Pearson Edexcel

Examiners' Report

Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE

AL Further Mathematics (9FM0)

Paper 3A Further Pure Mathematics 1

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Overall, there was good access into all of the questions, with little evidence that candidates ran out of time as even question 9 was well answered. All question had a modal score of full marks achieved by at least 35% of candidates except for question 7, with 30% achieving full marks.

The paper gave opportunities for good candidates to flourish while giving access to lower grade candidates in each question to score marks. Algebraic skills were generally good throughout, with the methods required being well demonstrated by the majority.

Question 1

With 70% scoring full marks and a mean score of over 6/7, this was the easily the most accessible question of the paper, so well placed at question 1. A good start for high and low grade candidates alike to ease in to the paper on a familiar and expected topic.

In part (a) the vast majority of candidates were able to use the correct formula to find a value for e_1 or e_1^2, however it was not unknown to see a and b substituted the wrong way round in instances where errors were made, and occasionally candidates forgot to square either a or b. One the equation was set up they usually successfully proceeded using $e_1 \times e_2 = 1$ to set up an equation in a and b, although not always in the most efficient manner. Common errors included using $b^2 = a^2 (1 - e^2)$ for both the ellipse and hyperbola and simple slips with fractions and roots. Despite being in the Formula Booklet a few candidates used incorrect equations.

Again in part (b) most all candidates started well by successfully finding the focus of the ellipse, but after this success rates varied with maybe a mark or two dropped. A common error was to assume a was the same value for the hyperbola as the ellipse. Others did not see how to proceed and made little progress. Candidates who clearly wrote out what they were doing (thereby demonstrated clear thinking) most usually arrived at the equation of the hyperbola with ease. Many found b before a by solving simultaneous equations, failing to spot the much easier method of using the foci coordinates with their eccentricity from (a).

Question 2

While this question proved accessible for the majority of candidates it was less well done than question 1, or even questions 4 and 6, which proved more accessible. The likely reason for this is the context of the modelling, which led to some confusion with the date at the end, and many did not achieve the final 3 marks. However, the modal score was full marks and achieved by 45% of candidates with just under 30% achieving 6/7, and 10% achieving 4/7 the next most common scores.

In part (a) most were able to demonstrate a suitable substitution to arrive at the correct answer with a suitable step shown. Indeed, most did show a value correct to more than 3 significant figures to exemplify the calculation had been made.

Part (b) was also well attempted by most, with the correct formulae identified and used by the vast majority. Common errors were mainly poor algebraic manipulation leading to an incorrect result, with incorrect half angle formulae being used only rarely seen.

Part (c) was the real differentiator with most able to access the first mark using the 'hence', utilising the part (b) of the question, with less success at proceeding from there to a correct answer. Some candidates appeared to be confused between the variables, for example it was common among the incorrect responses to see $t = 1.05$ which was then interpreted as the number of days, forgetting to undo the substitution. Such responses were unable to access the final three marks. The value awrt 97 (usually 97.25 was seen) was found by many but not all were able to convert this into a correct date, either omitting the date entirely or by saying the wrong month (March was popular) or day. For those who solved to find a value of t, it was common to see 'counting' days in each month, but it was very surprising to see how many did not know how many days were in each month, and some appeared were unsure whether 2029 was a leap year. It was also rare to see incorrect values due to calculators being in degrees rather than radians, which is good to note students take care of the mode.

Question 3

Vectors is never a popular topic, and with only 35% achieving the modal full marks, this question proved less accessible than its position on the paper suggests it should be, with better access for questions 4 and 6 (the other vector question) being seen. Scores of 7 and 8 were also common, with a more even spread across other marks. In many cases one or two errors were made, but the parts they were made in varied a lot.

Part (a) perhaps caused the greatest difficulty, with a number of candidates unsure of which vectors to use. The magnitude of OB was usually found correctly and though most candidates could then form a correct equation from the information given, there were many who did not set up a suitable equation, instead attempting the scalar product of $\overrightarrow{OB}$ with $\overrightarrow{OA}$. The most common accuracy error involved candidates failing to find the negative solution when square rooting. The value of cos 45° was sometimes incorrectly evaluated and mistakes were common in the manipulation of the equation to arrive at a value for p.

For part (b) most of candidates attempted $\overrightarrow{OB} \times \overrightarrow{OA}$ and the majority were successful, with occasional sign slips in the **j** term. However, the rest of this part was the less well done, with an argument that this was the most challenging part. All 3 methods described in the scheme were seen, the most common being setting the vector product equal to a multiple of the parallel vector. Many wrong answers were seen this part, for example some candidates incorrectly equated to zero the dot product of $\overrightarrow{OB} \times \overrightarrow{OA}$ with the given vector, and not all candidates narrowed down their answer to be only p=3, failing to reject values of p that did not hold for all three equations.

Part (c) was usually very well answered by all candidates who attempted it, with the vast majority achieving full marks, and it was easily the best answered part of this question. Slips in the vector product (as described above) or in simplifying to the 3 term quadratic were the most common errors, but the method required was shown by most, via the main scheme. The alternatively, long winded method was attempted by a few, but usually did not reach a solution.

Question 4

The second most successfully answered question on the paper, with full marks achieved by nearly two thirds of candidates, and 85% achieving at least 6/7. The next most common score was zero marks, scored by 7%, perhaps not entirely surprising in that if the method is not familiar, little progress was likely, and the question was left blank (even though the single mark in (b) could have been gained independently of (a)).

Most candidates were able to achieve full marks in part (a) from a correct interpretation of the given formulae, though occasional slips were made during the second iteration. Common errors here were in basic numerical slips such as $10 \times 0.5 = 20$. Some candidates set out working well using a table to show their evaluated values. However, working should still be shown as an error would have meant that they would lose method marks. One major error sometimes made in those who scored few marks was failing to realise $h = 0.5$ (usually using 1 instead) though this was rare. Some mistakes arose from confusion between v and $\frac{\mathrm{d}v}{\mathrm{d}t}$ when substituting in values to find the final velocity.

Most realised in part (b) that the constant 10 needed to be reduced, though overall the attempts varied in success a lot more than in part (a). Some candidates lost marks here by not being specific enough or too vague in their response. Others tried to manipulate the v^2 coefficient instead of the constant changing the -0.1 to -0.05 or -0.01, forgetting that the initial velocity was zero. The most successful responses here were the ones which gave a specific example to highlight their explanation, the most common being changing the constant from 10 to 9.8, though any number less than 10 but greater than 0 was acceptable, and a variety of values were seen.

Question 5

There was a much more mixed response to this question than the other questions on the paper, with 40% scoring the modal full marks, but scores of 3, 5 7 and 8 also very common. The 5% scoring no marks was also higher than all except the 7% in question 4.

It was clear in part (a) that candidates were very well versed in this kind of ‘bookwork’ question, with this part being mostly very well answered. A variety of successful approaches were taken to finding the gradient, either using implicit or parametric differentiation. The most common approach was parametric differentiation followed by use of $y - y_1 = m(x - x_1)$. Using $y = mx + c$ to find the equation often led to more problems with simplification.

In part (b) candidates usually scored either both marks or neither. Many employed the same approach as in part (a) and they tended to be successful, while some very astute candidates noticed they could substitute t for $2t$ in their answer for part (a) and again were successful. The incorrect approaches usually assumed the gradient was the same as in part (a) leading to no marks in (b). In general, students who had an incorrect answer for (b) usually made little progress with part (c) if any.

Part (c) proved to be a test of competence in basic algebra. There were a significant number of candidates who found solving this pair of simultaneous equations a challenge. However, many students correctly solved their simultaneous equations from (a) and (b) to find x and y in terms of t but not all then went on to show that this represented a rectangular hyperbola by multiplying the x and y together to reach a constant. Some argued that the parametric form was enough to show that the locus was a rectangular hyperbola, but this did not achieve full marks. Some also lost marks for referring to the resulting Cartesian equation as a ‘hyperbola’ rather than ‘rectangular hyperbola’. Solutions which earned full marks were able to briefly state the point of their mathematical working into appropriate words such as “hence the form of a rectangular hyperbola”.

Question 6

Despite vectors being a topic many find difficult, this proved to be a very accessible question on the topic. Over 60% were able to attain full marks, 95% scored at least two marks, and the mean mark was 5/6, overall being the third most accessible question of the paper. The position of the two vector questions on the paper would have been better interchanged.

It was rare to see an incorrect answer to part (a) with incorrect responses usually due to numerical errors when calculating the directions (a sign error/miscopy was relatively common), or mixing up the point vector and the direction vectors of the two vectors on the plane.

In part (b) both approaches shown in the scheme were commonly seen, though the main version was the more popular. The most common error in this approach was to set the x coordinate equal to 1 and attempt to solve this with one of the other equations, losing the last three marks. Slips in solving the correct equations were uncommon, but did occur. Another error made by some candidates who used the main method on the scheme there was to assume that $x = 0$ at the intersection point with the x – axis and obtain awkward equations to solve.

Of the candidates who used the alternative method, most were able to find the normal vector and transform the plane into either Cartesian or dot product form, with a successful substitution of $y = z = 0$ to follow. Of the candidates who used this method, calculation errors or using $x = 0$ were the most common reasons for failing to get to the correct point of intersection.

It is worth noting many answers to part (b) were expressed as a column vector as opposed to the requested coordinates though this was condoned. An appreciation of the difference between vectors and coordinates is not well understood.

Question 7

This proved to be the most challenging question on the paper with less than 30% obtaining full marks, though this was still the modal score. The mean 5.85 out of 8 was proportionally the lowest for all questions, though most did score at least 2 marks, for work in part (b). There was a good spread of marks from 2 to 8 making it a good discriminating question.

In part (a) the majority of candidates did considered the discriminant of the relevant equation $8-x^2=mx+c$, albeit in many cases through trying both cases, though some tried to force the result from an incorrect equation, either using $x^2-8=mx+c$ or $x^2+8=mx+c$. Both those who started with the correct equation and those considering both cases were very usually successful and in the latter case were permitted the marks.

Part (b) proved to be accessible as equations needed were given in the question, so it was a case of solving the given equation with $c = 3m$. The values of m and c were usually easily found, but many candidates left their answer with 2 possible values for each of them, not realising the relevance of the second pair of values. A minority selected the wrong values, but many selected the correct values, some with very long demonstrations as to why. The visualisation of the problem was not good.

Part (c) of the question caused the most problem to candidates, either because they were working with 2 possible values for both m and c or because they forgot to solve both equations. Many candidates who correctly found the critical values then missed out on the final A1, either because they did not include $x = -2$ in their answer or because they did not include the boundaries in their inequalities. Those who ended up solving four equations and finding 6 critical values could only access the first mark. On the other hand, there were many candidates who only solved one equation and consequently missed the third critical value, who scored no marks for this part.

Question 8

Over half of the candidates were able to score full marks for this question, by far the most common score. The rest generally scored in the range 4-8 marks, with only 5% scoring fewer than this.
Part (i)(a) of this question was very generously given 4 marks and most candidates were able to obtain all of them with careful work showing their first and second derivatives evaluated at $x = 1$. Some candidates did not show f(1) and others substituted values directly into their Taylor's series formula, which is risky strategy if errors are made when dong this as they may lose method marks if incorrect.

Part (i)(b) also saw many successful attempts, though some candidates were careless with details for a "show" question and should be reminded to show every stage in their working. The most common mistake was not simplifying both terms correctly, but only cancelling the first term, while some lost the factor $\frac{1}{2}$ in the second term. Also, candidates need to note that "hence prove that" means the previous result in (a) must be used, but some did not see (or ignored) the "hence" in the question and tried to use L'Hopitals rule with the original function to prove the limit, scoring no marks.

Part (ii) was more of a differentiator, with finding a relevant indeterminate form elusive to some. However, many candidates did succeed in writing the given expression in a relevant indeterminate form and then attempting the differentiation. Though many were successful in this, some arrived at the "correct" answer via incorrect differentiation and this led to the loss of the final two marks. Some candidates persisted in differentiating the original denominator given in the question, and did not arrive at a limit, while others tried taking the "$x + 3$" into the numerator, so did not achieve a relevant form. A few mistook cosec as the reciprocal of cosine.

The most successful strategy here was to rewrite in terms of sine and cosine functions, and some candidates diligently checked that the form evaluated to a quotient of zeroes. The sine and tangent approach was also common, but was more prone to error in the differentiation, usually losing the "6".

There were some excellent answers, with many candidates showing fluency with L'Hopital's rule and appropriate rules of differentiation.

Question 9

Just under 50% achieved the modal full mark score for this question, which proved to be routine to many, though a substantial amount forgot to undo the substitution at the end of (b). The second most common mark 11/13, usually for the reason cited, though in some cases two accuracy marks were lost due to a slip in either the complementary function or particular integral. The 5% scoring no marks in this case was partially due to being the last question, and so a stretch for some to proceed this deep into the paper, with a few blank responses noted for this question.

In part (a) it was clear that most candidates had a good knowledge of how to find the relevant derivatives, and the correct equation was reached by nearly all candidates that attempted this question, although slips in working did occur in some cases. A few were unable to obtain a correct first derivative and usually these made little relevant progress in this part.

For part (b), candidates seemed very comfortable solving this type of non-homogenous differential equation. The first 6 marks were achieved very frequently, with the most common errors here involving coefficient slips or errors in writing the auxiliary equation. The auxiliary equation was usually correctly formed and solved, leading to a correct complementary function. A common mistake, however, was an forming $m^2 + 16m = 0$ for the auxiliary equation, the missing middle term confusing some and losing the first two marks. Such errors were not fatal as the next 5 marks were all still available following this. Most candidates successfully selected a suitable particular integral and found values for λ and μ, leading to a correct particular integral, though $3\sin 2t$ was a fairly common error following correct work up to the point of stating the integral. Errors usually arose from mistakes in manipulation, leading to incorrect values and hence an incorrect PI. The last two marks were more elusive, with many candidates failing to write the general solution using the original variable, x. Those who did not even identify the preceding equation as being for y also lost the A1ft mark, but this was rare.

Overall this topic proves a good source of marks for all grades, and was well approached, with some very good solutions seen.