them. Even among those, it was the most poorly answered question on the whole paper, with one-third of the attempts gaining only 0 or 1 mark, a median of 4 marks and an upper quartile of 8 marks.

(i) In this first part, many candidates did not even attempt to find $k$, and algebraic errors during the integration were common. A number of attempts to find $k$ were obviously wrong, as they gave a negative area, but candidates did not notice this.

Most were unable to integrate $x\sqrt{4-x^2}$, with failed attempts to integrate by parts far outnumbering correct integrations of this expression.

A number of candidates attempted to calculate the median rather than the mean. Other bizarre interpretations of the term "mean" were also seen.

(ii) Few candidates made it this far. Of those who did, there were some very good solutions. One of the hardest parts was getting the logic correct: the phrasing of the question as "Show that X if Y" was often misinterpreted to mean "Show that if X then Y", though the majority of the marks were awarded in such cases.

(iii) The handful of students who made it this far were generally successful at this part, too.

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