Chapter 10

MATHEMATICS

The following should be read in conjunction with the Mathematics question papers of the November 2019 Examinations.


The number of candidates who wrote the Mathematics examination in 2019 decreased by 11 824 in comparison to that of 2018. The performance of the candidates in 2019 showed a noticeable decline at the 30% level from 58,0% in 2018 to 54,6% and a slight decline at the 40% level from 37,1% in 2018 to 35,0%.

Table 10.1: Overall Achievement Rates in Mathematics

<table>
<thead>
<tr>
<th>Year</th>
<th>No. wrote</th>
<th>No. achieved at 30% and above</th>
<th>% achieved at 30% and above</th>
<th>No. achieved at 40% and above</th>
<th>% achieved at 40% and above</th>
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</thead>
<tbody>
<tr>
<td>2015</td>
<td>263 903</td>
<td>129 481</td>
<td>49,1</td>
<td>84 297</td>
<td>31,9</td>
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<td>2016</td>
<td>265 912</td>
<td>136 011</td>
<td>51,1</td>
<td>89 119</td>
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<td>2017</td>
<td>245 103</td>
<td>127 197</td>
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<td>86 096</td>
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<td>233 858</td>
<td>135 638</td>
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<td>222 034</td>
<td>121 179</td>
<td>54,6</td>
<td>77 751</td>
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Performance in the 2019 examination showed deficiency in the understanding of basic concepts across some topics in the curriculum hence the decline in performance, both at the 30% and the 40% level of achievement. It appears that candidates are becoming over-reliant on past examination papers. While past examination papers may serve as a valuable resource for revision, the teaching and learning of basic concepts cannot and should not be overlooked. It was pleasing to note that the candidates’ answering of routine questions in Euclidean Geometry shows continuous improvement.

Performance will be further enhanced if attention is given to the following areas: strengthening the content knowledge in Trigonometry and learners’ exposure to complex and problem-solving questions across all topics in the curriculum, starting in the earlier grades.
Graph 10.1.1: Overall Achievement Rates in Mathematics (Percentage)

<table>
<thead>
<tr>
<th>Year</th>
<th>% achieved at 30% and above</th>
<th>% achieved at 40% and above</th>
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<tr>
<td>2015</td>
<td>49.1</td>
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<tr>
<td>2019</td>
<td>54.6</td>
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Graph 10.1.2: Performance Distribution Curves in Mathematics (Percentage)

<table>
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<th>Year</th>
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<th>10-19.9</th>
<th>20-29.9</th>
<th>30-39.9</th>
<th>40-49.9</th>
<th>50-59.9</th>
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<tr>
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<td>18.4</td>
<td>18.4</td>
<td>17.6</td>
<td>12.2</td>
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<td>5.7</td>
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</tr>
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<tr>
<td>2019</td>
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<td>1.5</td>
<td>0.4</td>
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10.2 OVERVIEW OF LEARNER PERFORMANCE IN PAPER 1

(a) Many candidates were able to answer the routine questions correctly and scored some marks in a majority of the questions. This suggests that the candidates were well prepared to deal with the knowledge and routine questions in the paper.

(b) The algebraic skills of the candidates are poor. Most candidates lacked fundamental and basic mathematical competencies which should have been acquired in the lower grades. This becomes an impediment to candidates answering complex questions correctly.

(c) While calculations and performing well-known routine procedures form the basis of answering questions in a Mathematics paper, a deeper understanding of definitions and concepts cannot be overlooked. Candidates did not fare well in answering questions that assessed an understanding of concepts.

10.3 DIAGNOSTIC QUESTION ANALYSIS FOR PAPER 1

The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 10.3.1 Average Percentage Performance per Question for Paper 1

<table>
<thead>
<tr>
<th>Question</th>
<th>Equations, Inequalities and Algebraic Manipulation</th>
<th>Number Patterns &amp; Sequences</th>
<th>Number Patterns &amp; Sequences</th>
<th>Functions and Graphs</th>
<th>Functions and Graphs</th>
<th>Finance</th>
<th>Calculus</th>
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<td></td>
</tr>
</tbody>
</table>
10.4 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: ALGEBRA

Common Errors and Misconceptions

(a) In answering Q1.1.1, some candidates factorised the quadratic expression incorrectly i.e. they factorised it as $(x - 6)(x + 1) = 0$ instead of $(x + 6)(x - 1) = 0$. Others factorised it as $(x + 5)(x - 1) = 0$. Some candidates omitted the ‘$= 0$’. They converted an equation to an expression and their answer would read:

$$(x + 6)(x - 1) : \therefore x = -6 \text{ or } x = 1.$$  

(b) Writing down the quadratic formula correctly and correct substitution therein remains problematic among some candidates. Some candidates wrote the quadratic formula incorrectly, e.g.

$$x = \frac{b \pm \sqrt{b^2 - 4ac}}{2a},$$  

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \text{ or } x = \frac{-b \pm \sqrt{b^2 + 4ac}}{2a}.$$  

Such candidates lost marks for an incorrect formula. Incorrect rounding still poses a problem. Some candidates rejected the negative solution. These candidates confused the quadratic formula with surd equations.
In Q1.1.3 candidates were unable to determine the critical values of a quadratic inequality that had only 2 terms. Some candidates drew a parabola with the correct information but were unable to write down the solution. Many candidates treated the inequality in the same way as they would treat an equation. Their answer read:

\[ 4x^2 - 1 < 0 \]
\[ 4x^2 < 1 \]
\[ x < \frac{1}{2} \text{ or } x < -\frac{1}{2} \]

Candidates also showed little or no understanding of the set builder or interval notation. The use of the words and and or were not understood.

Most candidates had some idea that they had to square both sides of the equation in Q1.1.4. However, many candidates were unable to multiply the binomials containing the surds. Very few candidates checked if the solutions obtained were valid in the original equation and consequently failed to reject \( x = -4 \) as a solution. Some candidates only squared one side of the equation. The candidates who squared the LHS only, did not reject the invalid solutions that they obtained.

In Q1.2 some candidates opted to make \( x \) the subject of the formula in \( xy = 14 - 3x \), thereby making the question more complicated. Some candidates simplified \( 14 - 3(12 - y) \) to \( 11(12 - y) \).

When attempting to solve \( y^2 - 9y - 22 = 0 \), some candidates used the quadratic formula and then gave the answer as \( x = 11 \) or \( x = -2 \) instead of \( y = 11 \) or \( y = -2 \).

Candidates had very little idea on how to answer Q1.3. A number of candidates attempted to answer the question as follows:

\[ 30! = 3^k \]
\[ k = \log_3 30! \]
\[ k = 67.956855... \]

These candidates showed little understanding of the concept of a factor.

Suggestions for Improvement

(a) More thorough teaching of factorisation in Grades 9 and 10 is needed. Learners should be taught to always multiply out again after they factorised, just to make sure that they get back the expression that they started off with.

(b) Skills learnt in earlier grades should be revised from time to time. These skills are essential to solve many questions in Grade 12. Learners must be reminded to use the information sheet for the correct formula. Learners should write down, e.g. \( a = 4; b = 3 \) and \( c = -5 \), before substituting into the formula for the roots of a quadratic equation. Encourage learners to use brackets when substituting negative numbers, and when multiplying (e.g. \( 4(4)(-5) \)).

(d) Teachers should check whether learners know how to round off to a required number of places.
Teachers should take some time, preferably in Grade 10, to focus on teaching learners how to represent inequalities (e.g. \(- \frac{1}{2} < x < \frac{1}{2} \); \( x < -\frac{1}{2} \) or \( x > \frac{1}{2} \)) on a number line and also how to write an inequality from the illustration on a number line. This will hold learners in good stead as they are required to write inequality solutions for a number of questions in both examination papers.

Teachers should explain the difference between and and or in the context of inequalities. Learners cannot use these words interchangeably as they have different meanings.

When dealing with surd equations, learners should be reminded that they need to square both sides of the equation in order to maintain the balance. They should not square the radical parts of the equation only. Teachers must emphasise that implicit restrictions are placed on surd equations and that learners should continue to test whether their answers satisfy the original equation.

When attempting to solve simultaneous equations, teach learners to make one variable the subject of the formula in the simpler of the two equations. Where possible, avoid creating fractions as this creates complexity when solving the equation.

**QUESTION 2: PATTERNS**

**Common Errors and Misconceptions**

(a) In Q2.2.1 a few candidates added the previous first difference of -27 to determine the next two terms in the quadratic number pattern. These candidates failed to realise that the first differences of a quadratic number pattern are not constant.

(b) In answering Q2.2.2, some candidates calculated the second difference to be -2 instead of 2. Another common error was that some candidates used \( 2a + b = -31 \) instead of \( 3a + b = -31 \).

(c) A few candidates assumed that \( n \) was 74 instead of \( T_n \) being 74. Some candidates made errors in determining an expression for \( T_n \). They then obtained decimals or negative values for \( n \) but did not discard these values.

(d) Many candidates did not realise that the word 'least' meant the minimum value of the terms in the sequence. Further, they could not make the association between the quadratic number pattern and the quadratic function.

(e) In Q2.2.1 some candidates calculated the value of \( r \) as 2 instead of \( \frac{1}{2} \). Some candidates calculated \( T_{21} \) instead of \( S_{21} \). They did not realise that 'series' implied the sum of the first 21 terms.
Many candidates were able to write down the first line of the solution correctly, i.e., \( \left( \frac{5}{8} \right) \left( \frac{1}{2} \right)^{n-1} > \frac{5}{8192} \).

However, poor application of the laws of exponents resulted in incorrect simplification: \( \left( \frac{5}{16} \right)^{n-1} > \frac{5}{8192} \).

Many candidates successfully simplified their solution to \( \left( \frac{1}{2} \right)^{n-1} > \left( \frac{1}{2} \right)^{10} \). However, they did not change the inequality sign around when solving for \( n \), i.e., \( n - 1 < 10 \).

Suggestions for Improvement

(a) While teaching this section, teachers should emphasise the difference between the position and the value of a term in a sequence. Learners must read the questions carefully so that they know what is required of them. Remind learners that \( n \) cannot be a negative number, zero or a fraction.

(b) Learners need to analyse the type of sequence they are working with and which formulae are applicable to it. Teach learners how to identify whether the question requires the learner to calculate the value of the \( n \)-th term or the sum of the first \( n \) terms.

(c) In calculating the difference between two terms, it must be reinforced that the correct process is to subtract the term on the left from the term on the right. This is applicable to both first and second differences. When working with quadratic number patterns, it is good practice to develop a scheme that clearly shows the first and second differences of the pattern.

QUESTION 3: PATTERNS

Common Errors and Misconceptions

(a) It is evident that many candidates do not understand sigma notation. In Q3.1 they answered as follows:

\[
\sum_{y=3}^{10} \frac{1}{y-2} - \sum_{y=3}^{10} \frac{1}{y-1} = \frac{1}{3-2} - \frac{1}{3-1} - \frac{1}{2}.
\]

Other candidates expanded to 3, 7 or 10 terms.

Some candidates ignored the instruction that the question had to be answered without using a calculator.

(b) In Q3.2 some candidates were confused about which formula to use. They used the formula for the volume of a rectangular prism or the total surface area of a rectangular prism instead of the area of a rectangle. A number of candidates only calculated the area of the 3 steps shown in the diagram and not the 12 that was required. Some candidates calculated the area of one or two steps but could not see the pattern on account of the fractions.
Suggestions for Improvement

(a) Attention needs to be paid to the basics in number patterns. The concept of ‘sum of terms’ needs to be explained. This topic is not merely about using a formula to obtain an answer, but it requires a deeper understanding of concepts.

(b) Teachers need to clarify that the sigma notation is a short-hand notation of a series of terms. Give learners enough examples where they have to expand the sigma notation. Use simple ones to start with, probably containing only a few terms. Also give them examples that do not represent arithmetic and geometric series.

(c) Teach learners that when one needs to calculate the area of a complex shape, it is often a good idea to break this area up into smaller parts. One can then calculate the area of each of these smaller parts and add the answers to determine the area of the whole shape.

QUESTION 4: FUNCTIONS (PARABOLA AND HYPERBOLA)

Common Errors and Misconceptions

(a) In Q4.1 many candidates gave the answer as \( p = 1 \) instead of \( p = -1 \). Some gave the answer as the equation of the asymptote: \( x = -1 \). This was not required.

(b) In answering Q4.2 some candidates assumed that \( a = 3 \) and \( b = 2 \) in their calculations to show that \( a = 3 \) and \( b = 2 \). This is not acceptable. Some candidates did not realise that the coordinates of D were required to answer this question.

(c) Some candidates were unable to recall the formula to calculate the \( x \)-coordinate of the turning point. They used \( x = \frac{-2b}{a} \) or \( x = \frac{-b^2}{2a} \) instead of \( x = \frac{-b}{2a} \). Other candidates calculated the derivative correctly but did not equate the derivative to zero when calculating the \( x \)-coordinate of the turning point.

(d) Many candidates confused the domain and range and gave the answer to Q4.4 in terms of \( x \) instead of \( y \). Some candidates knew the values but wrote the answer as \( (-\infty; -4] \) instead of \( [4; \infty) \).

(e) In Q4.5 many candidates failed to link the angle of inclination (45°) with the gradient of the line. Instead candidates attempted to find the gradient by using the coordinates of C and the \( x \)-intercept of the parabola without realising that the tangent did not pass through the \( x \)-intercept.

(f) Many candidates correctly indicated that the line could not be a tangent to the graph, but they could not provide a correct reason for their answer.
Very few candidates answered Q4.7 correctly. They failed to recognise that the transformation involved a reflection as well as a vertical and horizontal translation. In most cases, candidates gave the answers as \( q = -4 \) and \( m = 1 \) instead of \( q = 4 \) and \( m = -1 \).

Suggestions for Improvement

(a) Teachers should pay attention to the concepts and definitions when teaching functions.

(b) It is important that teachers use the equation for a hyperbola as given in the CAPS document, i.e. \( y = \frac{a}{x + p} + q \), and not \( y = \frac{a}{x - p} + q \). If a teacher uses the second format, it could be confusing to learners as they will make mistakes with the sign of \( p \).

(c) Teachers need to illustrate how transformations influence the equation of a graph. There should be a good understanding of how the graph changes when the equation changes and vice versa.

QUESTION 5: FUNCTIONS (EXPONENTIAL AND INVERSE)

Common Errors and Misconceptions

(a) Some candidates substituted correctly, i.e. \( 16 = k^4 \), but could not proceed to calculate the value of \( k \). Some candidates determined \( \sqrt[4]{16} \) instead of \( \frac{\sqrt[4]{16}}{2} \) when they calculated the value of \( k \).

(b) In Q5.2 many candidates did not know that the graphs of a function and its inverse will always be symmetrical around the line \( y = x \). Instead, many candidates wrote the equation of the graph that would be obtained reflecting the given graph about the \( y \)-axis or \( x \)-axis. Many candidates did not write the log equation in the correct way. They wrote \( y = \log_2 x \) instead of \( y = \log_2 x \). These two expressions have different meanings.

(c) The graph that some candidates drew in Q5.3 did not correspond with the equation that was determined in Q5.2. Many candidates did not indicate the coordinates of two points on the graph as required. Some candidates were unable to establish the correct equation in Q5.2 but drew the correct graph by reflecting the given graph about the line \( y = x \).

(d) Candidates did not understand what was required in Q5.4. Many provided answers that were not related to the graphs. Some candidates had some idea about the answer to Q5.4.2 but did not realise that the graph did not pass the \( y \)-axis. They wrote their answer as \( x \leq \frac{1}{2} \) instead of \( 0 < x \leq \frac{1}{2} \).
Many candidates had difficulty in establishing that \( f(-x) \) was actually \( (2)^{-x} \). This hindered any further progress in this question. Some candidates applied exponential laws incorrectly, e.g. \( 2^x - \left( \frac{1}{2} \right)^x = \left( \frac{3}{2} \right)^x \) and \( 2^x - \left( \frac{1}{2} \right)^x = 2^x \left( 1 - \frac{1}{2} \right) \).

### Suggestions for Improvement

(a) Teachers should spend some time teaching exponential equations and they need to clearly distinguish between the different types of exponential equations.

(b) When dealing with the inverse function, one of the basics to be explored and taught is symmetry about the line \( y = x \). Reinforce among learners that by ‘swopping the \( x \) and \( y \) coordinates’ they are obtaining points that lie on the inverse of the given graph. This is particularly useful in establishing the intercepts of the inverse.

(c) Initially, learners should be encouraged to sketch graphs by using the point-by-point plotting method. However, the characteristics and features of each graph should be noted. After much practice, learners should be able to draw a sketch graph by only displaying the key features of the function.

(d) Teachers should demonstrate in a systematic way, how to read off solutions from graphs. Learners must also be able to devise their own strategies do this.

### QUESTION 6: FINANCE

#### Common Errors and Misconceptions

(a) Many candidates used the future value annuity formula in Q6.1. These candidates did not realise that the investment made by each person was a single payment and not recurring payments. Some candidates did not take into account the bonus that was applicable to Kuda’s investment. Some candidates made mistakes when converting the rates of interest to decimal values. Some used the incorrect interest rate for the incorrect person. It was also observed that candidates made the correct substitution into the correct formula but arrived at incorrect answers. This suggests that some candidates were unable to use their calculators correctly.

(b) In Q6.2.1 some candidates calculated the value of the monthly repayment instead of the number of payments required to settle the loan. Other candidates used R5 066,36 instead of R6 000. They did not read the question correctly. Some candidates showed poor simplification skills.

They wrote \( -\left( \frac{121}{120} \right)^n \) as \( -\left( \frac{121}{120} \right)^n \). When determining the number of payments required to settle the loan, some candidates rounded down to 157 instead of rounding up to 158.
Many candidates did not comprehend the question and did not realise that the question revolved around the difference between R6 000 and R5 066.36. Some candidates only calculated R933.64(108). They did not take into account the interest that R933.64 earned over the 9 years. Many candidates incorrectly used the present value annuity formula as the context of the question was a loan.

**Suggestions for Improvement**

(a) Learners should be discouraged from only looking for key words in a finance question, they must read the entire question instead. In this way they will be able to understand what the question requires. Having a complete picture of the question will assist in selecting the appropriate formula. Although the context of Q6.2 was a loan, the problem in Q6.2.2 was actually one of savings and therefore the future value annuity formula was applicable to this question.

(b) Learners need deeper insight into the relevance of each of the formulae and under which circumstances each can be used. The variables in each formula must be explained. More practice in Financial Mathematics is necessary so that learners can distinguish amongst the different formulae.

(c) Teachers should demonstrate all the steps when using a calculator.

**QUESTION 7: CALCULUS**

**Common Errors and Misconceptions**

(a) In Q7.1 candidates made simplification or notational errors. Many candidates made the following notational errors: 

\[ f(x) = \lim_{h \to 0} \frac{f(x + h) - f(x)}{h} \quad \text{or} \quad \lim_{h \to 0} \frac{f(x + h) - f(x)}{h} \quad \text{or} \quad \lim_{h \to 0} \frac{f(x + h) - f(x)}{h} \]

Some candidates made mistakes when removing brackets: 

\[ \lim_{h \to 0} \frac{4 - 7(x + h) - 4 - 7x}{h} \]

Some candidates 'converted' the linear expression \((4 - 7x)\) to a quadratic expression \((4 - 7x^2)\).

(b) The common error in Q7.2 was to rewrite \(\sqrt{x^3}\) as \(x^{\frac{1}{3}}\) or \(x^{\frac{2}{3}}\) instead of \(x^{\frac{3}{2}}\).

Another common response that included incorrect notation and unnecessary differentiation was:

\[ y = 4x^6 + \sqrt{x^3} \]

\[ \frac{dy}{dx} = 32x^7 + \frac{3}{2}x^{\frac{1}{2}} \]

\[ = 224x^6 + \frac{3}{2}x^{\frac{1}{2}} \]
Many candidates could not differentiate terms with literal coefficients as presented in Q7.3.1.

A common response was \( y = ax^2 + a \). Candidates differentiated with respect to \( x \) and \( a \) in the same question.

In Q7.3.2 many candidates could not differentiate with respect to \( a \), i.e. they could not interpret \( \frac{dy}{da} \). A common error was to divide throughout by \( a \):

\[
\frac{y}{a} = x^2 + 1
\]

Most candidates were able to calculate the value of \( b \) in Q7.4. However, they were unable to proceed correctly from this point. Many did not calculate the gradient of the perpendicular line. Another common error was that many candidates assumed that the gradient of the tangent was 1 and therefore the gradient of the perpendicular line was \(-1\). Some candidates could not calculate the derivative of

\[
y = x + \frac{12}{x}
\]

correctly. Their answer was \( \frac{d}{dx} = -12x^{-2} \).

**Suggestions for Improvement**

(a) Emphasis should be placed on the use of the correct notation when determining the derivative, either when using first principles or the rules.

(b) Teachers should explain the need for brackets when determining the derivative from first principles. This prevents the incorrect simplification that follows.

(c) Teachers should explain the meaning of the notation \( \frac{dy}{dx} \), namely that it is the instruction to determine the derivative of \( y \) with respect to \( x \). This should remind learners that \( y \) must be the subject of the formula of an expression that has \( x \) as a variable. The derivative can then be determined. The derivative of variables other than \( x \) should also be discussed.

(d) Learners should be reminded that the value of a derivative for a certain value of \( x \) is the gradient of the tangent to the curve at that point.

**QUESTION 8: CALCULUS**

**Common Errors and Misconceptions**

(a) In Q8.1 many candidates gave the answer as \( t = 6 \). They calculated the value of \( t \) when \( h = 0 \) instead of calculating the value of \( h \) when \( t = 0 \).

(b) Many candidates confused ‘how many times’ with ‘at what time’ in answering Q8.2. They gave the answer as \( t = 6 \) instead of indicating that the insect reached the floor only once.
(c) In answering Q8.3 some candidates could not correctly multiply out \( h(t) \). Some candidates calculated \( h'(t) \), but did not equate \( h'(t) \) to 0. Some calculated the values of \( t \) but did not calculate the maximum height. Other candidates calculated \( h''(t) \), equated it to 0, and solved for \( t \) not realising that in this way they will calculate the \( t \)-value of the point of inflection and not the maximum.

**Suggestions for Improvement**

(a) When teaching graphs of cubic functions, teachers should also include those that have one stationary point.

(b) Teachers need to expose learners to word problems in order for them to gain confidence.

(c) The calculation of critical values should not only be restricted to graphical questions. Expose learners to calculating critical values in contextual questions as well. This will help learners to appreciate the calculations that they perform in Mathematics.

**QUESTION 9: CALCULUS**

**Common Errors and Misconceptions**

(a) In Q9.1 some candidates used first principles to calculate the derivative. This was not required.

(b) Many candidates calculated the derivative of \( 3x^3 \) as \( 6x^2 \) instead of \( 9x^2 \). Many candidates did not factorise \( 3x^3 - 9x^2 \). They merely divided both sides of the equation \( 3x^3 - 9x^2 = 0 \) by \( x^2 \), and so lost one of the solutions.

(c) Very few candidates attempted Q9.2. Most candidates were unable to interpret what the question required.

(d) Some candidates calculated the distance to be \(-9\). They did not realise that distance cannot be negative.

Many candidates opted to use the algebraic method to answer this question. However, they incorrectly treated the inequality like an equation. Their answer was:

\[
3x^2(x-3) < 0 \\
3x^2 < 0 \quad \text{or} \quad x - 3 < 0 \\
x < 0 \quad \text{or} \quad x < 3
\]
Suggestions for Improvement

(a) Teachers need to ensure that learners have a clear understanding of turning point and point of inflection. Learners need to be aware of how the first and/or second derivatives change at the turning point and point of inflection.

(b) Teachers should draw the graphs of $f(x)$, $f'(x)$ and $f''(x)$ on the same system of axes. This will allow learners to see the relationships among the critical values of each graph as well as the shape of each graph.

(c) Teachers should ensure that there is enough time for learners to understand the application of Calculus fully.

QUESTION 10: PROBABILITY

Common Errors and Misconceptions

(a) In Q10.1 some candidates did not read the question and used 7 days of a week in their calculations. Many candidates did not know how to answer this question. The most common response to this question was $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$.

(b) Many candidates did not answer Q10.2. Some candidates attempted to draw a tree diagram but could not draw it correctly.

Suggestions for Improvement

Tree diagrams are a useful tool to visualise compound events. Tree diagrams also assist learners in understanding the sequence of events. Teachers should make greater use of tree diagrams when dealing with questions that involve compound events. These should include independent events and dependent events.

QUESTION 11: PROBABILITY AND COUNTING PRINCIPLES

Common Errors and Misconceptions

(a) In Q11.1.1 some candidates confused mutually exclusive events with independent events. They drew a Venn diagram having no intersection of A and B. Some candidates were able to calculate that $P(A \text{ and } B) = 0.1$. However, they were unable to calculate the other probabilities correctly. On the Venn diagram they indicated $P(A \text{ only})$ as 0.4 instead of 0.3.

(b) In Q11.1.2 many candidates calculated $P(A \text{ or } B)$ instead of $P(A \text{ or not } B)$. A few took into account that there was an intersection of the two events: A and not B.
(c) Many candidates used factorial notation when writing down the various options, e.g. $5! \times 1 \times 6!$ instead of $5 \times 1 \times 6$.

**Suggestions for Improvement**

(a) When teaching Probability, emphasis should be placed on the understanding of the concepts like mutually exclusive events, independent events and complementary events.

(b) The formulae in this section should not be an abstract idea. Teachers should explain these formulae in the context of Venn diagrams.

(c) The section on the fundamental counting principle needs to be taught as clearly and simply as possible, using diagrams to explain scenarios. Choose practical scenarios to demonstrate the concepts of ‘repetition is allowed’ and ‘repetition is not allowed’. Learners will then be able to relate to these concepts.

(d) Teachers should refrain from teaching rules to different situations, rather aim at reasoning out the calculations that are required to answer the question.

(e) Teachers should only introduce factorial notation once learners have a good understanding of the fundamental counting principle.

### 10.5 OVERVIEW OF LEARNER PERFORMANCE IN PAPER 2

(a) Individual performance in the paper varied from very poor to excellent.

(b) Integration of topics is still a challenge to many candidates. Mathematics cannot be studied in compartments and it is expected that candidates must be able to apply knowledge from one section to another section of work.

(c) It is evident that many of the errors made by candidates in answering this paper have their origins in a poor understanding of the basics and foundational competencies taught in the earlier grades.

(d) Candidates struggled with concepts in the curriculum that required deeper conceptual understanding. Questions where candidates had to interpret information or provide justification, presented the greatest challenge.

(e) In general, candidates need to exercise caution with algebraic manipulation skills since overlooking certain basic principles or practices results in the unnecessary loss of marks. Although the calculator is an effective and necessary tool in Mathematics, learners appear to believe that the calculator provides the answer to all their problems. Some candidates need to realise that conceptual development and algebraic manipulation are often impeded as a result of the dependence on the calculator.

(f) Candidates need to read the questions with due diligence. By glossing over questions, candidates are overlooking the critical information contained in the questions.
10.6 DIAGNOSTIC QUESTION ANALYSIS FOR PAPER 2

The following graph was based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 10.6.1 Average Percentage Performance per Question for Paper 2

<table>
<thead>
<tr>
<th>Question</th>
<th>Average Performance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>53</td>
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<td>3</td>
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<tr>
<td>9</td>
<td>44</td>
</tr>
<tr>
<td>10</td>
<td>44</td>
</tr>
</tbody>
</table>

Q1: Data Handling
Q2: Data Handling
Q3: Analytical Geometry
Q4: Analytical Geometry
Q5: Trigonometry
Q6: Trigonometry
Q7: Trigonometry
Q8: Euclidean Geometry
Q9: Euclidean Geometry
Q10: Euclidean Geometry
10.7 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: DATA HANDLING

Common Errors and Misconceptions

(a) In Q1.1 some candidates could not calculate the values of \( a \) and \( b \) correctly. This was on account of entering incorrect values into the calculator. Some could not round off correctly to two decimal places. A few candidates swopped the values of \( a \) and \( b \) in the equation. Their equation was \( \hat{y} = 0.41 - 1946.88x \). A few candidates did not identify the independent and dependent variables correctly from the table.

(b) Some candidates substituted incorrectly in Q1.2. They substituted 14 000 for \( y \) instead of \( x \). Some candidates were confused by the word ‘predict’ and resorted to merely guessing random answers. Others calculated the predicted value to be the sum of R3 000 and R3 500 divided by 2. This was incorrect.

(c) Some candidates did not realise that this question required the value of \( r \). Instead they commented on the strength of the relationship between the monthly income and the monthly repayment of a car.

(d) Candidates could not relate the question in Q1.4 to the information that was given. Many just guessed an answer.
Suggestions for Improvement

(a) Learners should be given multiple opportunities to practice calculator skills. Learners should be made aware that the operation procedure varies from one brand of calculator to the next. It is in their interest to use the same brand regularly.

(b) Teachers should emphasise correct rounding.

(c) Teachers should explain each definition or concept in detail. It is important that the definition of independent and dependent variables is discussed.

(d) Learners should be taught how to use the regression line to make predictions.

QUESTION 2: DATA HANDLING

Common Errors and Misconceptions

(a) In Q2.1 many candidates gave the frequency corresponding to the class interval, i.e. 12, as the answer instead of calculating the cumulative frequency.

(b) Many candidates used the given values of $a$ and $b$ in their calculations. Some candidates did not take the frequencies into account in their calculations. Some candidates used the lower or upper class limits in their calculations. They should have used the midpoints of the classes in their calculations. Other candidates divided by 6 because there were 6 class intervals in the table. They should have divided by 100, the total number of observations in the data set.

(c) A few candidates were unable to identify the modal class from the frequency table.

(d) A number of candidates were unable to draw an ogive correctly. They plotted the cumulative frequency against the lower limit or midpoint of the class interval and did not ground the ogive. Some were unaware that the ogive is a smooth curve and used a ruler to join the points. Some candidates drew a frequency polygon instead of the required ogive.

(e) In answering Q2.5, candidates were able to read off the ogive correctly but failed to subtract this number from 100.

Suggestions for Improvement

(a) Teachers should stress that it is not permissible for learners to use the information that they must prove as if it is given information.

(b) Graphs is an integral part of Data Handling. Learners should be able to draw graphs, read off from graphs and interpret graphs.
**QUESTION 3: ANALYTICAL GEOMETRY**

**Common Errors and Misconceptions**

(a) Some candidates did not write the equation of PR but gave the coordinates of P.

(b) Some candidates were unable to use the gradient formula correctly, e.g. \( m = \frac{x_2 - x_1}{y_2 - y_1} \) instead of \( m = \frac{y_2 - y_1}{x_2 - x_1} \). Others made incorrect substitutions into the correct formula or they swapped the x and y values in the formula.

(c) In answering Q3.2.3 some candidates used the correct gradient of RS but substituted a point that did not lie on RS, e.g. they used C(0 ; 5) in determining the equation. Some candidates assumed the D was the midpoint of RS and others assumed that CO was equal to FD.

(d) Some candidates did not make correct substitutions into the distance formula when answering Q3.3.

\[
2\sqrt{5} = \sqrt{(-3 + 5)^2 + (-7 + k)^2} \\
20 = 4 + 49 - 14k + k^2 \\
k^2 - 14k + 33 = 0 \\
(k - 11)(k - 3) = 0 \\
k = 11 \quad \text{or} \quad k = 3
\]

(e) Many candidates used the coordinates of D as the midpoint of the diagonals in parallelogram TDNS.

(f) Many candidates could not visualise triangle RDR. Consequently, they were unable to answer this question. Some candidates were not familiar with the notation R. In some instances, candidates named all the angles that they calculated as \( \theta \). This caused confusion and candidates used incorrect angles in their calculations.

**Suggestions for Improvement**

(a) Substitution into the formula remains a problem. Learners should first write down the coordinates and then substitute them into the formula.

(b) Learners should read the question for clues about which formula is to be used when answering the question.

(c) Teachers should request learners to label the coordinates as \( (x_1 ; y_1) \) and \( (x_2 ; y_2) \) on the diagram. This should prevent learners from making mistakes when substituting the coordinates into a formula.

(d) Teachers should encourage learners to write down the values that they have already calculated (lengths, angles and gradients) on the diagram. This will assist learners when answering follow-up questions. Learners should label different angles using different symbols, e.g. \( \alpha, \beta, \theta \), etc.

(e) To answer questions in analytical geometry well, learners should master the properties of quadrilaterals and triangles.
Learners should refrain from making assumptions about features in a question. These need to be proved first before the results can be used in an answer.

The different topics in Mathematics should be integrated. Learners must be able to establish the connection between Euclidean Geometry and Analytical Geometry.

QUESTION 4: ANALYTICAL GEOMETRY

Common Errors and Misconceptions

(a) Candidates could not interpret the diagram correctly and hence could not determine the coordinates of M. Some used A(−1 ; 0) as the centre of the circle.

(b) In Q4.2 some candidates were unaware that N was the midpoint of CB.

(c) In answering Q4.3 some candidates used the gradient of the radius to be equal to the gradient of the tangent. Some candidates used the coordinates of A or B to determine the equation of the tangent even though A and B were not on the tangent.

(d) Candidates were able to calculate the critical values but were unable to use this information correctly when writing down the answer. They wrote: \( t \geq 3 \) or \( t \leq 1 \), \( 3 < t < 1 \) or \( t > 3 \) or \( t < 1 \) as their answers. All of these were incorrect.

(e) Many candidates were able to calculate the coordinates of D but were unable to make any further progress in Q4.5.

(f) In many instances, candidates did not indicate the figures that they were working with. For example:

\[
\text{Area of quad BCDO} = \frac{1}{2} b \times h + \frac{1}{2} b \times h + l \times b
\]

\[
= \frac{1}{2} (2)(1) + \frac{1}{2} (\sqrt{2}) \times (1) + \sqrt{2} \times 2
\]

Suggestions for Improvement

(a) Teachers should encourage learners to analyse the diagram before attempting any questions. They must first write down any given information on the diagram and then make deductions from the given information.

(b) Teachers need to revise the concept of perpendicular lines and gradients, in particular that the tangent is perpendicular to the radius at the point of contact.

(c) Teachers should revise the work done in earlier grades.

(d) Learners should be reminded to refer to the information sheet for the relevant formula.
(e) Although learners determine the equation of a straight line from Grade 9, they should be reminded that the minimum requirements to determine the equation of a straight line is the gradient of the line and the coordinates of one point through which the line passes.

(f) Teachers should ensure that they expose learners to assessments that integrate Analytical Geometry and Euclidean Geometry. Learners must also be exposed to higher-order questions in class and in school-based assessment tasks.

**QUESTION 5: TRIGONOMETRY**

Common Errors and Misconceptions

(a) In Q5.1 candidates lacked knowledge of the reduction formulae. In particular, they reduced as follows:

\[
\cos(90^\circ - x) = \cos x \quad \text{or} \quad \cos(90^\circ - x) = -\sin x .
\]

(b) Candidates missed critical steps of working in Q5.2.

\[
\begin{align*}
\sin^2 35^\circ - \cos^2 35^\circ &= \frac{4 \sin 10^\circ \cos 10^\circ}{2 \sin 2(10^\circ)} \\
&= -\cos 2(35^\circ) \\
&= -\cos 70^\circ \\
&= -\frac{1}{2}
\end{align*}
\]

(c) Some candidates could not manipulate the double-angle expansion correctly when answering Q5.3. They incorrectly wrote \( 2 \cos^2 A \) as \( \cos 2A - 1 \) instead of \( \cos 2A + 1 \).

(d) Many candidates could not identify the compound angle expansion in

\[
\sin(x + 25^\circ)\cos 15^\circ - \cos(x + 25^\circ)\sin 15^\circ .
\]

Instead of writing this as \( \sin \left( (x + 25^\circ) - 15^\circ \right) \), many candidates expanded \( \sin(x + 25^\circ) \) and \( \cos(x + 25^\circ) \). This made the question more complicated.

(e) Many candidates could not understand what was required in Q5.4.2 and hence they did not attempt it.

Suggestions for Improvement

(a) Learners need to understand the reduction formulae and know which formula to use in the given situation. They must take cognisance of the quadrants when determining the signs of trigonometric ratios.

(b) Learners must be advised to show all steps when working with reduction formulae. Marks are not awarded to candidates who make errors with the signs.
(c) Learners should master fundamental algebraic manipulation. These skills are integral in simplifying trigonometric expressions.

(d) Learners need exposure on the simplification of expressions containing double and compound angles. Examples should include variables for angles as well as specific angle values. Learners should also be required to write down the compound angles when given the expansion.

(e) Teachers should ensure that learners revise Grade 11 Trigonometry regularly in the Grade 12 year.

QUESTION 6: TRIGONOMETRY

Common Errors and Misconceptions

(a) In Q6.1 many candidates were confused between domain and range. Some candidates gave an answer in terms of $x$. Some candidates did not identify graph $f$ correctly and gave the range of the incorrect graph. Some candidates wrote down the interval incorrectly as $0 \geq y \geq -2$.

(b) In Q6.2 some candidates were unable to read off the critical values correctly and consequently were unable to answer when graph $f$ was decreasing.

(c) In answering Q6.3, many candidates inadvertently calculated the points of intersection of the two graphs by letting $PQ = 0$. They did not realise that they were stating that the distance between the two graphs was zero. This was very different to what the question required. Some candidates were able to arrive at the expression $PQ = -2\sin^2 x - \sin x + 2$ but could not proceed any further.

Suggestions for Improvement

Teachers should not confine the teaching of graphs to sketching. Learners should also be exposed to exercises in which they have to interpret graphs and read off solutions from the graphs.

QUESTION 7: TRIGONOMETRY

Common Errors and Misconceptions

(a) In Q7.1 some candidates did not understand what ‘in terms of $x’ meant. Some candidates used the incorrect trigonometric ratio. Some did not substitute $\sin 60^\circ$ with $\frac{\sqrt{3}}{2}$.

(b) Some candidates could not recall the properties of a rhombus. Many candidates gave the answer to $KFC$ as $90^\circ$ and a few others gave the answer as $60^\circ$. 
(c) Some candidates did not understand that the two rhombuses were on two different planes, one was horizontal and the other was inclined. Candidates were not sure which rule to use to calculate the length of KF. Some candidates deduced that $\theta = 90^\circ$, $K\hat{C}F = 90^\circ$ and then used the formula for the area of a triangle to calculate the area of $\triangle AKF$.

**Suggestions for Improvement**

(a) Teachers should inform learners that ‘Determine AK in terms of $x'$ means that AK must be the subject of an expression and that the expression must be in terms of $x$.
(b) Teachers need to develop strategies to be used when solving right-angled triangles and triangles that are not right-angled. Teach learners the conditions that decide which rule should be used to solve the question.
(c) Learners should be encouraged to highlight the different triangles using different colours.
(d) Initially, expose learners to numeric questions on solving 3-D problems. This makes it easier for learners to develop strategies on how to solve such questions. Once learners have gained confidence with numeric type questions, they should then be exposed to non-numeric and higher-order questions.

**QUESTION 8: EUCLIDEAN GEOMETRY**

**Common Errors and Misconceptions**

(a) In Q8.1.1 to Q8.1.4 candidates either lost marks for incorrect or incomplete reasons or for naming angles incorrectly.
(b) In Q8.1.1 some candidates struggled to differentiate between a parallelogram and a cyclic quadrilateral. Some candidates used the exterior angle of a cyclic quadrilateral incorrectly, i.e. they made this statement $\hat{R} = \hat{S}_2 = 136^\circ$ [ext angle of cyclic quad].
(c) Some candidates incorrectly assumed that QWKR was a cyclic quadrilateral in attempting to answer Q8.1.2. Some candidates incorrectly indicated that $\hat{P} = 90^\circ$ [subt by dia].
(d) Candidates could not identify $P\hat{Q}W$ correctly. They were used to the angles being named as $\hat{Q}_Z$.
(e) Candidates could not differentiate between alternate and corresponding angles.
(f) In Q8.2.1 some candidates incorrectly assumed that the angles at T were $90^\circ$. They then used trigonometric ratios to calculate the sizes of $E\hat{F}D$ and $E\hat{C}D$. Some candidates incorrectly deduced that since $EF = 9$ and $DC = 18$ then $EF \parallel DC$ [midpoint theorem].
(g) In answering Q8.2.2 some candidates used the reason ‘angles in the same segment’ instead of the converse of this theorem.

**Suggestions for Improvement**

(a) Learners should be encouraged to scrutinise the given information and the diagram for clues about which theorems could be used in answering the question.

(b) Teachers must cover the basic work thoroughly. An explanation of the theorem should be accompanied by showing the relationship in a diagram.

(c) Learners are encouraged to use the list of reasons provided in the *Examination Guidelines*.

(d) Teachers need to insist that learners name the angles correctly. The fact that learners are naming angles incorrectly at Grade 12 level indicates that this issue has not been dealt with effectively in earlier grades.

(e) Learners should be taught that all statements must be accompanied by reasons. It is essential that the parallel lines be mentioned when stating that corresponding angles are equal, alternate angles are equal, the sum of the co-interior angles is 180° or when stating the proportional intercept theorem.

(f) Learners should be given exercises where the converses of the theorems are used in solving questions.

**QUESTION 9: EUCLIDEAN GEOMETRY**

**Common Errors and Misconceptions**

(a) Candidates could not link the correct angle at the centre with the correct angle at the circumference.

(b) Some candidates incorrectly assumed that TMPO was a cyclic quadrilateral.

(c) Some candidates could not link $\hat{1}$ with $\hat{P}$.

**Suggestions for Improvement**

(a) Learners should be taught that all 4 vertices of a quadrilateral must lie on the same circle for the quadrilateral to be cyclic.

(b) Learners should be discouraged from writing correct statements that are not related to the solution. No marks are awarded for statements that do not lead to solving the question.

(c) Learners should be forced to use acceptable reasons in Euclidean geometry. Teachers should explain the difference between a theorem and its converse. They should also explain the conditions for which theorems are applicable and when the converse will apply.
Learners need to be told that success in answering Euclidean Geometry comes from regular practice, starting off with the easy and progressing to the difficult.

QUESTION 10: EUCLIDEAN GEOMETRY

Common Errors and Misconceptions

(a) Many candidates did not show or state the construction, nor did they indicate the construction correctly on the diagram. Most failed to indicate that the heights were perpendicular to the sides of the triangle. Some candidates used the incorrect triangles in their proof. This did not lead them to the desired conclusion. Some could not provide the correct reasons in Q10.1.

(b) In Q10.1.2 candidates assumed that WSTV was a cyclic quadrilateral. Some candidates wrote incorrect statements: \[ \hat{W}_2 = \hat{V}_1 = x \] [alt angles, WT \parallel RV] and \[ \hat{W}_2 = \hat{S}_2 = x \] [both = x].

(c) It became confusing for candidates who assumed that WSTV was a cyclic quadrilateral in Q10.1.2 to now prove that WSTV was a cyclic quadrilateral in Q10.2.2(a). Again, many gave the reason as ‘angles in the same segment’ when the converse was applicable.

(d) In Q10.2.2(b) many candidates incorrectly started their answer with WR = WV and therefore struggled to conclude that \( \triangle WRV \) was isosceles.

(e) Many candidates could select the correct pairs of equal angles that will result in \( \triangle WRV \) being similar to \( \triangle TSV \). Instead they stated a number of angles that were each equal to \( x \) and then concluded that \( \triangle WRV \parallel \parallel \triangle TSV \).

(f) In answering Q10.2.2(d) many candidates could only state that \( \triangle WRV \parallel \parallel \triangle TSV \). They could not proceed any further.

Suggestions for Improvement

(a) More time needs to be spent on the teaching of Euclidean Geometry in all grades.

(b) Learners need to be told that there is no short-cut to mastering the skills required in answering questions on Euclidean Geometry. This requires continuous and deliberate practice.

(c) Learners need to be made aware that writing correct but irrelevant statements will not earn them any marks in an examination. Learners must refrain from making assumptions.

(d) Learners need to be exposed to questions in Euclidean Geometry that include the theorems and the converses.