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GCE Further Pure Mathematics FP3 (6669) Paper 1

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General

This paper proved accessible to the candidates. The questions differentiated well, with most giving rise to a good spread of marks. All questions contained marks available to the E grade candidate and there also seemed to be sufficient material to challenge the A grade candidates.

Generally the standard of presentation was not good and handwriting was hard to read. The examiners saw a lot of careless or unclear notation and occasionally almost impenetrable handwriting. With careless writing hyperbolic functions can easily became trigonometric functions and vice versa and there were a number of transcription errors seen, caused by candidates misreading their own handwriting, with minus signs in particular being missed.

Those candidates who simplified as they went in question 8 were more successful than those who tried to manage long complicated expressions. Communication was also an issue, candidates did calculations without saying what they were finding, and this was particularly bad in question 6. Poor presentation cost some candidates marks that they probably would have been quite capable of achieving.

Report on individual questions

Question 1

This question, which was succinctly and accurately answered by the better candidates, proved to be a very challenging opening question for many candidates, who were unable to effectively progress beyond substituting in the appropriate formula. Just under 50% of the candidates scored at least 4 marks out of 5 for this question with 41% scoring below 2.Surprisingly some candidates were let down right at the start by differentiating $2x^3$ incorrectly, or for not squaring their result when substituting in the formula for the surface area. It was disappointing at this level to see the number of candidates who did not recognise that $\int 2x^3 \sqrt{1+36x^4}\,\mathrm{d}x$ is of the form $k(1+36^4)^{\frac{3}{2}}$. The majority of candidates who did spot this often went on to be successful, although some did have difficulty in finding the correct value for k.

The most common unsuccessful strategy for integrating was to attempt to integrate by parts, and although the use of a substitution was sometimes successful it often proved fruitless, and in both approaches there was a feeling that often candidates had spent a disproportionate amount of time on this question, with only one mark to show for it.

A small number of weaker candidates changed $\int 2x^3\ \sqrt{1+36x^4}\ \mathrm{d}x$ to $\int \sqrt{x^6+36x^{10}}\ \mathrm{d}x$, which presented an interesting challenge, sometimes "solved" by conveniently "forgetting" the square root sign. Others stated that '$\sqrt{(1 + 36x^4)} = 1 + 6x^2$'

Question 2

This question was well answered by most candidates with 47% scoring full marks and only 8.8% gaining fewer than 3 marks.

In part (a) the vast majority of the candidates were able to use the product rule correctly. Some candidates when evaluating the exact value in the second part of (a) did not have their calculator in radian mode and gave 30 as part of their answer rather than the required $\frac{\pi}{6}$. Others confused arcsin with arcsinh and so had logs in their answers. Others confused arc sin with cosec

In part (b), many, although disappointingly not all, of the candidates were able to apply the Chain rule to obtain $\frac{\mathrm{d}y}{\mathrm{d}x}$ in terms of e^{2x} and e^{4x} although on a number of occasions, the initial function was written in the form tan $y = 3\mathrm{e}^{2x}$ and implicit differentiation subsequently used. Many candidates then went directly to the hyperbolic form. Most though then started with the given expression in hyperbolic form and turned it into the exponential form. Some however never mentioned the hyperbolic form in their solution, and others did not relate the two forms to each other even in a simplistic way. A few alternative approaches tended not to get far, for example writing cosh $2x$ and sinh $2x$ in terms of e^x not e^{2x}, or getting just a cosh or sinh term.

Question 3

This was probably the most accessible question on the paper with over 75% of the candidates gaining full marks and only just under 15% failing to get at least 7 marks. It was done consistently well and it was clear from the scripts that candidates were usually comfortable with these integrations and the work flowed well with little crossing out.

Almost all candidates were able to write the quadratic in the form $(x - 5)^2 + 9$ and went on to quote the correct arctan or arcsinh functions often in terms of x; however, many substituted $(x - 5) = u$ first. Errors, when they did occur, usually resulted from not applying the change of limits correctly, or having the wrong value of k in k arctan$\left(\frac{x-5}{3}\right)$ but errors from weaker candidates included writing $\frac{1}{(x-5)^2+9}$ as $\frac{1}{(x-5)^2}+\frac{1}{9}$, or writing the given integrals as $\int (x^2-10x+34)^{-1}dx$ and $\int (x^2-10x+34)^{-\frac{1}{2}}dx$ respectively and trying to find a purely algebraic result.

In part (b) the quickest way was to use arcsinhu between limits 0 and 1 leading to arcsinh 1 = ln (1 + √2). There were sometimes errors in selecting the correct ln form for arsinh $\left(\frac{x-5}{3}\right)$ or arsinh $\frac{u}{3}$, and those who used the ln form with limits 3 and 8 to give ln (3 + √18) – ln 3 sometimes made errors in simplifying, but generally it was successfully managed.

Question 4

This question was well answered by the majority with 64% gaining at least 7 marks out of 8 and just under 12% getting fewer than 4 marks.

The first part of this question was well answered with the vast majority of candidates realising that integration by parts was required and using the correct functions for u and $\frac{dv}{dx}$. The most frequent error seen was the omission of $\frac{1}{x}$ from the differential of $(\ln x)^n$. When candidates are asked to prove a printed result they must make the steps clear. A number of candidates did not make their use of limits clear. Many candidates were very careless about omitting dx at the end of some of their integrals, which was penalised. In a few cases it was difficult for examiners to distinguish between In and I_n.

In part (b) of the question, a significant number of candidates did not realise that an evaluation of either I_0 or I_1 was required to evaluate I_3 and thought that use of only the recurrence formula would produce the desired result. Consequently I_{-1} was seen with some regularity with most candidates assuming that it had a value of zero. Others simply incorrectly declared that $I_0 = 0$ or $\frac{e}{3}$ without doing any integration. Those who started by working out I_0 right at the start of part (b) certainly helped themselves.

Those candidates who worked methodically by evaluating one integral at a time generally did better than those who wrote the entire expression as a set of nested brackets and tried to obtain the answer in one line. Many of those who attempted the latter method tended to make errors when removing their brackets and lost the final mark.

Question 5

This was a well-answered question in general with 34% of the candidates gaining full marks and just over 9% fewer than 4 marks.

In part (a) of the 2 graphs required to be sketched, $y = 3 \sinh 2x$ was drawn best. Occasionally a cosh graph was given and very occasionally the curvature was incorrect but this mark was usually gained. The exponential curve was less well drawn; in transforming e^x, candidates seemed to miss the reflection and showed exponential curves decreasing from second to first or fourth quadrants and flattening off. The mark most often not gained was for the asymptote; the *equation* of the asymptote was asked for and so just marking 13 on the y-axis was not sufficient, and some candidates lost the mark for including other asymptotes. Sometimes the values of the two intercepts were correctly found in the script but wrongly attached to the graph..
Part (b) was very well answered. The majority of candidates knew what to do and while some made basic algebraic errors with signs or constants most successfully arrived at the correct quadratic in e^{2x}. Most then solved correctly for x, rejecting or ignoring the root $-\frac{1}{9}$, although a small number of candidates gave 2 answers, thus losing the final mark.

Question 6

This question proved very discriminating with a good spread of marks, although good work was still frequently seen with 33% of the candidates gaining at least 9 marks out of 10 and 27% full marks, only 25% of the candidates gained fewer than 3 marks.

In part (a) the vast majority of candidates used the correct method to find the direction of the normal to the plane and found the desired answer although those candidates who made an arithmetical slip, even with some follow through in later parts of the question, paid a heavy price for their carelessness. Candidates would be well advised to pay more attention to accuracy, and take more care with their presentation in questions such as this so that they can avoid misreading their own handwriting and making transcription and sign errors .

In part (b) most candidates used the scalar product to obtain their answer although a small minority used the modulus of the vector product. Examiners remarked on the reluctance of candidates to draw clear diagrams in this question and the poor presentation of work of a significant number of them. There were many who just tried to find the scalar product of1i +3j+3k and 3i+1j+2k. Those who chose the correct vectors of which to find the scalar product often got the correct answer although some forgot that they needed the complimentary angle for α. Many candidates did not make their method clear just leaving a disordered collection of vector and scalar products for the examiner to try to make sense of.

In part (c) all of the methods outlined in the mark scheme were seen regularly. The most popular method was to find the distances from the origin to the plane P and the origin to the plane through A parallel to P and deducing the required result from these. Some candidates did part (c) before part (b), then used their answer from (c) to deduce the answer in (b). Once again a diagram would have helped many candidates in showing them they could use basic right angled triangle trigonometry here.

Question 7

This also proved a good discriminator and gave rise to a good spread of marks. Only 16% of the candidates gained full marks (the first time on the paper that the modal mark was not full marks, it was 7 out of 12) and 9.5% gained fewer than 4 marks.

Parts (a) and (b) proved very accessible to almost all of the candidates. In part (a) almost all candidates chose to use the top row of the matrix to find the determinant. In (b) the procedure of finding a matrix of minors, a matrix of cofactors and then transposing and dividing by the determinant was well known and well executed. Many candidates were successful in finding $\mathbf{M}^{-1}$ correctly but there were inevitably errors for some. A few lost the first method mark for incorrectly finding the matrix of minors by multiplying each 2×2 determinant by its element in $\mathbf{M}$.

Part (c) proved to be much less accessible. The most common approach was to attempt to use the inverse matrix with a general point on l_2. Although this was successfully completed by many candidates, rewriting the vector equation of l_2 in parametric form was a severe stumbling block for a significant number; some candidates were clearly less conversant with a line given in the form $(\mathbf{r} - \mathbf{a}) \times \mathbf{b} = 0$. Those who did use the parametric form rarely scored all 5 marks even if their inverse matrix was correct, often making numerical or sign errors or not expressing the answer in the required form

$\mathbf{r} = \mathbf{a} + \lambda\mathbf{b}$ or $(\mathbf{r} - \mathbf{a}) \times \mathbf{b} = 0$; common errors were to express the equation of the line as $l_1 = \mathbf{a} + \lambda\mathbf{b}$, or omit the zero from the vector product form. The same comments apply to those candidates who chose to use a line to line method by transforming two 3×1 matrices or a 3×2 matrix, without needing to use a parametric form. Those who chose to use $\mathbf{M} \times [x, y, z]^T = [(4 + 4\lambda), (1 + \lambda), (7 + 3\lambda)]^T$ did not usually complete, although there were a few successful outcomes.

Question 8

Once again this was a good discriminator giving rise to a good spread of marks. Only just over 8% of the candidates gained full marks and just under 10% gained fewer than 4 marks. The modal mark was 6 marks out of 14. Some candidates lacked the algebraic skills needed to manipulate the equations and coordinates.

Parts (a) and (b) were well answered by a large majority of candidates. In part (a), most candidates used the parametric form to find the gradient of the tangent and then substituted correctly into the equation for a tangent. The only mark that was occasionally lost was in not emphasising that $\cosh^2\theta - \sinh^2\theta = 1$. When the answer is given, candidates should be advised to be specific with their reasons for their working.

The vast majority of the candidates realised in part (b) that they had to substitute $y = 0$ into the equation of the tangent to find x. A surprising number having got $x \cosh\theta = a$ then got $x = a$ arccosh θ

The problems started in part (c) with a large number of candidates not realising that the equation of l_2 was $x = a$. Again examiners felt that a good diagram would have been a major benefit to candidates.

In part (d) it was disappointing to see a significant number of candidates *subtracting* rather than *adding* the two x-values before dividing by two to get the coordinates of the midpoint. Most candidates had abandoned the question by this stage and only the very best candidates were able to verify the final answer. The most popular method was to substitute into the left hand side of the given equation and attempt to simplify to get the right hand side. Those who started with a trig identity were less successful in general. Those who simplified as they went increased their chance of success.

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