# Examiners' Report

## Summer 2016

Pearson Edexcel GCE in Core Mathematics 3 (6665/01)

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# Mathematics Unit Core Mathematics 3

## Specification 6665/01

### General Introduction

The quality of responses seen for this paper was high, showing that students had been well prepared by their teachers. Q2(b), Q3(c), Q4(d), Q5(ii), Q8 and Q9(c) were found to be the most challenging on the paper. Overall the level of algebra was pleasing, although a lack of bracketing was apparent in some cases.

## Report on Individual Questions

### Question 1

Most students answered Q01(a) successfully by setting $fg(x) = x$, leading to the correct quadratic equation gaining both the answers $x = 6$ and $x = -5$. The alternative method of using $g(x) = f^{-1}(x)$ was used by only a few students. Errors included the use of $gf(x)$ instead of $fg(x)$ and instances where both the numerator and denominator were multiplied by 7. A small number of students could not solve the quadratic equation, but most used factorisation or the formula effectively.

In Q01(b) many students did not see the connection with Q01(a). The significance of it being worth 1 mark and the wording of the question "hence" should have been a trigger to many more students. Many restarted in Q01(b) with varying degrees of success, yet most obtained $a = 6$. Some students made errors in Q01(a) forming the quadratic equation, often writing $x^2 - x - 26 = 0$ , then restarted in Q01(b), obtaining a correct solution.

### Question 2

In Q02(a) most students made a successful attempt at differentiation using the quotient rule, with only a minority of students attempting the product rule. Quoting the quotient rule before its use is always to be recommended. Common errors included using a formula with a numerator of $uv' - u'v$ or $vu' + uv'$ but more frequently seen was a denominator of $v$ as opposed to $v^2$. Most students were able to simplify their expression for $\frac{dy}{dx}$ correctly, although there were a number who did not correctly multiply out the bracket in the numerator obtaining $4x^2 + 5$ and a greater number who factorised $-4x^2 + 20$ into $-4(x^2 + 5)$ and then cancelled leaving $\frac{-4}{x^2 + 5}$.

In Q02(b) the majority of students were able to score the first method mark by realising that the critical value(s) could be found when their numerator was set equal to zero. The most common reasons for losing further marks was selecting the inside region between their two roots or finding just one root. Only a minority of students were able to proceed from the simple quadratic inequality $x^2 > 5$ to correctly state $x < -\sqrt{5}$ or $x > \sqrt{5}$.

## Question 3

In Q03(a) the majority of students found $R$ and $\alpha$ correctly. The most frequent error was in stating tan $\alpha = -\frac{1}{2}$ or occasionally tan $\alpha = 2$. In just a few responses, a decimal value rather than a surd was given for $R$ losing the last mark.

A majority of students scored 3 or 4 marks out of 5 on Q03(b). A common error was the lack of accuracy in calculations, with answers of 32.9 (rather than 33.0) commonly seen. Many students were able to successfully find a second solution to the given equation.

Q03(c) proved to be discriminating with only a small minority of students being successful. Having solved Q03(b) by going from $\cos(\theta + 26.57) = 0.5068$ to $\theta + 26.57 = 59.54$ to $\theta = 59.54 - 26.57$, it was hoped that for Q03(c) we would see students go from $\cos(\theta - 26.57) = 0.5068$ to $\theta = 59.54 + 26.57$. However, most correct answers came from a total restart and students therefore undertaking a great deal of work. One common error was to state the smallest answer in Q03(b) with little or no working, assuming that the equation in Q03(c) was the same as that in Q03(b). Another error was to somehow attempt to use the minimum or maximum values of the cosine function, sometimes using –1 in any way possible.

## Question 4

Q04(a)(i) and Q04(a)(iii) were completed with ease in the majority of cases. In Q04(a)(iii) incorrect answers of –25 and more commonly 22 were seen. In part (a)(ii) most students were successful in gaining the first two marks for reaching $\frac{1}{2}\ln\left(\frac{25}{4}\right)$ but the majority did not recognise that this could be simplified to $\ln\left(\frac{5}{2}\right)$.

Q04(b) was generally done well with students showing each step from $g(x) = 2x + 43$ to the printed answer. There were very few instances of missing brackets. A small number chose to work backwards from the given answer and then often failed to give a concluding statement.

In Q04(c) the values $x_1$ and $x_2$ were correctly calculated by almost all students.

The majority of students realised that they needed to use a change of sign method in Q04(d), with most students able to define a suitable interval. Many, however, failed to gain the final mark because they either did not define their function or else used an incorrect function such as $g(x)$ or the right hand side of the iterative formula.

## Question 5

In Q05(a), most students demonstrated good knowledge of exponential and trigonometric differentiation, applying the product and chain rules successfully to find $\frac{dy}{dx}$ and setting it equal to 0. Having cancelled $e^{3x}$ to produce an equation in sin $4x$ and cos $4x$, three main approaches to the problem were undertaken. The simplest and most common was to use $\frac{\sin 4x}{\cos 4x}$ = tan$4x$, and proceed using the correct order of operations to obtain a value for $x$.

More complicated methods (with a greater risk to making errors) included squaring both sides of the expression and proceeding to a quadratic in sin $4x$ or cos $4x$, or else setting the equation in the form $5 \cos (4x + 0.93) = 0$ before solving. The vast majority of students worked in radians as required by the question, although those working in degrees could still access all but the final mark. It was not uncommon for students to misread this question, and give a final answer of 0.16 which was outside the required range. Those who did consider the range were able to produce the correct answer without difficulty.

In Q05(b) students realised that differentiation with respect to $y$ using the chain rule was required in order to produce $\frac{dx}{dy}$ in terms of $y$, followed by reciprocation in order to obtain $\frac{dy}{dx}$. The most common mistake was to omit the factor of 2 required by the second application of the chain rule, and the error for many was the move from $4 \sin 2y \cos 2y$ to $2 \sin 4y$. Students who were unable to spot this step were generally not unaware of the double angle formula for sin, but used it to write $\sin 2y$ as $2 \sin y \cos y$ and made little further progress.

A common algebraic error, writing $\frac{1}{2\sin 4y}$ as 2 cosec $4y$, cost some students the final mark in this question.

## Question 6

Q06(a) was successfully attempted by most students especially those who chose to divide by $x^2 + x - 6$ using a standard long division method. A number of students seemed unclear as to how to interpret the result of their long division and a common error was to write their final answer to Q06(a) as $x^2 + 3 + \frac{4x + 12}{x - 2}$.

The students who factorised the denominator first to get $(x + 3)(x - 2)$ were in general less successful; those that divided first by $(x + 3)$ were often able to access all the marks but students that started by attempting to divide by $(x - 2)$ usually struggled to make any progress. The students who attempted this question by equating terms were often able to gain full credit but others sometimes found the algebraic manipulation rather challenging and were only able to achieve part marks.

Many students who had completed Q06(a) correctly went to score full marks in Q06(b). A common error was to confuse differentiation and integration with the term $\frac{4}{(x-2)}$ incorrectly being differentiated to $4 \ln (x - 2)$. Most students were able to use their derivative to calculate a value for $f'(3)$ and use the correct method to determine the gradient and equation of the normal. Some students chose to differentiate the original form of $f(x)$ using the quotient rule. This was a more demanding approach but many of those choosing this method did go on to successfully complete Q06(b) of the question. In fact, there were a number of responses which had gained no credit in Q06(a) but by differentiating the original form of $f(x)$ were able to access all the marks in Q06(b).

## Question 7

Most students scored at least one mark in Q07(a). Students were able to sketch a curve passing through the origin in quadrants one and three only. A more demanding aspect was the curvature of the graph with many sketches looking linear or appearing more like $\sin x$ rather than having gradients that tended to infinity at either end.

In Q07(b) many students were able to substitute $g(x + 1) = \arcsin (x + 1)$ and then make $\arcsin (x + 1)$ the subject. However, many omitted brackets at this stage. Evaluating $\sin \frac{\pi}{3}$ did not cause significant problems for some, who then were able to go on to make $x$ the subject of their equation. A significant problem was caused by solutions with incorrect or ambiguous signs. For example, it was not often clear if the student meant $-\frac{2 + \sqrt{3}}{2}$ or $\frac{-2 + \sqrt{3}}{2}$ due to the minus sign being poorly positioned. In this question leaving the answer in the form $-1 - \frac{\sqrt{3}}{2}$ avoided any potential confusion.

## Question 8

The trigonometric proof in Q08(a) was well answered. The first two marks were achieved by the majority of students, with many quickly performing the proof in just a few steps. Generally, students were more successful when using the identities with tan $2x$. Those who used identities for sin $2x$ and cos $2x$ often over complicated their work and found it more difficult to complete the proof. The requirement to handle correctly the outside factor 2 in the 2 cot $2x$ term added some difficulty of the question, though it was only a minority of students inverted this 2 as well as tan $2x$.

There was less success in Q08(b). Most students recognised the link to Q08(a) and were able to set up a suitable equation in cot $x$ and cosec $x$. The majority then went on to form an equation in just cot $x$ and solve this quadratic by the correct use of the quadratic formula. A surprising number of students simply stopped at this stage, giving the solutions to the quadratic as their answers. For those who did employ the correct method from a correct quadratic, finding two correct answers generally followed, though accuracy was not always kept, with rounded values for cot $x$ often used. Indeed, it was not uncommon for three correct answer (to 3 decimal places) to be given, with the final mark being lost through the omission of the solution −2.848, or for incorrect rounding. Those that converted the original equation to sin $x$ and cos $x$ were usually less successful in achieving the correct angles though some very good answers via this approach were seen.

## Question 9

Q09(a) was a good source of marks. All except a very few students were successful in substituting the correct values into the formula, and most of these were able to write the answer to the required accuracy.

Though not quite as successfully answered as Q09(a), the majority of students were able to pick up at least one mark in Q09(b). However, answers were varied here, with some students writing down the correct expression then the answer, while others evaluated several expressions with $D$ =15 and various values of $t$ before finding two that added to the given answer, indicating that they may not have fully understood the model.

Q09(c) proved to be a discriminator for this paper. Many students made no attempt at all, either due to it being the last question on the paper, or because they had not understood the model (as noted above). Of those that did attempt Q09(c), many made no progress, usually attempting an equation in a single exponential term, $7.5 = 15e^{-0.2 \times T}$ being a common example.

There were also a good proportion of students who managed to set up a correct equation, but who then were unable to proceed correctly to the result. Taking logarithms (incorrectly), before factorising out the $e^{-0.2 \times T}$ term, was the most common error. Students who started with the equation $(15e^{-1} + 15)e^{-0.2 \times T} = 7.5$ were more successful and could generally solve this equation to give a correct value of $T$.

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