Examiners' Report
Principal Examiner Feedback

Summer 2019

Pearson Edexcel GCE AS Mathematics
In Core Pure Mathematics 2 (9FM0/02)

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Introduction

This paper proved to be a good test of student knowledge and understanding. It discriminated well between the different ability levels. There were many accessible marks available to candidates who were confident with topics such as hyperbolic and inverse hyperbolic functions, roots of polynomials, calculus, complex numbers, second order differential equations and matrices.

Reports on Individual Questions

Question 1

Part (a) required proving the logarithmic form of $\tanh^{-1}(x)$ and it produced a mixed response. Most candidates were able to obtain an appropriate equation in exponentials but some did not appreciate the need to rearrange it, particularly those who did not introduce another variable. Those who did make $e^{2\text{"}y\text{"}}$ the subject usually did so correctly, although a few did not convert the resulting $\frac{-1-x}{x-1}$ into the required $\frac{1+x}{1-x}$. Some solved a quadratic in e^y but often got bogged down in the algebra. A small number of candidates started with the given result and verified it appropriately. A few attempted to use $\frac{\sinh^{-1}x}{\cosh^{-1}x}$ for $\tanh^{-1}(x)$. A significant number neglected to state the value of *k*. Approaches using differentiation followed by integration could not get full credit.

Part (b) was more successful for most although slips occasionally led to candidates not achieving a quadratic when the logarithms were removed. There were a surprising number of errors seen producing the correct 3TQ from $\frac{1+2x}{1-2x} = 2 - 3x$. The quadratic was almost always solved correctly, but many failed to reject the ineligible solution, despite being asked about the range of validity of $\tanh^{-1}(x)$ in part (a).

Presentation of work was an issue for many. For example, many scripts were seen where “tan” was written when “tanh” was intended.

Question 2

Question 2 involved the roots of a cubic equation and it was common to be awarding the first six marks for parts (i) and (ii). Most began their answer with the correct values for the sum, pair sum and product with sign errors being very rare. In part (i) the vast majority expressed the new sum correctly in terms of the pair sum and product and proceeded correctly. A small number thought that $\frac{2}{p}+\frac{2}{q}+\frac{2}{r}$ was equal to $\frac{2(p+q+r)}{pqr}$. The alternative of substituting $x = \frac{2}{y}$ to find the cubic in y was not common but was usually correct.

In part (ii), most were able to multiply out and obtain a usable expression. A common error was the absence of the constant –64. As with (i), the alternative was not widely seen.

Part (iii) proved very difficult since only a relatively small number of candidates were able to recall a correct identity for the sum of the cubes. Those who tried to produce one were almost always unsuccessful.

Question 3

Part (a) required an integration by substitution. Unfortunately, some candidates merely used the formula book. Those who chose an appropriate substitution, usually $x = \frac{1}{2}u$ or $x = \frac{3}{2}\sinh u$, tended to proceed correctly. The method mark was still available to those who chose a substitution that did not lead to an easily integratable form. There were very few cases where $\mathrm{d}x$ was replaced with $\frac{\mathrm{d}u}{\mathrm{d}x}\,\mathrm{d}u$ rather than $\frac{\mathrm{d}x}{\mathrm{d}u}\,\mathrm{d}u$.

In part (ii) the concept of mean value was widely known. A few errors were seen in the use of the logarithmic form of $\sinh^{-1}(x)$ but generally the two marks here were widely scored.

Question 4

In part (a), obtaining C + iS as an exponential series was widely achieved. The majority were also able to use the sum to infinity formula to obtain the given answer. A few attempted to use the ordinary sum formula for a geometric series.

Part (b) proved tough for all but the most confident candidates. Incorrect attempts included multiplying numerator and denominator by $e^{\pm 4i\theta}$, $2 + e^{-4i\theta}$ or $2 - e^{4i\theta}$ rather than the required $2 - e^{-4i\theta}$. Those who knew the correct strategy usually obtained a correct expression and invariably went on to revert to trigonometric form and reach the given answer. The alternative of converting to trigonometric form and then rationalising was successful for some but there were often slips in the multiplications and some were unable to use the correct addition formula to reach the printed answer.

Question 5

Q5 featured a model involving a second order differential equation and the latter marks in part (b) were not widely scored.

In part (a), most formed and solved the auxiliary equation correctly although occasionally m was computed as $-\frac{1}{2} \pm 6\mathrm{i}$ rather than $-\frac{1}{2} \pm 3\mathrm{i}$. The correct form of the general solution was widely seen although the "$h =$" was sometimes missing or y or x were used instead of h and t.

In part (b), most candidates were able to appropriately obtain a value for both constants. Common errors were to set $h = 20$ rather than -20 and to not use the product rule when differentiating h. Finding the maximum proved challenging and many had an incorrect strategy. A significant number of candidates attempted to apply $R\sin(3t + \alpha)$ to the trigonometric part of their h instead of their derivative, leading to answers of R or $R\mathrm{e}^{-0.5t}$. The more sensible route of using $\frac{\sin 3t}{\cos 3t}$ to get an equation in $\tan 3t$ saw more success. Those who obtained the correct equation often failed to obtain the smallest positive value of t. Some just dropped the minus sign from the calculator value of $\tan^{-1}\left(-\frac{22}{21}\right)$. A small number did not go on to obtain h for their t. Occasionally, work in degrees was seen, often producing clearly unreasonable values for $h_{\max}$.

Part (c) required candidates to comment on the suitability of the model for large values of t and this was well answered on the whole. Most deduced that h tended to zero as $t \to \infty$ and were able to make a sensible comment which was often perceptive about the mechanics of the situation. A few however, did not offer any appraisal of the model's suitability in their answer.

Question 6

Q6 required candidates to use complex roots to solve a geometric problem. It was clear that a considerable number were poorly prepared for such a task and the simplest route – to multiply 6 + 2i by the complex cube roots of unity – was not widely seen. Those who knew this method usually emerged with all six marks although a few sign slips occurred. On occasion $\omega = \frac{1}{2} \pm \frac{\sqrt{3}}{2}\mathrm{i}$ rather than $\omega = -\frac{1}{2} \pm \frac{\sqrt{3}}{2}\mathrm{i}$ was used. Matrix methods were rare but usually correct. Of the remaining candidates who made a significant attempt, most knew that they had to add $\frac{2\pi}{3}$ and $\frac{4\pi}{3}$ (or $-\frac{2\pi}{3}$) to the argument of 6 + 2i but most could only deliver a decimal answer at best. Weaker attempts included the reflection of (6, 2) in the coordinate axes.

Part (b) was often not attempted by candidates who were unable to progress in (a) although full marks were still possible if the area of triangle AOB was found and this was a reliable route. A wide range of methods were seen, although those using the coordinates of B and C often fell foul of errors handling the surds. Some candidates got into difficulty with approaches that used $\frac{1}{2} \times$ base $\times$ perpendicular height rather than $\frac{1}{2}ab\sin C$.

Question 7

This matrix question also saw a wide range in the quality of response. In part (a) it was surprising to see a significant number of slips in obtaining an expression for the determinant. Most obtained an expression for det **M** conventionally although a few used the rule of Sarrus

– usually correctly. A small number gave their answer as “$k = 5$” but the question required the values of k for which $\mathbf{M}$ had an inverse and not the value of k for which $\mathbf{M}$ was singular.

Part (b) required the point of intersection of three planes to be found and the most successful candidates used Way 1. It is acceptable to obtain an inverse of a matrix with no variables as elements using a calculator and it was unfortunate to see some embarking upon a step-by-step method. This often led to errors such as omitting the $\frac{1}{\det \mathbf{M}}$ multiplier. The correct inverse was seen fairly widely and the subsequent matrix multiplication was also often correct. This specification has an assessment objective for the use of correct notation so the point of intersection had to be given as coordinates. Those who chose to solve the system of equations were much less successful, with many unable to obtain x, y and z in terms of p (including a small number who attempted to find a value for p).

Those who did not make any progress in (b) often left (c) unanswered but this part was still a reasonable source of marks for many. In part (i), correct strategies to obtain a value of q were common and although slips were evident, the correct $q = 3$ was often achieved. Weaker attempts tried to use an inverse, even with candidates who had scored both marks in (a). Part (ii) required a geometric interpretation of the solution to the equations. Some neglected to mention “planes”. A few candidates did this successfully with a diagram. The unfortunate misspelling of “sheaf” was condoned!

Question 8

The last question challenged many, but there were a lot of accessible marks here, although a fully correct solution to part (d) was rarely seen.

In part (a), most were able to use the model with $x = 1$ and $y = 0$ to find k correctly. candidates were slightly less successful in part (b) however, with a few unable to recognise the need to use the 1.18 given beside the model equation for curve BD. A small number left their answer as a natural logarithm.

Most knew that a volume of revolution was required in part (c) although some omitted the π from the formula (or had 2π) or they attempted $\int y^2 \mathrm{d}x$ rather than $\int x^2 \mathrm{d}y$. Most made x the subject of the formula correctly although slips were seen in squaring, including failing to find a middle term or not squaring the denominator in their single fraction expression for x. Integration was commonly successful although a significant number neglected to substitute the zero limit. Use of the answer to part (b) as the upper limit was occasionally seen.

Part (d) proved discriminating although most who made an attempt recognised that the chain rule could be deployed and for the most part it was used correctly. Weaker attempts tended to involve calculating V and then attempting to adjust its value. Many otherwise successful candidates were unable to correctly manage the different units used in the question. A very small number of exceptional candidates were able to deduce that the rate of change of h with respect to time was proportional to the circular surface area of the pool and correctly proceeded without any need for calculus.

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