Examiners’ Report

Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCE

In AS Mathematics (8MA0)

Paper 01 Pure Mathematics

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Report on AS Pure Mathematics (8MA0 01) – June 2023

General Comments

Overall, this was a varied paper of an appropriate standard that gave candidates a good opportunity to show what they knew and understood. The strongest candidates were given the opportunity to demonstrate their understanding, while the less confident candidates were able to score a reasonable number of marks. There were very few blank responses to questions and candidates demonstrated a greater awareness of the requirements of "show that" questions. Generally, centres had prepared their candidates well for modelling questions, as well as those that required an explanation, such as questions 3(b) and 7. There is still a need for greater understanding of when candidates need to show full working as evidenced by a reliance on using calculators to solve quadratic and cubic equations despite the warnings that candidates should now be familiar with. Examples of this included questions 2, 9 and 15(b). Question 8 proved to be unfamiliar to candidates, with the majority unable to find the equation of the quadratic or demonstrate the correct way to express a region using inequalities.

Question 1

This question was a friendly and well-attempted start to the paper. Most candidates were able to score a high proportion of the marks available here.

In part (a), most candidates scored both marks for a correct differentiation. Occasionally a persisting '$+5$' or an introduced '$+c$' led to the loss of a mark here. The most common error, however, arose in the coefficients of x^2 or x: with the fractional coefficients causing something of a challenge to some candidates. It was rare that attempts to integrate were seen.

In part (b), a significant minority of candidates were unclear on the correct way to identify the correct critical values and, as a result, some attempted to solve $\frac{d^2y}{dx^2}=0$ in pursuit of a 'critical value'. Perhaps because the question had asked where y was decreasing, an occasional misconception led candidates to find y values corresponding to the x values resulting from $\frac{dy}{dx}=0$ followed by an attempt to use these y coordinates to define a range rather than using the values of x.

Nonetheless, most candidates recognised the need to set $\frac{dy}{dx}=0$ to find the turning points of the curve and most were able to solve the three-term-quadratic set equal to zero. Commonly, the use of calculators was apparent. But many others took an algebraic approach with sometimes mixed results. Factorisation was the most successful of these, with errors mainly occurring with the signs within the linear factors. The quadratic formula was sometimes inaccurately applied and omissions of the – sign in front of 'b' in the numerator, or the use of '$2ac$' in the denominator, caused issues and the resulting loss of the M mark. Completing the square was seen but it seemed to be a fairly unreliable approach for the candidates that chose to use it. A significant minority of candidates did not write down their critical values clearly, instead confining them to being labelled only on a graph of the $\frac{dy}{dx}$ curve.

A significant number of candidates who had found critical values appeared to believe that stating them was sufficient to define the required range, or perhaps they were unable to make further progress in stating the range and so stopped short by simply stating the two values of x. Those candidates who did realise, however, that an interval needed more careful definition, usually did so correctly. This was most often achieved using standard inequality notation. The most successful candidates were those who drew a sketch of the quadratic to accompany their determination of the range for x, but some candidates determined $\frac{d^2y}{dx^2}$ as a means to identifying the correct region. A minority of candidates lost a mark for inconsistent use of inequalities by mixing, for example, $<$ and $\leq$ in their statement of the range. Only a relatively small proportion of candidates defined the outside region; a small number of whom wrote non-sensical inequalities such as $-\frac{1}{2} > x > 4$. Answers such as $x < -\frac{1}{2}, x < 4$ were also not uncommon. The use of set notation tended to be more problematic for those that used it as there was sometimes some confusion between the union and the intersection symbols.

Question 2

This question was generally not particularly well answered, especially as it appeared early in the paper, with the majority scoring two or fewer marks out of the available four marks.

The majority of candidates identified that a quadratic equation needed to be solved to progress, although some struggled to reach a suitable equation. It was notable that significant proportion of candidates ignored the question's requirement to show all stages of their work, directly solving their quadratic in u with their calculator. They immediately, therefore, forfeited the first two marks which required candidates to demonstrate that they can solve a quadratic without reliance on a calculator. Those who did show their method and attempted to factorise, generally did so successfully and reached solutions in terms of u. Another common error, however, was then to forget to square their values of u so they did not reach values of x. Furthermore, candidates very often also did not reject the invalid $x = \frac{25}{4}$, which resulted from $\sqrt{x} = -\frac{5}{2}$, so that the majority of candidates did not score the final mark.

While factorising was by far the most common approach to solve the quadratic, other approaches included use of completing the square or the quadratic formula, and a very few squared the original equation and attempted to solve $36x^2 - 289x + 400 = 0$.

Question 3

Part (a) of this question required the use of the cosine rule in combinations with bearings. The vast majority of candidates recognised the need to use the cosine rule, but were unsuccessful in labelling their diagram correctly, usually labelling the 72 or the 39 in the wrong place. This resulted in an incorrect attempt at applying the cosine rule and limited them to the method mark in part (a). A small proportion of candidates attempted to use the sine rule or Pythagoras, which were ultimately invalid approaches, but a further small proportion attempted this part using a vector approach with a good success rate.

Part (b) was generally well answered, with the most common, concise, explanation referring to it being unlikely that the engineer would be able to travel in a perfect straight line (either because of obstacles or because the road would not be straight). Other successful responses included challenging the assumption that the base of the masts was on the same horizontal plane. For those who did not score the mark, it was often because they were talking about the numbers being rounded or the bearings being inexact. Some candidates focused on speed and having to stop, i.e., referring to time rather than distance and appeared to misunderstand the requirement of the question.

Question 4

In part (a), most candidates appeared to know what the reciprocal graph should look like, and the majority positioned it in the correct quadrants. There were a few, though in the minority, who only sketched the section of the graph in the first quadrant. Some candidates actually worked out values and plotted the graph. Often the two asymptotes appeared to be quite adrift of the two axes and occasionally the ends of the curves drifted away from the axes, but it was usually apparent what the candidate's intention was.

There were many candidates who ignored the blank space and sketched their graphs on the lined page.

In part (b), most candidates only scored 1 mark out of 3 as they did not consider the section of the graph where x was negative. Those who sketched the line $y = 2$ on the graph were far more likely to identify the region $x < 0$, although this was often given as $x \leq 0$ despite the curve being undefined at $x = 0$. As such, fully correct answers were few and far between.

Question 5

Most candidates recognised the need and were able to solve the equation $4x^2 + 3 = 23$ to determine the upper limit, $x = \sqrt{5}$, although some candidates did not use the diagram to discard the $x = -\sqrt{5}$ and ended up integrating between the incorrect limits. It was also very common to see the limits 3 and 23 being used, with these candidates unclear about the area that is found through an integration strategy.

The most successful strategy for finding the area under the curve was through finding $\int_0^{\sqrt{5}} \left(4x^2 + 3\right) \mathrm{d}x$ and then subtracting that from the area of the rectangle. However, there were plenty of candidates that failed to subtract the area under the curve $\frac{29\sqrt{5}}{3}$ from the rectangle, and these candidates generally scored 3 marks out of 5.

Those candidates that elected to find the difference between the curve function and the line $y = 23$ and then integrated their expression were more likely to have slips in their working: some failed to subtract correctly, resulting in $\int_0^{\sqrt{5}} \left(23 - 4x^2 + 3\right) \mathrm{d}x$; while others subtracted the wrong way round, leading to a negative answer that some failed to recover to a positive answer. However, in both cases, once the integrand was determined, the majority of candidates using this strategy were able to achieve method mark for being able to perform integration of at least a term in the integrand.

There were very few candidates that tried to integrate the function bounded by the y-axis and those that did were generally unsuccessful: often their rearrangement to make x the subject was poorly done and in these cases they often lacked the experience of Year 2 integration to be able to integrate function of the form $\left(ax + b\right)^n$, where n is a fraction.

Question 6

Part (a) of this question was well answered as candidates appeared to be able to complete the square to determine the coordinates of the centre as being $\left(3, -5\right)$.

However, part (b) appeared to be inaccessible to the majority of candidates as they failed to interpret and/or apply the information given in the question. The majority failed to determine the lower limit of k, $k > 9$, which arose from the requirement that the circle did not touch the *x*-axis. Here, the most common mistake was in assuming the circle must not touch the *x*-axis, resulting in $k > 25$. Some candidates approached this part of the question by substituting the coordinates of their centre and then using the discriminant involving *k*, while those who drew a decent sketch used the far simpler geometric approach and arrived at the result in a far more concise fashion.

In contrast, a good number were able to determine the upper limit of *k*, $k \leq 34$. However, a good number of candidates did not attempt this part of the question, illustrating the candidates' struggle with circle geometry and that, for many centres, it would be worth investing more time into developing deeper understanding of the various types of problems that can arise in circle geometry.

Question 7

Most candidates attempted this question, with only a small number leaving it blank. Most candidates achieved at least one mark overall, but few candidates achieved full marks due to part (c).

In part (a), candidates who set up a linear model correctly tended to go on to get the correct linear model required and performed well in the rest of the question. Those who were successful tended to use the gradient and $y - y_1 = m(x - x_1)$ rather than attempting to use simultaneous equations. The most common error was to use the coordinates the wrong way round, which resulted in candidates' incorrectly calculating the gradient as –8 instead of $-\frac{1}{8}$. However, a good proportion of candidates recovered by using the gradient of –8 to achieve a formula in terms of *V* (i.e., *d* = 400 – 8*V* or equivalent). There were a few candidates who did not include the '+*c*' part of a linear model and instead seem to think the relationship was proportional. These candidates were often limited to one mark in this question for correctly identifying the link of 1 litre = 8km. Where a linear equation was not recognised an exponential was the most common alternative.

Candidates who achieved a formula in part (a) generally continued onto part (b) and used their formula to attempt the question correctly. A common error was to omit the units, which cost just the final mark in part (b). Of the candidates who had *V* and *d* the wrong way round in their linear model, none seemed to realise that their answers of 400L and 50km were unrealistic. In part b(ii) a small number of candidates used their answer to part (i) 50 as the new value for *V*, rather than set *V* = 0 and rearrange.

Very few candidates achieved the mark for part (c). Most candidates recognised it was not acceptable but failed to comment on the significance of the difference. Centres must be clear with candidates that models do not have to be perfect to be appropriate, and so it is only if the model is significantly out that it becomes unviable to use. A small number of candidates calculated percentage difference, which was acceptable. Some candidates focussed incorrectly on practical reasons (e.g., different routes, fuel consumption, more accelerating and breaking, etc.). A small number of candidates worked out the remaining fuel (10L) but often did not correctly conclude the significance of this amount.

Question 8

Very few candidates achieved full marks on this question. The vast majority of candidates were able to find the linear equation successfully, with a significant proportion making no further attempt at the question. While the majority did recognise the form of the quadratic equation using the two *x*-intercepts, most simply stated $y = x^2 - 6x$ or equivalent and did not use the coordinates on the graph to find the coefficient of the x^2 term.

There were a lot of candidates who did not understand what the final part of the question required as they were trying to find intercepts (often assuming that the region needs to be defined as $-3 < x < 10$) or find the area between the curves. Very few candidates seemed to understand what the regions were and how to use the inequalities to determine the region. Incorrect use of notation was also seen here with *R* used instead of *y* linking the two equations.

Question 9

This question was an effective discriminator between candidates. There was evidence of log misconceptions in a substantial proportion of candidates' work and there were a number of completely blank scripts seen. Often though, even weaker candidates were able to pick up the first mark for evidence of a log law correctly applied, albeit amidst otherwise erroneous work which limited them to the first mark only. Most commonly this was earned in isolation either for use of the power law $2\log_5(3x-2) \to \log_5(3x-2)^2$ or for $2 \to 5^2$ when both sides of the equation were raised to base 5 in an attempt to remove logs. It was not uncommon, however, to see the right-hand side become 2^5 rather than 5^2. Another common error involved a misapplication of the log law for subtraction whereby $\log A - \log B$ was believed to be equal to $\frac{\log A}{\log B}$ with the log terms on numerator and denominator subsequently 'cancelled'. In contrast, however, there were a large number of candidates who were well-prepared for this question and were able to demonstrate clear understanding and apply their log knowledge accurately to gain the first three marks.

Following a successful removal of logs, most were able to rearrange their equation into a solvable form and gain the final method mark for solving the resulting quadratic equation. There was a surprising proportion of candidates who chose to attempt to simplify the algebraic fraction $\frac{9x^2-12x+4}{x}$, often correctly, to $9x-12+\frac{4}{x}$. Of these, a good proportion managed to recover, but many candidates simply used an equation solver on their calculator to arrive at the two solutions, and thus forfeited the final two marks. Similar errors to those observed in question 1 were also apparent here in the solving of a quadratic equation and factorisation proved again to be the most successful algebraic method.

The final mark was a particularly good discriminator as only a minority of stronger candidates checked the viability of each root in the original equation and so most candidates failed to reject the $x=\frac{1}{9}$ root.

It was again disappointing to see the number of attempts that jumped straight to $x=\frac{1}{9}$ without showing sufficient log work to achieve an equation without logs. Candidates must be clear that using calculators to solve equations must be treated with caution and that they risk losing a substantial number of marks.

Question 10

This question on straight-line coordinate geometry was well attempted by the vast majority of candidates and there was a good proportion of candidates scoring full marks.

This "show that" question in part (a) was generally very well done, with clear work to find the negative reciprocal gradient and then form a correct equation. The majority were able to manipulate this to the given form without errors, but the occasional slip in their processing resulted in the loss of the final accuracy mark. Those who took the alternative approach, which was essentially a verification process, candidates generally showed that the given line was perpendicular to the original line but very few verified that it went through the required point and hence only scored 1 mark out of 3.

Part (b) was also very well attempted, with the vast majority of candidates obtaining the correct coordinates for *A* and *C*. However, many failed to recognise that the base of the triangle was 18 and the height was simply the *y* coordinate of *C* and instead focused on the fact that *AC* and *BC* were perpendicular and used Pythagoras to find the lengths of *AC* and *BC*. Sometimes they lost the accuracy with this rather laborious method by using decimal answers, although some very accurate candidates were able to proceed using this method to the exact answer. Quite often candidates only obtained the *x* coordinate of *C* and were thus unable to proceed further. Very few attempts were seen that used discriminant approaches to find the required area.

Question 11

This question on exponential functions caused problems for the majority in part (b), as they failed to recognise that differentiation was required. However, generally parts (a) and (c) were answered well.

In part (a), most candidates identified that they needed to substitute $t = 0$ into the given equation and successfully reached $h = 0.6$ metres, which was often seen as 60cm or $\frac{3}{5}$, both of which were allowed. A few failed to use $e^0 = 1$ and as a result arrived at an incorrect answer.

In part (b), the majority of candidates failed to recognise that the 15.3 cm per year meant that they were required to differentiate to obtain a rate of change, and attempted instead to substitute $t = 4$ into the expression for h. This answer resembled 15.3 cm, so many incorrectly assumed that they had answered the question, even though the subsequent conversion from metres to cm made no sense. Some attempted to divide this value by 4, showing some appreciation for the units given in the question, but lacking an appreciation that the information given provided an instantaneous rate of change and not an average rate over the four years. Without an attempt at differentiation no marks could be scored in (b) but those candidates who did differentiate generally successfully answered this part of the question.

In part (c), most candidates identified that the limiting value was 2.3 m, although a number missed this part out, especially after a poor attempt at part (b).

Question 12

This question involving the use of trigonometric identities and solving a trigonometric equation was generally very well answered with the exception of part (c). There were very few blank scripts.

Part (a) was generally well answered. The majority of candidates scored the first mark for correctly identifying $\tan x = \frac{\sin x}{\cos x}$. Two common errors were to either use $\sin x = 1 - \cos x$, or to include the number 4 in the denominator $\left(\text{i.e.,} 4\tan x = \frac{4\sin x}{4\cos x}\right)$. Some candidates made errors in their notation (which was only penalised if it occurred more than once) with a few using $\sin x^2$. A small number started with the answer to try to work backwards, but this approach rarely scored full marks.

Part (b) was attempted by the majority of candidates with some good success. Calculators will solve this equation directly, and as a result there were some candidates (although a minority) who were unable to work out the correct answer using a clear written method combining the quadratic formula and using the inverse sine function. As mentioned earlier, candidates must be careful to show sufficient working. However, most candidates were able to solve the equation and find at least one value of *x* (usually awrt 42.6). Generally, where candidates understood the requirements of the question, both angles were found to the required accuracy. Some candidates stated additional incorrect answers inside the given range and so lost the final accuracy mark. It was surprisingly common to see candidates rounding their values from the quadratic equation (i.e., to 0.7) which resulted in inaccurate angles and as a result they lost the final accuracy mark.

Part (c) was much less successful, with only a small number of candidates gaining any marks. Most candidates only identified one of the adaptations to the question: either the stretch or the increase in the range. The most common incorrect answer resulted from them multiplying their number of solutions by 5 to achieve a total of 10 solutions. Of those candidates who realised there were 30 solutions nearly all were able to give a satisfactory explanation.

Question 13

Given that candidates often find vector problems quite challenging, this question proved to be quite accessible, and most candidates made good progress through parts (a) and (b) of this question, with part (c) more mixed.

In part (a), most candidates successfully reached $-18\mathbf{i}+12\mathbf{j}$ although a few subtracted the vectors the wrong way round or added the position vectors of *A* and *B* instead.

Most were then able to calculate |*AB*| in (b) using their answer from (a), and many correctly reached $6\sqrt{13}$, which was allowed even if candidates had achieved an incorrect vector in (a), e.g., $18\mathbf{i}+12\mathbf{j}$

Attempted methods in (c)(i) were many and varied but most did not use vectors. The most common method was to establish the equation of the straight line through *A* and *B*, and this was then used with $x=-2$ to find $p=5$. Other methods simply looked logically at the information given and found the appropriate scaling factor between, for example, the vectors $\overrightarrow{AB}$ and $\overrightarrow{BC}$. Methods like this were often poorly written down but were clearly correct and gained full marks.

Many candidates did not successfully reach $p = 5$. Typical errors in (c)(i) were assuming $\overrightarrow{AB} = \overrightarrow{BC}$, setting the sum of the position vectors of *A*, *B* and *C* equal to zero or assuming that $-18\mathbf{i}+12\mathbf{j}=k\left(-2\mathbf{i}+p\mathbf{j}\right)$.

A significant number of candidates omitted (c)(ii) after an unsuccessful attempt at (c)(i), and when responses were seen they were often lengthy and involved unnecessary attempts at calculating the areas of the triangles *AOC* and *AOB*. A common incorrect answer was $4:9$, reached after assuming incorrectly that the two triangles were similar. Some candidates did, however, successfully reach a ratio of $2:3$ either after area calculations, or by, for example, examining the relative lengths of *AB* and *AC*. Part (ii) did not rely on an answer to part (i) and so a reasonable number of candidates scored the final mark having been unable to find *p*, with some doing so very concisely. It was notable that many of the concise solutions to both parts came from a simple, well-constructed and clear diagram.

Question 14

This question required candidates to isolate the required terms from the binomial expansion of $\left(3-\frac{1}{2}x\right)^6$ and is a reasonably familiar question from previous papers, but this was less structured to those that candidates have seen before. Many candidates elected to attempt the first few terms of the binomial expansion of $\left(3-\frac{1}{2}x\right)^6$ despite there being no requirement to do so, probably due to it being the most common first step of these questions. For those that took this approach, most candidates managed to begin the expansion correctly, but there were a lot of instances where the brackets were missing around $-\frac{1}{2}$. Often this was recovered and either one or both of the required terms were found correctly.

A significant proportion of the candidates who got so far progressed either to multiply the x^5 term by 5 and/or the x^3 term by 8 and gained the second method mark, but often only one of the two required terms were found, scoring a maximum of 3 out of 5.

Many candidates who achieved a 'correct' answer had left in the x^5 and were only able to achieve full marks because the mark scheme condoned this. Candidates in future series must ensure that they fulfil the demand of the question and select the coefficient required.

There were, however, a pleasing number of concise solutions in which candidates decided which terms were needed at the outset and elected only to find those that were required. These were often fully correct.

Question 15

This question began with the familiar calculator warning which was unfortunately ignored by a significant proportion of candidates. As mentioned previously, candidates must be clear on what is allowed when these warnings are stated, or they risk losing a number or marks.

In part (a), the majority of the candidates were able to gain the first mark by either substituting 1 into the two equations separately (and almost always achieving $y=3$ in both cases) or by setting the two equations equal to each other and then substituting in 1 as required. The majority of candidates, having achieved the point of intersection, drew the correct conclusion but there were many candidates who did not make any suitable comment.

In part (b), the vast majority of candidates achieved the cubic equation required by equating the two given equations and rearranging to set equal to 0, but a significant proportion ignored the guidance at the top of the question and proceeded to solve the question directly on their calculator, resulting in a maximum mark of 1 out of 5. For those that proceeded further, many used inspection to factorise the cubic using the given factor $(x-1)$, while others attempted algebraic division, generally very successfully, achieving the correct quadratic x^2-4x-6. Occasionally, the rearrangements that candidates used resulted in a negative cubic, but despite making the division more challenging it was pleasing that candidates were still generally able to complete this part successfully.

However, having arrived at a suitable quadratic, another significant proportion relied on their calculator to solve the resulting equation (set equal to 0) and forfeited the final two marks. For those that showed full working, many assumed that $k>0$ and chose the incorrect solution, despite often writing $k<0$ as their justification for rejecting (the correct) $2-\sqrt{10}$. As a result, there were very few candidates who achieved full marks for this question.

Question 16

Generally, the candidates that made a full attempt at this question did very well by achieving full marks or at least 4 out of 6. However, many failed to use the information in the second bullet point fully (that the curve has a stationary point at $(4,3)$).

The majority of the candidates achieved the first mark by understanding that the stationary point at $(4,3)$ meant that the first derivative must be equal to zero at $x=4$, arriving at $16+2a+b=0$. Again, the majority went on to perform the integration of the gradient function $\int\left(4x+a\sqrt{x}+b\right)\,\mathrm{d}x$ to achieve

$\mathrm{f}\left(x\right)=2x^2+\frac{2}{3}ax^{\frac{3}{2}}+bx+c$ with the majority able to determine that $c=-5$. A common error was to achieve

$\frac{3}{2}ax^{\frac{3}{2}}$ following integration, although those who had written the unsimplified $\dfrac{ax^{\frac{3}{2}}}{\left(\frac{3}{2}\right)}$ were still able to access

the intermediate accuracy mark.

Common problems were for candidates to misinterpret the information about the stationary point, either using $\mathrm{f}'\left(4\right)=3$ or $\mathrm{f}\left(4\right)=0$, or to miss out a constant of integration, which often resulted in concluding that b was -5.

It was fairly common to see candidates substitute a rearranged $16+2a+b=0$ into their integrated expression (usually for *b*) and this typically did not hinder further progress, although it did result in some sign errors that meant their final expression $\mathrm{f}\left(x\right)$ was incorrect.

Question 17

This was a relatively accessible proof question and gave candidates two opportunities to demonstrate their knowledge and understanding of proof. It was pleasing to see that the general standard of response to this proof question was good, and it is clear that candidates' confidence in and experience of tackling proof questions has improved over recent sessions.

In part (a), most candidates understood what was meant by a counter example and many successfully found a pair of suitable numbers. The mark here was often lost only due to insufficient reasoning. Candidates should be reminded that when showing a falsehood via counter-example it is necessary to provide accompanying minimal reasoning. It was a shame that a significant number of candidates did not notice, or forgot, that the question specified that p and q were positive and that $q > p$ and it was not uncommon to see candidates chose numbers that broke these constraints which meant they were ineligible for this mark. A small proportion of candidates misunderstood or perhaps misread the question and believed they were being asked to demonstrate instead that $q^3 - p^3$ is a multiple of 5.

Part (b) was more challenging and weaker candidates spent time here testing specific values for p and q, but in general it provided good access for the majority of candidates. Most candidates pursued general forms for p and q as consecutive even numbers and most of these chosen forms had merit (usually $2n$ and $2n + 2$ but sometimes $2n + 2$ and $2n + 4$). Incorrect forms included n and $n + 2$ (without consideration of n as an even number), or sometimes n and m which were neither consecutive nor even. The issue of failing to recognise that $q > p$ persisted into part (b) and a number of candidates lost marks for selecting p as the larger even number and subtracting the two terms the wrong way around. Expanding $(2n + 2)^3$ also proved problematic for many candidates and so it was common for candidates to lose the accuracy marks. It was also common for poor subtraction to result in a cubic expression rather a quadratic which was even more costly in terms of marks. Unfortunately, many candidates failed to give even a minimal conclusion following impeccable algebra and so lost the final mark. Again, candidates should be reminded of the importance of a final statement in proof such as this.

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