Pearson Edexcel

Examiners' Report

Principal Examiner Feedback

January 2023

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In Further Pure Mathematics (4PM1)

Paper 01R

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Introduction

It was pleasing to note that performance of candidates is now beginning to return to pre-pandemic levels with many good scripts scoring well in this paper.

Question 1

This question proved to be a difficult start for quite a few candidates. Some got no further than either rationalising the denominator or multiplying across by $\sqrt{3}+1$. Having completed the first step it was necessary to equate rational and irrational parts to form two simultaneous equations, something which a significant minority of candidates failed to do. Those candidates who realised this almost invariably went on to score full marks in this question to find that $a = 6$ and $b = 5$.
Although we allowed just one page for the working, and candidates who knew exactly how to proceed generally found the solution in just a few lines of working, some candidates filled the page with various attempts and then became confused with a plethora of crossing out and workings.

Question 2

This was a very simple trigonometry question on the application of sine rule in the ambiguous case of a triangle. Despite the question clearly stating 'find the two possible values, to one decimal place, of *x*' the majority only wrote down the one that popped up on their calculator display. There is clearly a need for firstly, a better understanding of the ambiguous case of the sine rule, and secondly, the careful reading of questions.

Reassuringly the vast majority candidates drew a useful and correct diagram to help them determine the trigonometry required and correctly found the first solution. It was quite rare in fact to see a complete solution with both angles correctly stated.

Question 3

This was another short introductory question for candidates and many tackled it with aplomb. The formula for the sum of an arithmetic series is given on the second page of the examination booklet, but we still saw occasional errors, the most common being $S_n = \frac{n}{2}\left(a+\left(n-1\right)d\right)$ which will automatically lose the first M mark and then any subsequent A marks.

Most candidates managed to find the correct three term quadratic [3TQ] equation and proceeded to solve it correctly. We are seeing an increase in the use of calculators to solve 3TQ's and a word of warning to centres is given here. If the 3TQ is correct and the correct roots are found then we will condone the lack of working and award the marks. If however, the 3TQ is incorrect and a calculator is used to find the roots of a candidates' incorrect 3TQ, we would always award the M mark for correct working seen [e.g., correct substitution into a correct formula], but in the absence of any working, we will not award the M mark. Centres will do well to advise their students to show working as a matter of course.

A significant number of candidates solved the 3TQ or used their calculator to obtain roots 17.617.. and – 10.217, thereafter obtaining the correct answer of n = 18. Some candidates did not realise that an integer value for n was required and lost the final mark by leaving the answer as 17.61….

Question 4

(a) In any question involving vectors it is important that candidates first write a vector path, in this case for example, $\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA}$ because not only will that act as an aid to candidates for further work, but importantly shows the examiner that the candidate is tackling this question correctly, and with the exception of very simple vectors, is always worth the first M mark. Most candidates here correctly identified the vector pathway and expressed vector $\overrightarrow{AB}$ in the required form in terms of p. Thereafter many did realise that a scalar parameter was required and either equated their $\overrightarrow{AB}$ directly to $\mathbf{i} - 2\mathbf{j}$ or in many cases simply left the rest of this part of the question not attempted.

Those that did not how to proceed, equated to components of **i** and **j** and went on to solve the resulting simultaneous equations for each component simultaneously, or formed a ratio using the given information $\left[\frac{5-p}{1}=\frac{7p}{-2} \Rightarrow p=-2\right]$.

(b) We allowed a follow through for both marks using the value of *p* found in part (a) to find the vector $\overrightarrow{AB}$. Many candidates scored both marks here despite using spurious methods and a value of *p* in part (a).

(c) We were fairly surprised to find that the concept of a unit vector seemed to elude so many candidates, with only a minority knowing that use of Pythagoras theorem is required subsequent to forming the unit vector. Those who knew how to proceed usually scored full marks in this part of the question.

Question 5

(a) This part of the question was generally carried out very successfully, and it was a good source of marks to virtually every candidate. It is clear that factor theorem is a well-known mathematical method.

(b) Many candidates are relying on their calculators to solve polynomial equations where only a few years ago, they would have shown us full methods. As there were two questions solving a cubic on this paper, we allowed full credit **in this case only** for a correct factorisation of the cubic seen. Centres must impress upon their candidates the need to show all working. The rubric on the front page of the paper is clear: 'Without sufficient working, correct answers may be awarded no marks'. We did not penalise use of a root finder in this question, (because candidates still had some work to do to find the factors), but we did penalise lack of working in question 8.

Those candidates who did show us their working, generally used polynomial division, or equating coefficients in roughly equal measure.

(c) It was pleasing to note how many candidates were able to conflate the cubic functions f(*x*) with h(*y*) and were able to see that *x* could be replaced with 2^y and use the factorised form of f(*x*) to obtain three equations in 2^y which they successfully solved to give $y = 0$ and

$y = -0.415$. Of those candidates who were able to solve this part of the question, just a few did not reject $2^y = -2$ and so did not receive the final mark. Less able candidates were a little surprised to find logs in a question on factor theorem, and there were many non-attempts at part (c).

Question 6

(a) The formula for quotient rule is given on page 2 of the booklet so we now insist it must be applied correctly for the M mark. Having said that, this part of the question was a good source of 3 marks for simply applying the formula without the need for simplification. We awarded the first 3 marks for $\frac{dy}{dx} = \frac{(x^2+1)2xe^{(x^2+1)} - 2xe^{(x^2+1)}}{(x^2+1)^2}$ seen. Any further erroneous simplification was ignored.

Many candidates however, then went on to quite successfully either take out a common factor of $2xe^{(x^2+1)}$ or otherwise multiply out the bracket and obtain the required answer very easily and successfully.

(b) Virtually every candidate was able to make a decent attempt at part (b) by finding a numerical value of the gradient and the value of *y*. Some candidates seem to shy away from working in terms of e and gave us approximate values which we allowed for all but the final A mark. It is not only acceptable but preferable to work with exact values in Pure Mathematics. Those candidates who used the formula $y - y_1 = m(x - x_1)$ will automatically score the M mark for merely correct substitution, whereas candidates using $y = mx + c$ will need to find the value of *c* before the M mark can be awarded.

Question 7

(a) There is very little to say here except that virtually every candidate scored this first mark.

(b) Most candidates realised that integration was required to find an expression for the distance. Not every candidate however, realised that the information given in the stem of the question was there to allow them to find the constant of integration and some lost both the M and the A marks if they failed to do that. We gave credit for substitution of $t = 5$ into a changed expression, but many candidates answered this part of the question with aplomb. It is some time since we last saw the equations for uniform motion used in these questions in this specification, but several candidates attempted this question this way.

(c) Most candidates differentiated the given v to find the acceleration of P when $t = 5$ correctly.

(d) (i) We saw some interesting attempts to answer this part of the question. Some candidates completed the square or used the discriminant, to show that there were no real solutions to the equation $v = 0$. Some used their result from part (c) set the derivative = 0 and found that the minimum velocity [3 m/s] occurred when $t = 5$.
What we did see several times was candidates using their root finder function on their calculators to achieve values of t of $5+\sqrt{3}\mathrm{i}$ and $5-\sqrt{3}\mathrm{i}$ but without any comment that the roots are not real so there is no value of t when $v = 0$. Although imaginary numbers are far beyond the syllabus of 4PM1 we always give credit for any valid mathematical methods, but in this case not one single candidate understood what they had found and therefore could not be awarded marks as there was no evidence of working.

(ii) Interestingly, a few candidates gave us an answer of $t = 5$ for the minimum velocity although the majority who were able to get this far wrote down the correct velocity of 3 m/s.

<u>Question 8</u>

(a) This part of the question was generally well done with clearly set out proofs integrating the gradient function presented, including a constant of integration, and recognising the need to show clear substitution of the given x value (-1) setting equal to 0, evaluating the constant and reaching the given equation for C.

(b) Candidates who were successful on this part showed clear algebraic division of f(x) by (x + 1) achieving a quadratic factor that they then factorised to find a and b. Candidates who reached for the factorisation / root finder function of their calculator failed to achieve the three marks specifically allocated for explicitly showing this working, or four marks if they did not even bother to write the function in its fully factorised form. Almost all gained the B mark for recognising that *c*, the *y* intercept is equal to the constant of integration already found.

(c) Most candidates then went on to integrate the function from $x = 0$ to $x = 5$ and subtract the area of the triangle or find the equation of the line *l* and integrate directly curve – line. Again it was assumed that candidates not evidencing the required algebraic integration and substitution of correct limits were assumed to have done definite integration by calculator with even correct answers not credited. The instruction in the question is quite clear – 'Use algebraic integration to find the exact area of region R'. Those failing to give an exact answer also threw away a mark needlessly.

Question 9

As is usual in questions involving 3 dimensional trigonometry, those candidates who draw careful thumbnail sketches for every part of the question are generally successful, whilst those who do not, cannot find the angles or lengths required.

(a) and (b) The vast majority of candidates found both the length *AC* and the length *x* successfully gaining four straightforward marks.

(c) There were two methods in the mark scheme. The first [which was seldom used – but yielded important angles that were also required for part (d)] and the second, which was overwhelmingly the most popular method, which involved finding the height of one of the triangular bases leading to use of $\frac{1}{2}\times\text{base}\times\text{height}$ for the area of the triangle and then adding on the area of the square base. Although the question specified an answer given to the nearest cm^2 we allowed for the final A mark the exact answer of $48\sqrt{15}+144 \quad (\text{cm})^2$ or its exact equivalent.

(d) This part confused and defeated all but the most able candidates. Had they used the slightly more involved method of solving part (c), they would have found some of the angles they needed for this part. The greatest obstacle was actually identifying the required angle. Once that was accomplished, a strategy could be formed to find the angle. In the event, we only saw a handful of correct final solutions.

Question 10

For those candidates who reached this far in the paper, many scored well on this question.

(a) and (b) Most candidates were able to use the formulae on page 2 to complete these two simple proofs. However, centres do need to remind their students, that a ‘show that’ question requires full methods shown, without which, marks cannot be awarded.

(c) Almost all candidates recognised the need to substitute the result from part b to solve the equation, but most immediately proceeded to cancel $\sin 7\theta$ form each side thereby not only losing two solutions, but also the three marks that would have flowed from setting $\sin 7\theta = 0$. Better prepared candidates knew to rearrange the equation and **factorise** finding all **four** solutions.

(d) Candidates who reached this far in the paper and this question, applied the trig identity for $\tan = \dfrac{\sin}{\cos}$, then used the identity from (b) to make the required substitution and showed clear algebraic integration of the resulting function with correct substitution of the limits given then evaluated by calculator.

It was pleasing to see that a significant minority of candidates were able to achieve a value of the integral using full and correct methods of 0.973.

Those candidates who just wrote down an integral with correct limits but no further working $\left[\int_0^{\frac{\pi}{7}} 4\left(\cos 5x - \cos 9x\right)\,\mathrm{d}x\right]$ together with a value of 0.973 scored just the M marks for correctly changing the function into a form that can be integrated, and so 3 out of 6.

We also saw some solutions $\int_0^{\frac{\pi}{7}} 8\sin 7x \sin 2x\,\mathrm{d}x = 0.973$ which scored no marks at all.

We must see working in order to be confident that we can award marks for correct methods and work seen.

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