STEP 3 2012 Examiners' report

The number of candidates attempting more than six questions was, as last year, about 25%, though most of these extra attempts achieved little credit.

1. In spite of the printing error at the start of the question, two thirds of the candidates attempted this question. Most candidates earned a quarter of the marks by obtaining *z* in terms of *y* in part (i), and then went no further. Some candidates realised the significance of the first line of the question that the expression given was an exact differential, and those that did frequently then scored highly. Some candidates found their own way through having obtained *z* in terms of *y* in part (i), then making y the subject substituted back to find a second order differential equation for z, which they then solved and hence completed the solution to each part.

2. Three quarter s of the candidates attempted this question, making it the second most popular, and one of the two most successful. Generally, part (i) was successful attempted, though at times marks were dropped through insufficient explanation and quite a few struggled to deal with the "remainder term". Some candidates expanding the brackets worked with the second and third, the fourth brackets etc., only including the first bracket last. About half the candidates considered the product of all of the denominators in part (ii) and replicated the method for the first part, whilst others used the results from part (i), replacing x by x^3 and employing the factorisations of sums and differences of cubes. Full marks were not uncommon on this question, nor were half marks.

3. Two thirds of candidates attempted this question, but generally, with only moderate success earning just less than half marks. The vast majority of candidates (more than 85%) did not observe that, regardless of the case, the two parabolas "touch exactly once", dropping 4 or 5 marks immediately. However, most managed to obtain the three results in part (ii), though a few seemed to forget to derive that for *k*. Unaccountably, many threw away the final marks, only considering the case $a = 1$.

4. Just over 70% of the candidates attempted this, with marginally less success than question 3. Lots of attempts relied on manipulating series for e, and would have struggled had the first two results not been given, and even so, there were varying levels of success and conviction. This approach fell apart in the this part with the cubic term. Some candidates used a generating function method successfully with an $(x) = \sum_{n=1}^{\infty} \frac{n+1}{n!} x^n$. However, whilst this worked well for part (i), it got very nasty for part (ii). There were lots of sign errors with the log series in part (ii), having begun well with partial fractions.

5. This was only very slightly more popular than question 4, though with the same level of success. A lot of candidates scored just the first 5 marks, getting as far as completing the simplification in part (i) (b) , but then, being unable to apply it for the final result, and then making no progress with part (ii). The biggest problem was that candidates ignored the definitions given at the start of the question, most notably that "*a* and *b* are rational numbers". The other common problem was that candidates chose a simple value for θ such as $\frac{\pi}{4}$ or $\frac{\pi}{3}$ rather than for $\cos\theta$ such as $\frac{4}{5}$. In part (ii), quite frequently, candidates substituted $x = p + \sqrt{2}q$, and $y = r + \sqrt{2}s$ and some then successfully found solutions. For part (ii) (c), a method using $\cosh\theta$ and $\sinh\theta$ was not unexpected, although the comparable one with $\sec\theta$ and $\tan\theta$ was quite commonly used too.

6. Two thirds attempted this, with less success than its three predecessors. Very few indeed scored full marks, for even those that mastered the question rarely sketched the last locus correctly, putting in a non-existent cusp. Most candidates managed the first part, good ones the second part too, and only the very best the third part. Quite a few assumed the roots were complex and then used complex conjugates, with varying success. Many candidates lost marks through careless arithmetic and algebraic errors. Given that most could do the first part, it was possible for candidates to score reasonably if they took care and took real parts and imaginary parts correctly.

7. Two thirds attempted this too, with marginally greater success than question 2. Most did very well with the stem, though a few were unable to obtain a proper second order equation. Those that attempted part (i) were usually successful. The non-trivial exponential calculations in part (ii) caused problems for some making computation mistakes whilst others were totally on top of this. Part (iii) tested the candidates on two levels, interpreting the sigma notation correctly, and recognising and using the geometric series. Some managed this excellently.

8. This was the most popular question attempted by over 83% of candidates, and the third most successful with, on average, half marks being scored. Part (i) caused no problems, though some chose to obtain the result algebraically. Part (ii) was not well attempted, with a number stating the two values the expression can take but failing to do anything else or failing with the algebra. Part (iii) was generally fairly well done although frequently the details were not quite tied up fully.

9. The second least popular question attempted by only a couple of dozen candidates with very little success, less than any other question. The problem was none of the candidates appreciated how to handle the algebra to obtain the first result, even if they had obtained the equations of motion. Unfortunately, they rarely had the full set of equations of motion. As a consequence, they made no progress on the second part.

10. This was the most popular of the non-Pure questions, being attempted by about a sixth of candidates, and with more success than all but three questions on the paper. Many attempts failed to include a clear, legible, accurate diagram, and so an unclear mess of variables invariably failed to lead to satisfactory conclusions. On the other hand, the general standard of mechanics was above average, and the initial energy equation was usually correct. Many candidates came to grief with the general energy equation, confusing signs. A good number of strong candidates ploughed straight through correctly, and all who did so, then gained credit at the end for using the discriminant to demonstrate that R is non-zero.

11. This was slightly less popular than question 10, and slightly less success was achieved. Most candidates correctly evaluated the kinetic and potential energies of the particle, and the kinetic energy of the rope. However they had more difficulty finding the potential energy of the rope, and put themselves at an unnecessary disadvantage by not explaining their logic. There were different ways of splitting up the rope, which one they used they frequently failed to make clear, and likewise those calculating potential energy relative to a reference point failed to make the choice of that point clear. The second part of the question was done very well using the result given for the first part. The last part was fairly easy, but quite a few candidates did not justify the logic fully.

12. Under 9% of candidates attempted this, though the level of success was comparable with that achieved in questions 3 to 6, 10 and 11. The derivation of the pdf was, in many cases, the stumbling point whether being found directly, or via the cpf, lacking clear explanation. The expectation caused few problems. The second part reflected the first in each respect.

13. Even fewer attempted this than question 9. It was the second least successfully attempted question. Generally, part (i) was reasonably attempted although a number of attempts were very unconvincing as candidates failed to approach this as conditional probability. Hardly any got properly to grips with the second part, though some cashed in with the final variance result.