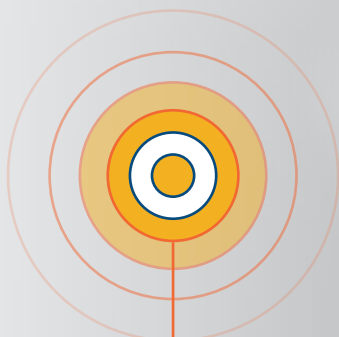
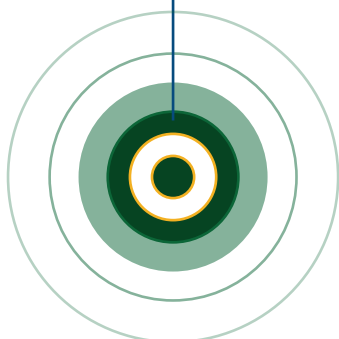




2021 NATIONAL SENIOR CERTIFICATE

DIAGNOSTIC REPORT PART 3: TECHNICAL SUBJECTS



basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA



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Foreword from the Minister

The Class of 2021 will remember their Grade 12 year as one of challenge and triumph, as the country grappled with the unknowns of new Covid-19 variants and managing its subsequent effects on the education sector.

The year 2020, when the Class of 2021 faced great uncertainty in their Grade 11 year, will be recorded in the annals of history as an *annus horribilis*. It is not a year on which we will look back with undiluted pleasure.

The Class of 2021 sat for the National Senior Certificate (NSC) examinations in an academic year that was the second most challenging one in their school career due to the adverse effects of the Covid-19 pandemic.

By South Africans' concomitant actions, we are enabled to provide quality public schooling in our lifetime. With the support of our stakeholders in education, the challenges in 2021 were dealt with in a strategic manner. The Department of Basic Education and Public Examinations lived up to the expectations to administer credible public examinations.

The education sector faced numerous challenges in 2021 but the true heroes, our teachers, principals, subject advisors and all officials in the sector confirmed that persistence conquers all challenges. It was heartwarming to witness how teachers reported for duty long before their



official working hours, offered additional classes over weekends and school holidays and left no chalk unfinished to offer their relentless support to the Class of 2021. I salute you!

In 2021, South African Sign Language Home Language (SASL HL) candidates sat for the fourth SASL HL examinations in the National Senior Certificate Examinations.

Furthermore, the DBE adapted 61 question papers for Braille candidates, and 55 question papers for Deaf candidates, while 72 question papers were made available in large print. In addition, 63 question papers were offered in audio version in the November 2021 examinations.

A dynamic education system keeps abreast with the demands of the fourth industrial revolution. In 2021, Marine Sciences was offered for the first time as an examinable subject in the Grade 12 NSC examinations.

Various technical vocational specialisations, Technical Mathematics and Technical Sciences were offered for the fourth year since their introduction in

2018. A remarkable improvement in the 2021 NSC results was noted in both Technical Sciences and Technical Mathematics.

In the face of the challenges posed by the pandemic, the 2021 learner support programmes encompassed a broad collection of educational strategies, including supplementary materials, vacation classes (during autumn, winter and spring vacations), after-school classes, teacher content with pedagogical and assessment support, mobilising volunteer tutors, as well as alternative and differentiated ways of grouping and teaching learners.

Schools also provided learner support programmes to address specific performance results or trends. NGOs, corporates, institutions of higher learning, community groups, and volunteer-based learning programmes, often worked in partnership with schools and provided highly valuable support to our learners – for that we remain grateful. Stakeholders and partners in education contributed immensely to the readiness of the Class of 2021 for the NSC examinations.

The Quality Assurance Council, Umalusi, approved the 2021 NSC results. The Class of 2021 attained an improved pass rate of 76.4%! It must be noted that the approval was preceded by punctilious verification of all examination processes. This approval confirms the milestones achieved by the DBE in 2021. South Africa offers a credible public examination system, comparable internationally.

The integrity of the 2021 NSC examinations is further confirmed by the fact that none of the high-quality question

papers was compromised by serious irregularities, such as leakages. This will allow the National Senior Certificate of 2021 to be acknowledged as credible by the higher education institutions, employers and our people.

The National Senior Certificate has stood the test of time and after 12 years of teaching and learning, this qualification has intrinsic value for both individuals and society.

Once again, I wish to thank parents, teachers, principals, teacher unions, communities, district and provincial officials, and social partners for carrying the Class of 2021. I believe that our unity will make us find new frontiers of cooperation and innovation. I am confident that by working together yet again, we can support the Class of 2022 in the manner that we supported their predecessors.

All social partners have a role to play in fulfilling the Freedom Charter's clarion call that: 'The Doors of Learning and Culture Shall be opened!'



**MRS AM MOTSHEKGA, MP
MINISTER OF BASIC EDUCATION
20 JANUARY 2022**



CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION, SCOPE AND PURPOSE

The Class of 2021 entered the formal schooling system in Grade 1, in January 2010. This cohort has had the advantage of being the eighth cohort to be exposed to the *Curriculum Assessment Policy Statement (CAPS)*. The Class of 2021 is the first cohort to sit for the newly introduced Marine Sciences and the second cohort to sit for two question papers in Accounting and Business Studies.

They are also the fourth cohort to offer a series of new subjects in the Grade 12 NSC examinations. These include South African Sign Language at Home Language level (SASL HL), Technical Mathematics, Technical Sciences, Civil Technology (Construction/Civil Services/Woodworking), Electrical Technology (Digital Systems/Electronics/Power Systems) and Mechanical Technology (Automotive/Fitting and Machining/Welding and Metal Work).

These learners are therefore the beneficiaries of the educational transformation that heralds the move towards a technologically enhanced curriculum.

The 2021 Diagnostic Report delves into key observations in learner performance. Therefore, it serves as a primary resource for teaching and learning in the ten high-enrolment subjects, Afrikaans First Additional Language, English First Additional Language, the 12 official home languages, the technologies, technical subjects and Engineering Graphics and Design. This report needs to be used in conjunction with the 2015 to 2020 diagnostic reports. The seven reports outline key subject didactic principles and content matters that can be used effectively in the classroom in 2022.

On conclusion of the marking processes for the November 2021 examinations, the chief markers, internal moderators and subject specialists compiled subject reports that outline qualitative data. The 2021 diagnostic report is based on this data. In the ten key subjects and English First Additional Language, quantitative data was gathered from the analysis of 100 scripts per paper, per subject, randomly selected from each province.

This qualitative and quantitative data highlight the areas of weakness in each of the identified subjects and articulate the remedial measures to be adopted at school level to improve performance in these subjects. As a result, this National Diagnostic Report on learner performance provides teachers, subject advisors, curriculum planners and curriculum implementers with a picture of learner performance in each of the key subjects.

Each subject's diagnostic report commences by presenting comparative data on the performance trends observed over a five-year period in the subject from 2017 to 2021. In the ten key subjects and English First Additional Language, it also provides an overall performance of candidates per question in the respective question papers, in each subject. In all subjects, common errors, misinterpretations and misconceptions identified during marking and suggestions for improvement are also outlined.

Although the pandemic was cited in numerous reports as a possible reason for poor performance in certain examination centres and certain subjects, it cannot be ignored that content coverage was compromised and that teaching methodology needs targeted intervention in 2022.

It is imperative that Subject Advisory Services devise intervention measures to address recurrent areas of weakness. This diagnostic report needs to serve as a baseline for intervention in 2022. This also suggests that continued reference to previous diagnostic reports is essential since the areas of weakness identified in previous years may still be applicable in certain cases.

1.2. METHODOLOGY

In the ten high-enrolment subjects and English First Additional Language, 100 scripts per question paper were randomly selected from each province during the marking. These scripts included samples of low, medium and high achievement scores. The internal moderators and chief markers analysed and noted learners' responses to each question. This entailed recording the marks obtained by learners from the 100 scripts on a per question basis. The individual scripts were scrutinised to provide an in-depth understanding of the range of different responses and to note the strengths and weaknesses. Particular attention was given to common errors and misconceptions identified in the learners' responses.

Based on the analyses, a detailed explanation is provided per question/subquestion under the following three main titles:

Section 1: Performance trends (2017–2021)

A comparative analysis of the performance of learners over the last five years in terms of the number of learners who wrote, the number and percentage of learners who achieved at 30% and above, and the number and percentage of learners who achieved at 40% and above, is presented in this section. The information is represented by tables and graphs to enable easier interpretation of any trends, especially on changes over the medium term, as well as changes from year to year.

Performance distribution curves are also provided to graphically present the distribution of learner scores in the last three examinations. Any improvement or decline in the performance can be observed from the position of the 2019 graph, relative to previous years. If the 2020 graph lies to the right of the two previous graphs, this suggests an improvement in performance, while a slant to the left indicates a decline in performance.

Section 2: Overview of learner performance

This section summarises the performance of learners in the question paper as a whole. It makes reference to generic areas of good performance or weakness and the possible reasons for these observations.

Section 3: Diagnostic question analysis

This includes the following:

- A graphical representation of the average percentage marks obtained per question
- An analysis of the performance of learners in each specific question, stating whether the question was well answered or poorly answered (and the reason)
- Common errors and misconceptions that were identified in candidates' responses
- Suggestions for improvement in relation to teaching and learning, content and methodology, subject advisory support and provision, and utilisation of LTSM

The internal moderators' reports from all nine provinces for each question paper, per subject, were consolidated and the findings are summarised in this report.

It is recommended that this report be read in conjunction with the November 2021 NSC question papers since particular references are made to specific questions in the respective question paper, in each subject. This will enable teachers to establish a baseline for the new cohort of Grade 12 learners in 2022; develop strategies for differentiated learning and provide a frame of reference for the development and design of school-based assessment during the course of the year.

1.3. LIMITATIONS

While further quantitative data would have been useful to provide feedback for the purpose of test development, this is not the intention of this report. The focus of this report is more qualitative than quantitative. The quantitative aspects are limited to the performance trends in each subject and the average performance per question in the 2021 examination papers.

It needs to be noted that areas of weakness could be unique to each district and each school. Therefore, this report provides a national summary of the general areas of weakness. However, district specialists are encouraged to develop a district diagnostic report. Ultimately, there should also be a school diagnostic report, which focuses specifically on the areas of weakness at school level.

The diagnostic analysis of learner performance in this publication is limited only to the ten subjects with high Grade 12 enrolments, Afrikaans First Additional Languages, English First Additional Language and the 12 official home languages, the technologies and technical subjects. The remaining subjects will be covered in reports compiled by the provincial chief markers and internal moderators during the marking process. The DBE will endeavour to broaden the scope of the subject coverage in future.

1.4. GENERAL FINDINGS AND AREAS OF CONCERN

The 2021 diagnostic reports for the ten key subjects covered in this publication (Part 1), indicate that the pass rate has improved in five of these subjects (Agricultural Sciences, Business Studies, Life Sciences, Mathematics and Physical Sciences) at the 30% levels. However, the pass rate has declined to varying degrees at the 30% level in the remaining key subjects. The pass rate for English First Additional Language decreased at both the 30% level and at the 40% level. In the home languages (Part 2) the pass rate remained the same in isiNdebele, Setswana and Tshivenda, improved to varying degrees in three home languages (isiXhosa, isiZulu and Sesotho) and declined in the rest. The most notable decline in the pass rate at 40% was observed in English Home Language.

It is imperative that we reflect on and learn from the performance of candidates of the 2021 NSC examinations.

The following areas of concern were identified in past diagnostic reports and they are, once again, highlighted as concerns in the 2021 NSC examinations.

- Although candidates performed well in questions that required lower-order thinking skills, many learners performed poorly in questions that demanded analytical, evaluative and problem-solving skills. In view of this, teachers are encouraged to expose learners to a wide array of exercises that also include questions that assess higher-order thinking skills.

- In addition to the above, it was observed that many candidates did not have a solid grasp of the subject matter, specifically complicated topics. The diagnostic report is geared towards addressing these concerns and the aim is that teachers need to devise intervention measures to improve on this concern.
- In subjects where new topics were introduced or the formats of question papers changed, it was evident that many candidates were not fully familiar with the new expectations. Teachers and subject advisors need to be well informed of the changes in the CAPS and the *2021 Examination Guidelines*.
- In most home languages, it was noted that candidates were not able to recognise the demands of abstract topics and higher-order questions. There is therefore a need to enhance thinking in an abstract context in languages. Challenging topics need to be included in the classroom and homework exercises to allow learners to get accustomed to employing critical language skills to think analytically and critically.
- In all languages, it was witnessed that many candidates were not aware of the various formats of transactional texts. It is advised that teachers revise the required formats on a regular basis throughout the academic year. Informal writing must be taught as per the CAPS prescripts. Learners' writing skills will improve if informal writing activities become part of classroom and homework activities. This pertains to all grades and all subjects. A few suggestions to encourage writing in schools is to launch a letter writing competition, establish school newspapers and allow learners to write articles.
- Once again, in 2021, it was noted that a large number of candidates did not understand the vocabulary used in questions, extracts and comprehension texts. Schools are encouraged to initiate reading projects/reading periods/vocabulary/dictionary exercises to expand learners' vocabulary. Teachers are encouraged to expose learners to a wide array of texts to build their vocabulary, improve their comprehension skills and sharpen their critical thinking skills.
- There was a remarkable improvement in both Technical Sciences and Technical Mathematics but it can be deduced from weaker candidates' responses that focused intervention strategies need to be initiated and implemented to ensure that candidates have a solid understanding of the more complex topics.
- In SASL HL, it was observed that candidates did not give sufficient responses in the writing papers and literature. It is imperative that literature needs to be studied in detail and candidates need to be accustomed to the register, style and conventions for transactional writing texts.

1.5. KEY RECOMMENDATIONS

1.5.1 Examination Guidelines and changes in the CAPS

It is imperative that teachers and subject specialists fully familiarise themselves with the changes introduced in the CAPS, and subsequently the *2021 Examination Guidelines*. This entails that teachers need to be well informed about the new topics, format of question papers and restructured mark allocation to topics.

1.5.2 Diagnostic reports from 2015 to 2020

The diagnostic reports published from 2015 to 2021 are pertinent to gain a holistic grasp of learners' performance and to identify weaknesses in the teaching and learning of the ten key subjects (Part 1). Part 2 of this diagnostic report, published for the first time in 2017, will serve

as a teaching and learning tool in the language classroom. Part 1, Part 2 and Part 3 must be used in preparing the Class of 2022 for the NSC examinations.

1.5.3 Past question papers

Teachers are discouraged from teaching to the paper. However, past question papers should be used as teaching and learning resources, particularly for revision purposes. It must be stressed that the CAPS and the examination guidelines for each subject must be followed to ensure that all topics are covered. It must also be noted that in instances where the format of a question paper changed, candidates need to be made aware of such changes.

1.5.4 Language in teaching

Language Across the Curriculum (LAC) acknowledges the fact that language education does not only take place in specific subjects explicitly defined and reserved for it, such as the home languages, first additional languages and second additional languages. Language learning also takes place in each subject in school, whether teachers or learners are conscious of it or not.

Consequently, it is imperative to develop a comprehensive understanding of language learning in school that takes place across all subjects – in addition to the central role of language as a subject itself and all that it involves. Language teaching across the curriculum aims to equip learners with the intellectual and linguistic abilities to learn, understand and conceptualise subject matter. This linguistic dimension in each learning activity is sometimes hidden and partly implicit and therefore often underestimated in its importance.

In an effort to build learners' language proficiency and their confidence in decoding both the Language of Learning and Teaching (LoLT) and the language of assessment, teachers are encouraged to add their own language aspects, as these apply within the context of their schools or classrooms. The following points serve as a guide to teachers:

- It was observed in the marking of the November 2021 examinations that while candidates may have a good grasp of subject matter, many do not have adequate language skills to formulate responses in addressing the requirements of questions.
- Coupled with language skills, a lack of a solid understanding of examination techniques impact negatively on candidates' performance. There needs to be greater emphasis on aspects of language competence, time management and examination technique.
- In view of the point above, it is imperative that learners must have a firm understanding of action verbs that are used in the phrasing of questions. It is also essential that learners understand the meaning of each action verb in its context and in terms of the cognitive demand that is expected.
- Subject terminology and definitions must be clearly understood by learners. A firm understanding of subject matter can only be guaranteed if learners understand terminology and concepts used in the subject. It is suggested that a glossary of subject specific jargon and their definitions is provided to learners.
- Language and comprehension skills must be developed in each classroom across subjects.

1.5.5 Integrated intervention strategies

Given that the 2022 cohort of Grade 12s had an interrupted Grade 10 and Grade 11 year in 2020 and 2021, it is imperative that integrated intervention strategies are used to address gaps in teaching and learning. Such strategies could include the following:

- The extended lockdowns in 2020 and 2021 have proven the benefits of online study groups to facilitate revision activities and examination preparations. This practice needs to continue and expand. Platforms such as Microsoft Teams, Zoom and Google Classroom could be used to good effect.
- At the start of the academic year, teachers should provide the learners with the topics to be covered during the year and the relevant websites for each topic.
- Learners and teachers can gain access to online learning platforms such as YouTube that offer visual presentations and explanations of challenging topics. Teachers and subject specialists can source video clips and incorporate these in their lessons to give learners a clear understanding of subject matter.
- Learners who cannot log on to digital portals could be issued with DVDs, with the information from various websites. Hard copies of the information should be provided to learners who do not have access to electricity and/or technology. This is particularly important as the pandemic has highlighted the great divide between those who have online access and those who do not.
- Teachers from different schools in a given circuit or district could collaborate to support one another in mediating challenging topics to learners.
- Challenging topics must be revisited regularly during the course of the academic year, through extension activities and they should form the basis of all extra classes. Stronger candidates can be paired with weaker candidates to complete assignments on challenging topics.
- Teachers from different schools can build an item bank of higher-order questions and this bank can be used as a resource for revision purposes.

1.6. RESPONSIBILITIES

Provincial Education Departments

- Given that the target audience of this report includes the teacher and learner, this report must be cascaded from the provincial to the district level and finally to the school.

Subject Advisors and District Officials

- Subject specialists should do a baseline assessment of the 2022 Grade 12 cohort to establish the impact that the pandemic had on teaching and learning during 2020 and 2021, in terms of Grade 11 content coverage.
- It is also important that subject advisors emphasise that the Revised Annual Teaching Plan reflects the *minimum* requirements of the subject.
- Subject advisers are encouraged to convene meetings/workshops (on online platforms or in groups that adhere to Covid-19 protocol) that aim to mediate this diagnostic report. It is further suggested that the use of this diagnostic report must be encouraged during on-site support visits.

- Subject advisers should also monitor the improvement plans of their teachers, looking specifically for the inclusion of recommendations emanating from the individual subject reports.
- District officials should closely monitor curriculum coverage to ensure that all the topics in a subject have been covered according to the Revised Annual Teaching Plan (ATP). This will ensure that all topics receive due attention, allowing candidates to be better prepared for the examination.
- The monitoring process also needs to focus on the standard and quality of the assessment tasks used for SBA, as these tasks prepare learners for the NSC examinations. They also provide an opportunity for the teaching and learning interventions to gain traction well before the NSC Examinations.
- Subject Advisors should direct teachers to websites that will enhance teaching and learning.

1.6.3 Teachers

- With the pandemic still posing a possible threat to normal schooling, teachers should ensure that learners are provided with adequate resources to facilitate self-regulated learning.
- In order to develop learners' holistic understanding and applied competence, teachers must prepare learners adequately by creating learning opportunities to reflect, analyse and evaluate the content.
- Teachers should ensure coverage of the curriculum and the full range of cognitive levels in their teaching and assessment strategies. The mere recall of procedures or specific content on the part of learners will not enable them to respond fully to the demands of the question paper.

CHAPTER 2

TECHNICAL MATHEMATICS

The following report should be read in conjunction with the Technical Mathematics Paper 1 and Paper 2 question papers for the NSC November 2021 examination.

2.1 PERFORMANCE TRENDS (2018–2021)

In 2021, 13 403 learners sat for the Technical Mathematics examination. The number of candidates increased by 2 672 in 2021.

The performance of the candidates in 2021 shows a very significant increase when compared to the performance in 2020. The pass percentage at 30% (Level 2) improved from 32,4% in 2020 to 60,1% in 2021.

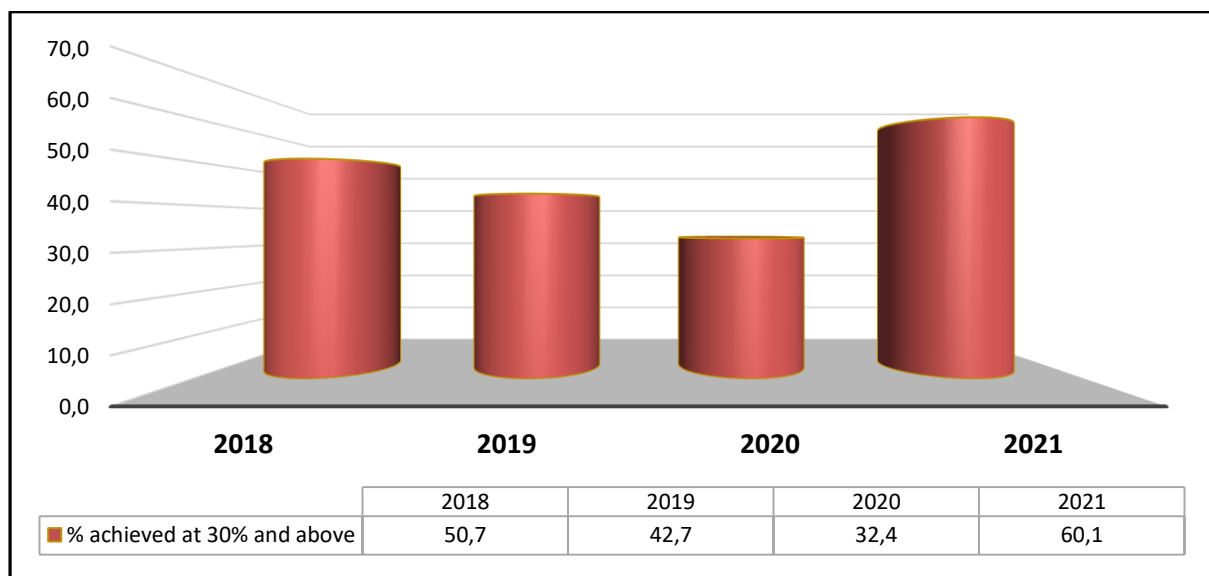
It was also very encouraging that 17,2% of candidates achieved over 50% this year in comparison to 8,4% of candidates doing so in 2020. This could be attributed to the inclusion of a PAT in the subject.

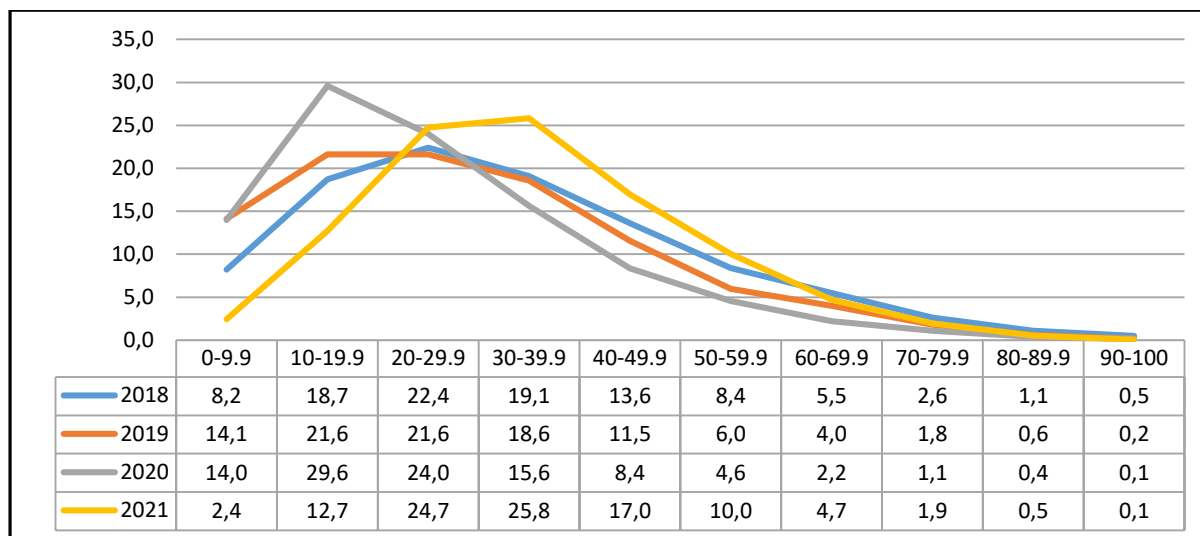
The percentage of distinctions (80% and above) increased marginally from 0,5% in 2020 to 0,6% in 2021. This translates to an increase in the distinctions from 54 in 2020 to 80 in 2021.

Table 2.1.1 Overall achievement rates in Technical Mathematics

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	10 025	5 078	50,7
2019	9 670	4 125	42,7
2020	10 731	3 476	32,4
2021	13 403	8 060	60,1

Graph 2.1.1 Overall achievement rates in Technical Mathematics (percentage)



Graph 2.1.2 Performance distribution curves in Technical Mathematics (percentage)


Revision of work from earlier grades will play an integral part in improving performance in the subject. There is still room for improvement in the performance of candidates if the challenges surrounding mathematical skills, conceptual understanding and integration of topics are addressed.

As stipulated in the Technical Mathematics CAPS, 'Mathematical modelling is an important focal point of the curriculum' and that 'Real-life technical problems should be incorporated into all sections whenever appropriate'. Adequate attention should be paid to this comment. Performance will be further enhanced if candidates improve their ability to solve problems.

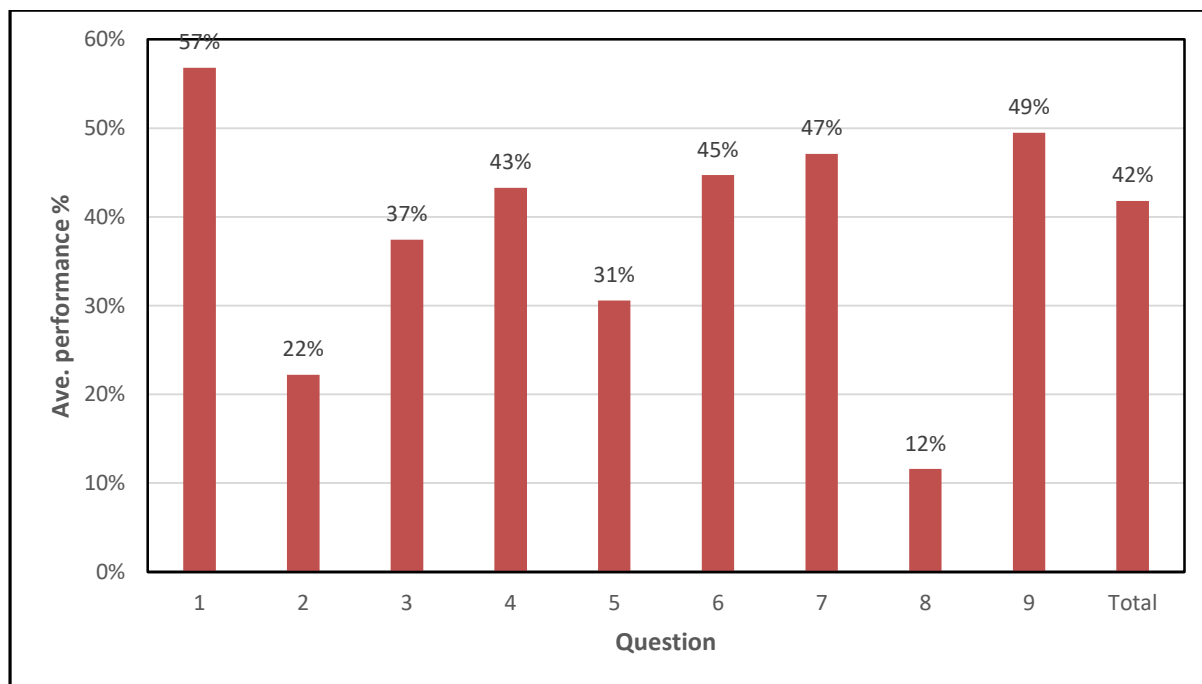
2.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 1

General comments

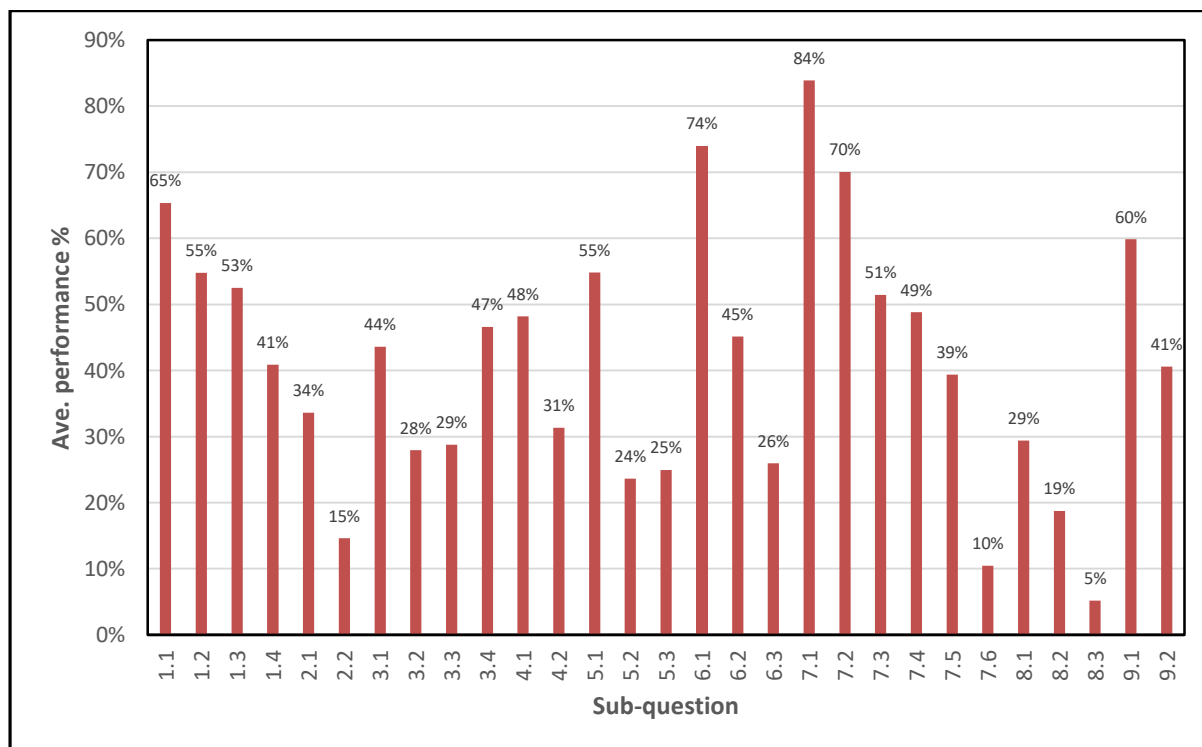
- Candidates performed very poorly in questions involving applications and modelling.
- Performance in topics taught in earlier grades was poor in comparison to performance in topics done in Grade 12. This was probably due to inadequate time being allocated for revision of work from the earlier grades.
- Higher-order questions such as the interpretation of graphs as well as measurement and mensuration were either not answered or poorly answered. Questions in which topics were integrated proved to be challenging for many candidates.
- Candidates did not adhere to the instructions as stipulated in the question paper.

2.3 DIAGNOSTIC QUESTION ANALYSIS OF 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 2.3.1 Average performance per question in Paper 1


Q	Topic	Q	Topic
1	Equations, inequalities & binary numbers	6	Differential calculus (differentiation)
2	Nature of the roots of quadratic equations	7	Differential calculus (Cubic function)
3	Exponents & surds, logarithms & complex numbers	8	Differential calculus (Maxima and Minima)
4	Functions and graphs	9	Integration
5	Finance, growth & decay		

Graph 2.3.2 Average performance per subquestion in Paper 1


2.4 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: EQUATIONS AND INEQUALITIES (ALGEBRA)

Common errors and misconceptions

- (a) In Q1.1.1 candidates did not realise that the factors were given. Instead, they expanded and got to a standard quadratic form and then factorised again incorrectly or used a quadratic formula. Some failed to get $x = 0$.
- (b) In Q1.1.2 some candidates failed to distribute the terms and copied the formula incorrectly. They displayed incompetency in using the calculator and rounding off to the required number of decimal places.
- (c) Many candidates had difficulty in interpreting the inequalities in Q1.1.3. They showed limited understanding of the meaning of 'or' and 'and'. They failed to differentiate between greater than and less than.
- (d) In Q1.2. candidates did not realise that x in the linear equation is the subject of the formula. They tried to create a third equation which had a fraction in it and found simplification a challenge later on in their answer.
- (e) Candidates failed to remove the radical sign by squaring in Q1.3. Many candidates failed to simplify and make L the subject.
- (f) In Q1.3.2 many candidates had difficulty in using a calculator after substitution and did not know what to do with 2π .
- (g) In Q1.3 candidates were unable to square a binomial, simplify correctly and then determine the correct standard form.
- (h) In Q1.4.1 many candidates failed to subtract the binary numbers and few omitted the base 2.
- (i) In Q1.4.2 some candidates were unable to convert a binary number to a decimal number.

Suggestions for improvement

- (a) Regular revision of topics done in earlier grades, e.g. factorisation, products, subject of the formula, solution of simultaneous equations and binary operations, is strongly suggested. Emphasise the writing of the correct notation and encourage the correct use of calculators.
- (b) In teaching inequalities, graphical representation of the solution must be emphasised. Teachers should integrate Algebra with Functions so that learners have visual understanding of the region of the graph that is applicable to the inequality under consideration and explain the difference between "or" and "and" in the context of inequalities. Teachers should expose learners to different methods of solving inequality problems so that learners may choose the method best suited to solving the problem.

QUESTION 2: NATURE OF ROOTS

Common errors and misconceptions

- (a) Some candidates failed to state the nature of roots satisfying the given conditions. In Q2.1.1, since the discriminant was negative, some concluded that roots are undefined.
- (b) In Q2.1.2 candidates failed to describe the nature of roots but instead solved for x .
- (c) In Q2.2 candidates omitted q when substituting in $\Delta = b^2 - 4ac$. They also used the '=' sign instead of '<' for non-real roots. Candidates accepted the positive value of q but rejected the negative value. This was incorrect.

Suggestions for improvement

- (a) Teachers should demonstrate and explain to learners that the discriminant, $\Delta = b^2 - 4ac$, originates from the quadratic formula $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$. In other words, the quadratic formula could be written as $x = \frac{-b \pm \sqrt{\Delta}}{2a}$. Teachers should emphasise that $\Delta = b^2 - 4ac$ is used to determine the nature of roots of the quadratic equation.
- (b) By integrating the topics of functions and nature of roots, teachers can explain to learners that *non-real roots* and *undefined* are different concepts.
- (c) Learners should be exposed to application involving the nature of roots. Examples should include proving problems about nature of roots applicable to given conditions.

QUESTION 3: EXPONENTS, SURDS, LOGARITHMS AND COMPLEX NUMBERS

Common errors and misconceptions

- (a) In Q3.1.1 many candidates could not write 81 in exponential form.
- (b) Some candidates failed to apply logarithmic properties in Q3.1.2.
- (c) Candidates had difficulty in multiplying surds in Q3.1.3. This would have enabled them to simplify the expression. Also, they were unable to convert from surd form to exponential form and apply exponential rules.
- (d) In Q3.2 some candidates failed to apply logarithmic properties and convert the log form into an exponential form. They confused $2 + \log_3 x$ with $2\log_3 x$ leading to $\log_3 x^2$.
- (e) Many candidates were unable to differentiate between the modulus and the real part of the complex number, p , in Q3.3.1. They showed a lack of understanding that $p^2 = \sqrt{4}$ has 2 roots. They only wrote 2 as the value of p , disregarding the given condition for p .
- (f) In Q3.3.2 candidates failed to get the correct angle within the given interval. They gave θ in terms of an acute angle.

- (g) In Q3.4 some candidates did not apply the distributive property. Furthermore, they did not equate the real part to a real part and imaginary part to an imaginary part.

Suggestions for improvement

- (a) Revision of all exponential, surd and logarithmic laws done in earlier grades by learners is strongly suggested in Grade 12.
- (b) Teachers need to strengthen the concept of factors and products and reinforce the method of converting from exponential form to surd and/or logarithmic forms and vice versa.
- (c) The use of calculators to check the correctness of their solutions should be emphasised to learners.
- (d) Teachers should expose learners to different types of problems involving complex numbers and ensure that learners adhere to the given instructions.

QUESTION 4: FUNCTIONS

Common errors and misconceptions

- (a) In Q4.1.1(a), (c) and (d) some candidates had difficulty differentiating between the intercepts and the turning point. They failed to factorise the quadratic equation and opted to use the quadratic formula. They swapped the values of a , b and c when substituting into the formula.
- (b) Many candidates failed to write the equation of the asymptote in Q4.1.1(b). Furthermore, they were unable to differentiate between a function value, asymptote and a parameter. They wrote the equation of the horizontal asymptote as $h(x) = 5$ and some wrote it as $q = 5$.
- (c) In Q4.1.2 some candidates could not sketch the graphs.
- (d) Some candidates struggled with interpreting Q4.1.3. They were unable to identify and substitute the parameters correctly. They substituted the y -value of the given point for q , which is an asymptote, and 0 for $p(x)$.
- (e) In Q4.2.1, Q4.2.2 and Q4.2.3 candidates were unable to identify the characteristics of graphs. They failed to write the equation of the semi-circle correctly. Some substituted the value of r and x . This was incorrect.
- (f) In Q4.2.4 candidates had difficulty with the interpretation of graphs.

Suggestions for improvement

- (a) Characteristics of graphs and the effect of parameters should be thoroughly demonstrated and explained to learners.
- (b) Teachers should point out to learners that when a question asks the equation of the asymptote, it should be presented as $y = \dots$ or $x = \dots$, depending on which asymptotes are required.

- (c) When learners do not recognise the correct shape of the graph, they should be advised to use several points from a table to draw functions.
- (d) Teachers should explain the meaning of inequalities and the definition and correct notation of the domain and range of a function.
- (e) Teachers should expose learners to different ways of determining the equations of the graphs.
- (f) Teachers should expose learners to different questions involving two graphs on the same system of axes. This should not be limited to drawing graphs but also the interpretation of graphs as well.

QUESTION 5: FINANCE, GROWTH AND DECAY

Common errors and misconceptions

- (a) Some candidates failed to express the fraction as a percentage in Q5.1.1.
- (b) In Q5.1.2 candidates failed to use the correct formula.
- (c) Many candidates had difficulty interpreting Q5.2. Some candidates did not realise that they had to use the reducing-balance depreciation formula. Some candidates interchanged the values of A and P . This was incorrect. Some candidates used the method of verification by using the compound growth rate. This was not acceptable. Many candidates did not realise that the final answer was $n > 5,67$ while they wrote $n = 5,67$ instead.
- (d) Some candidates used an incorrect formula in Q5.3.1. They failed to interpret the question correctly and used R15 000 instead of R25 000 as the value for P .
- (e) In Q5.3.2 many candidates showed a lack of understanding of the different compounding periods. Some candidates failed to use the correct formula. Most candidates did not realise that R6 823,54 had to be added to the value of the investment after 27 months.
- (f) Many candidates failed to use the calculator correctly and they did not make a conclusion.

Suggestions for improvement

- (a) Revision of work done in earlier grades, among others, fractions, percentages, interest, hire purchase, inflation and other real-life problems, is strongly suggested.
- (b) Learners should identify the correct formula from the information sheet given with the question paper.
- (c) Teachers need to explain to learners that in all formulae, P represents the initial value. In the case of a population, P represents the initial number and A represents the final number of species in the situation. Teachers need to emphasise that in scenarios that involve depreciation, the value of P will be greater than the value of A .
- (d) Teachers should also demonstrate to learners how to change the subject of the formula. It is advised that learners first substitute values in a formula and then change the subject of the formula.

- (e) All compounding periods (annually, quarterly, monthly, semi-annually/half-yearly and even daily) should be taught to learners. The use of timelines in order to better understand a complex problem involving several investments, deposits and withdrawals, is strongly advised.
- (f) Learners should be competent in using a calculator.
- (g) A good understanding of Financial Mathematics is best developed through practice.

QUESTION 6: CALCULUS

Common errors and misconceptions

- (a) In determining the derivative using first principles in Q 6.1, some candidates:
 - incorrectly used the rules for differentiation instead.
 - failed to copy the definition correctly from the information sheet.
 - used incorrect notation by omitting $\lim_{h \rightarrow 0}$ or by placing the = sign in the incorrect position $\lim_{h \rightarrow 0} = \frac{f(x+h)-f(x)}{h}$ or by using the incorrect notation $f(x) = \lim_{h \rightarrow 0} \frac{f(x+h)-f(x)}{h}$.
 - failed to substitute correctly into the formula. Some omitted brackets when substituting for $f(x)$.
- (b) In Q6.2.1 candidates failed to differentiate the expression correctly because it had 2 variables, x and p . They did not realise that p should be treated as a constant. They incorrectly wrote the derivative of p^3x^2 as $3p^22x$ or $6p^2x$.
- (c) Candidates had difficulty simplifying a fraction that contained exponents.
- (d) In Q6.2.2 most candidates failed to write the surd in exponential form, i.e., $\sqrt[3]{x^2}$ as $x^{\frac{2}{3}}$.
- (e) A few candidates integrated the given expressions instead of differentiating between them.
- (f) In Q6.3.1 many candidates failed to interpret the question correctly. They did not recall that when two lines are perpendicular to each other, then the product of their gradients is equal to -1 . This was possibly due to the fact that this concept is mainly assessed in Paper 2.
- (g) In Q6.3.2 many candidates demonstrated limited knowledge of the relationship between the gradient of the tangent and the derivative of the curve at the point of contact. They equated the derivative to 0 and solved for x instead of equating the derivative of the curve to the gradient of the tangent.
- (h) In Q6.3.3 candidates used an incorrect formula for average gradient. They incorrectly wrote Average grad. = $\frac{x_2 - x_1}{y_2 - y_1}$. Some candidates failed to get the correct values for $g(-2)$ and $g(3)$ because of poor simplification skills.

Suggestions for improvement

- (a) Learners should copy the formula for first principles correctly from the information sheet attached to the question paper.
- (b) Teachers should emphasise that when using first principles, correct notation should be used. The $\lim_{h \rightarrow 0}$ must be written down in each step and should only be left out when writing the final step, i.e. once the learner has substituted the value of h .
- (c) Simplification of expressions involving algebraic fractions should be revised with learners.
- (d) Learners should be exposed to various notations used in differentiation. The notations $f'(x)$ if $f(x) = x^n$, $\frac{dy}{dx}$ if $y = x^n$, $\frac{d}{dx}(x^n)$ and $D_x(x^n)$ all have the same meaning. Teachers should thoroughly explain the difference between the Derivative and an Integral of a function and demonstrate the difference of each by calculating the derivative and integral of the same function.
- (e) Differentiation involves working with the exponent. Revision of exponential and surd laws is encouraged before starting with the topic of differentiation.
- (f) Teachers should define the derivative in relation to gradient at a point on a curve or gradient of a tangent and demonstrate this relationship using dynamic mathematical software.

QUESTION 7: CUBIC FUNCTION

Common errors and misconceptions

- (a) Few candidates failed to calculate the y-intercept correctly in Q7.1
- (b) In Q7.2 some candidates demonstrated limited understanding of the Factor Theorem.
- (c) Some candidates did not realise that the information in Q7.2 should be used in Q7.3. They used a quadratic formula to solve for x in the cubic function. Some candidates calculated the coordinates of the turning points.
- (d) In Q7.4 some candidates calculated the x-intercepts instead of the coordinates of the turning points. Other candidates used the method of finding the turning point of a quadratic function without realising that this method was not applicable to cubic functions. Most candidates did not equate the derivative function to zero. Many candidates managed to calculate the two x-coordinates of the turning points correctly but failed to substitute these values into the original function when determining the corresponding y-coordinates.
- (e) Many candidates had difficulty drawing the graph as this question was dependent on the responses from Q7.1, Q7.2, Q7.3 and Q7.4. A few candidates did not attach their answer sheet nor did they draw the graph in their answer books.
- (f) Many candidates were unable to identify the interval in which the graph was decreasing. They made errors with the notation and/or critical values.

Suggestions for improvement

- (a) Teachers should explain the characteristics of graphs and demonstrate them by examples and illustrations.
- (b) Learners should read the given information carefully and respond to the questions asked.
- (c) Teachers should expose learners to various forms of graphical representations and all aspects of the functions, including sketching and interpretation of the graphs.
- (d) The concept of the derivative function and the turning point should be explained in detail. Teachers need to emphasise that the derivative function is equal to zero at the turning points. Teachers should indicate to learners that calculating the x-coordinate of the turning point using $x = -\frac{b}{2a}$ only applies to quadratic functions.
- (e) Teachers should explain the concept of minima and maxima and demonstrate to learners where the graph is increasing, decreasing and stationary by means of diagrams. Teachers should use a variety of available software to illustrate where the graph is decreasing, increasing or stationary. This should assist in the interpretation of functions. Software such as Geometry Sketch Pad, Graph and GeoGebra are useful tools to demonstrate these concepts.

QUESTION 8: APPLICATION OF CALCULUS

Common errors and misconceptions

- (a) In Q8.1 many candidates used an incorrect formula for volume. Others failed to substitute correctly into the formula for volume and then make h the subject. They manipulated the given equation and solved for x .
- (b) Many candidates were unable to determine the expression for the surface area of the container in Q8.2.
- (c) In Q8.3 many candidates did not realise they needed to use the given total surface area in Q8.2 to solve for x . They wrote the height in terms of x in Q8.1.1. Some candidates failed to differentiate with respect to x . Further, they did not find the cube root when solving for x . After calculating the value of x , some candidates did not realise that they still needed to calculate the value of h .

Suggestions for improvement

- (a) Learners should be given tasks where they are required to manipulate different formulae involving prisms, solids, cones and pyramids etc. Teachers should demonstrate how these problems relate to the real-life context.
- (b) Learners should be exposed to examples involving contextual applications.
- (c) Learners need to be taught that when the question asks to 'Show/Prove that ...', it means calculate (justify by means of mathematically correct steps) what is given and the final answer reached must match what is stated in the question.

- (d) Teachers should explain to learners that the word 'hence' means to use the information obtained in the previous question to solve the question at hand.
- (e) Teachers should explain the concept of minima and maxima in the context of optimisation. In optimisation, teachers need to explain that the first step is to find the derivative, equate the derivative to 0 and then factorise or use the quadratic formula to calculate the value of x and then substitute the value of x in the original function to find the dimension to be optimised.

QUESTION 9: INTEGRATION

Common errors and misconceptions

- (a) In Q9.1.1 some candidates failed to remove the bracket before integrating the expression. Only a few candidates removed the bracket incorrectly.
- (b) Many candidates did not realise that the expression in Q9.1.2 is similar to the one given in the information sheet. Some candidates omitted C when determining the indefinite integral.
- (c) In Q9.2 candidates failed to write the correct notation for area when using integrals. Some candidates differentiated the expression. Candidates calculated the area of the shaded part even though it was given. Very few candidates substituted the boundaries in the given function without first integrating. Many candidates failed to equate the area of the shaded part to the area bounded by the curve and the x -axis between $x = k$ and $x = 4$.

Suggestions for improvement

- (a) Simplification of expressions covered in earlier grades should be revised.
- (b) Teachers should explain to learners that when determining indefinite integrals, the constant C must always be added. The use of the correct integral notation should be emphasised.
- (c) In the teaching of integration, learners should be taught to include the lower and upper boundaries when setting up the area notation for definite integrals. The use of brackets should be emphasised when substituting negative values.
- (d) The calculation of the area bounded by a function and the x -axis should be demonstrated so that learners can observe how the value of the constant influences the area.
- (e) Learners should be exposed to a variety of problems involving integration to enhance their understanding of the concept of integration.

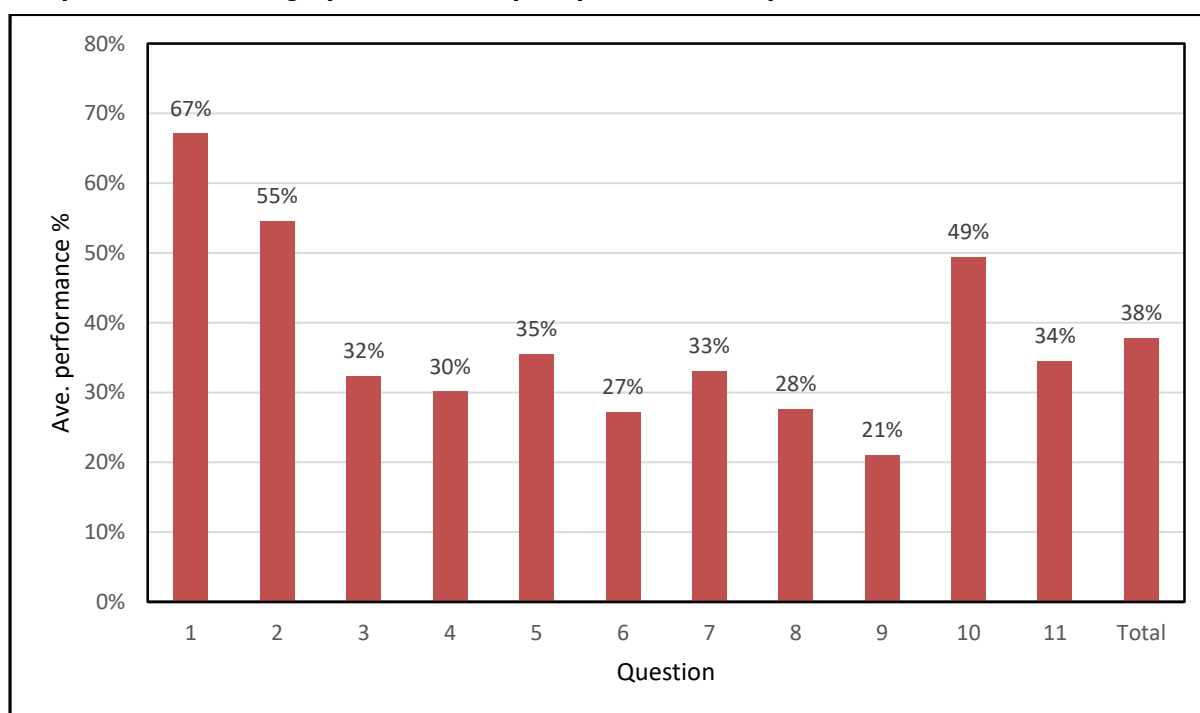
2.5 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN PAPER 2

- (a) Candidates performed relatively well in Q1. This question was based on Analytical Geometry. Candidates performed extremely well in questions involving gradient and the equation of the straight line, which are concepts covered in Grade 10.
- (b) Candidates performed poorly in Q3, Q4, Q6, Q7, Q8 and Q9 with Q9 being the worst answered question.
- (c) Candidates did not adhere to the instructions stipulated in the question paper.
- (d) Many candidates did not attempt the higher-order questions.

2.6 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 2

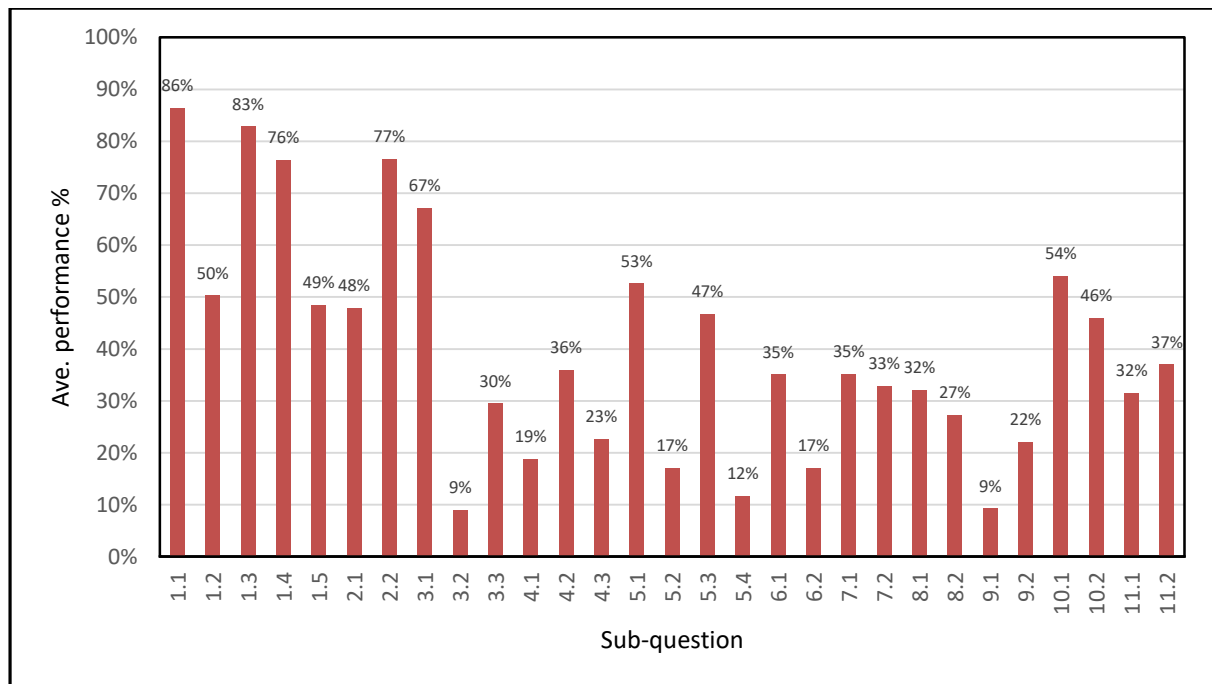
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful to assess the relative degrees of challenge of each question as experienced by candidates.

Graph 2.6.1 Average performance per question in Paper 2



Q	Topics	Q	Topics
1	Analytical Geometry - Lines	7	Euclidean Geometry - Circle with tangents
2	Analytical Geometry - Circle; Tangents; Ellipse	8	Euclidean Geometry - Circle - Cyclic quads
3	Trigonometry - General ratio's and equations	9	Euclidean Geometry - Proportionality
4	Trigonometry - Identities	10	Mensuration- Angular velocity
5	Trigonometry - Functions and graphs	11	Mensuration- Area and Volume
6	Trigonometry - 2D and 3D Applications		

Graph 2.6.2 Average performance per subquestion in Paper 2



2.7 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: ANALYTICAL GEOMETRY

Common errors and misconceptions

- (a) When answering Q1.2, candidates did not know that the reference angle was a positive acute angle. Some did not realise that the required angle was an obtuse angle.
- (b) In Q 1.4 candidates still made incorrect substitution into distance formula. Some candidates used irrelevant points in their calculation.
- (c) When answering Q1.5, candidates used the gradient calculated in Q1.1 instead of the negative reciprocal of the gradient calculated in Q1.1. These candidates confused the relationship of the gradients of perpendicular lines with that of parallel lines.

Suggestions for improvement

- (a) Learners should be taught that reference angle is an angle in the first quadrant, hence it should not exceed 90° .
- (b) When given the midpoint of a straight line and the coordinates of an end point, learners should not swap the coordinates when substituting into the midpoint formula. Teachers should emphasise correct substitution of x and y values.
- (c) Teachers should explain the difference in calculating the ratio of an angle and the size of an angle.
- (d) Teachers should emphasise the conditions for lines to be parallel and perpendicular. Learners should know the difference between the length of a line and its gradient.

QUESTION 2: ANALYTICAL GEOMETRY

Common errors and misconceptions

- (a) Some candidates calculated the value of r correctly but then did not write the equation of the circle.
- (b) Most candidates did not realise that they had to swap the signs of the coordinates of B in order to obtain the coordinates A.
- (c) In Q2.1.3 candidates were unable to answer questions that required them to “Show that ...”. Most assumed the value of t and used it to calculate the gradient of BC. This was not accepted as correct.
- (d) When answering Q2.1.4, some candidates did not use the value given in Q2.1.3 and the coordinates of B. This meant that the answer did not respond to the question asked.
- (e) Some candidates could not calculate the value of t because they could not determine the equation in Q2.1.4.
- (f) In Q2.2 some candidates did not use the square roots of 49 and 4 to determine the intercepts, hence their sketch was incorrect.

Suggestions for improvement

- (a) Learners should be trained to write down given information on the sketch.
- (b) Learners should be taught the rules for the various transformations of a point on a circle. It will help them to determine the coordinates of the translated points on the circle with ease.
- (c) Teachers should teach learners that ‘show questions’ require learners to use information available to arrive at what they are required to show.
- (d) Teachers should always integrate different topics in their teaching. The concept of the gradient of the tangent at a point requires the application of Euclidean Geometry.
- (e) Teachers should inform learners that they should use as given information that which they were expected to show in a previous question when answering subsequent questions.
- (f) Learners should be taught to how to determine the x- or y-coordinate of a point if they are given the coordinates of another point and the gradient of the line passing through these two points.
- (g) Learners should know the standard form of the ellipse and that when drawing, the values of a and b , and not a^2 and b^2 , are used

QUESTION 3: TRIGONOMETRY

Common errors and misconceptions

- (a) In Q3.1.1 some candidates misplaced the brackets in their calculation. They arrived at the incorrect answer of $\cos 15,8^\circ - \cos(2)74,1^\circ = -73,09$.

- (b) The coefficient of 3 in Q3.1.2 became a problem for many candidates as they made the following mistake in their final answer $\frac{1}{3 \sin 87,95^\circ}$ instead of $\frac{3}{\sin 87,95^\circ}$.
- (c) When answering Q3.2.1 many candidates did not draw a diagram or failed to use the quadratic identity. Many candidates did not understand the meaning of *write in terms of*.
- (d) In Q3.2.3 many candidates failed to reduce 317° to either 43° or 47° .
- (e) In Q3.3 many candidates stopped after calculating the reference angle and did not consider the interval for which they had to calculate the angle.

Suggestions for improvement

- (a) Learners should practise substituting correctly into an expression. They should also be aware that when calculating the value of a trigonometric ratio, the calculator assumes that the angle is within the set of brackets. Therefore, the correct use of brackets is important when calculating the value of trigonometric ratios, e.g. $\cos(2)74,1$ and $\cos[(2)74,1]$ will give two different answers on the calculator.
- (b) Learners should know that the coefficient of the reciprocal ratio is not affected when it is changed to trigonometric ratio. Teachers should demonstrate how to calculate the values of reciprocal trigonometric ratios using a calculator.
- (c) Teachers should emphasise the importance of drawing a diagram for the given ratio in the form of a right-angled triangle in the correct quadrant. This should allow learners to determine the third side and thereby enable them to write the values of all the trigonometric ratios and reciprocal trigonometric ratios for the given angle.
- (d) Learners should be taught reduction formulae in order to reduce angles to their equivalent acute angle.
- (e) Learners should practise algebraic manipulation skills and should be competent when performing these in calculating the magnitude of an angle for a given ratio.

QUESTION 4: TRIGONOMETRY

Common errors and misconceptions

- (a) Candidates did not recognise that the response to Q4.1 was a trigonometric identity.
- (b) Applying reduction formulae and simplifying trigonometric expressions using identities still proved to be a challenge in Q4.2.
- (c) In Q4.3 some candidates were unable to reduce angles given as radians.

Suggestions for improvement

- (a) Learners should be able to recognise identities where different symbols are used to represent the angle. It is advisable that the teacher uses a number of different symbols to represent angles in classwork.

- (b) Teachers should expose learners to a variety of problems that require reduction formulae and the use of different prescribed identities in simplifying trigonometric expressions.
- (c) Teachers should include reduction of angles given as radians when teaching reduction formulae.

QUESTION 5: TRIGONOMETRIC FUNCTIONS

Common errors and misconceptions

- (a) Most candidates managed to draw the required cosine graph in Q5.1. Some candidates were unable to draw the graph of $y = \sin x + 1$ correctly. They did not translate the graph of $y = \sin x$ one unit upwards.
- (b) Many candidates were unable to determine the period and range of the functions.
- (c) Some candidates still were unable to interpret the product of the functions. Some candidates did not realise that $f(x) - g(x) = 0$ represented the points of intersection of the functions.

Suggestions for improvement

- (a) When teaching trigonometric functions, teachers should discuss the effects of parameters a , p and q on the basic trigonometric graph.
- (b) As indicated in the previous report, teachers should explain the characteristics of each basic trigonometric function and how these characteristics change when the basic graph is transformed.
- (c) Teachers should also explain that $f(x) - g(x) = 0$ represents the points of intersection of f and g , i.e. where $f(x) = g(x)$.
- (d) They should also explain that the function is positive when it lies above the x -axis, zero when it lies on the x -axis and negative when it lies below the x -axis.

QUESTION 6: TRIGONOMETRY

Common errors and misconceptions

- (a) Some candidates were able to write down the length of LN in Q6.1.1.
- (b) In Q6.1.2 most candidates were unable to use the given information to determine KN, the length between the two cameras.
- (c) Most candidates did not attempt Q6.2 as they could not apply a congruency axiom to determine the length of RT and then apply the cosine rule.

Suggestions for improvement

- (a) Learners should be able to apply basic trigonometric ratios to determine the unknown side and angle of a right-angled triangle given the length of one of the sides and one of the acute angles.
- (b) Teachers should expose learners to problems that require them to add or subtract two lengths in order to calculate the required length.

- (c) Teachers should revise congruency axioms and expose learners to questions that integrate different topics.

QUESTION 7: EUCLIDEAN GEOMETRY

Common errors and misconceptions

- (a) Most candidates were unable to recall the statement of the theorem in Q7.1.
- (b) Candidates were unable to provide the reason in Q7.2.1.
- (c) Most candidates struggled to apply Circle Geometry theorems when a combination of these theorems was required to answer a question.

Suggestions for improvement

- (a) Learners should be encouraged to state theorems in full when they are engaging with questions on Euclidean Geometry.
- (b) Teachers should give learners more exercises to practise the application of circle theorems.

QUESTION 8: EUCLIDEAN GEOMETRY

Common errors and misconceptions

- (a) In Q8.2.2 most candidates managed to identify angles having a magnitude of 11° but struggled to give valid reasons for their statements.
- (b) Most candidates did not attempt the rest of the questions.

Suggestions for improvement

- (a) Teachers should revise theorems done in lower grades and show learners how to apply them as they move to Grades 11 and 12.
- (b) Learners should practise using the 'acceptable reasons' in classwork so that they get familiar with them.
- (c) Learners should be encouraged to indicate and add information on their diagrams as they unpack and solve riders.

QUESTION 9: EUCLIDEAN GEOMETRY

Common errors and misconceptions

- (a) Most candidates were able to recall congruency axioms in Q9.2.1. This prevented them from determining the length of BE.
- (b) Most candidates were unable to apply the proportionality theorems to calculate the lengths of AB, AT and FT.

Suggestion for improvement

Teachers should expose candidates to different ways of applying proportionality theorems even when the triangle has more than one pair of parallel sides given. They should be taught to view each triangle separately first, apply theorems and then look for connections.

QUESTION 10: CIRCLES, ANGLES AND ANGULAR MOVEMENT

Common errors and misconceptions

- (a) Some candidates struggled with conversion from revolution per minute to radians per second in Q10.1.1.
- (b) In Q10.1.2 most candidates used the correct formula but some made incorrect substitutions. Some calculated the two values of h correctly but did not indicate which of them is the correct length of PS.
- (c) Some candidates were still unable to convert an angle from degree to radians.
- (d) Most candidates were unable to use ratios to determine the radius of the smaller gear in Q10.2.4.

Suggestions for improvement

- (a) Teachers should revise the conversion of angles and time to different units as it is key in rotation, angles and angular movement. Some formulae require angle in radians and some formulae require time in seconds.
- (b) Learners should be exposed to high-order questions that require integration of different topics as was the case in Q10.2.4.

QUESTION 11: MENSURATION

Common errors and misconceptions

- (a) There was confusion among many candidates. They were unable to derive the correct formulae for the calculation of surface area and volume of various objects.
- (b) In Q11.1 some candidates copied the mid-ordinate formula incorrectly and some learners confused the value of “ a ” (the width) and the length of the rectangular portion.
- (c) Most candidates could not determine the area that was not covered with grass.
- (d) In Q11.2.1 most candidates did not subtract the area of the opening from the total area. Some candidates confused π as an angle in radian measure and not π as a number approximated to $\frac{22}{7}$.
- (e) In Q11.2.2 candidates did not express volume of the container and cylindrical bottle in the same unit.

Suggestions for improvement

- (a) Teachers need to encourage learners to use the information sheet and remind them to copy the formula correctly. They should also explain each of the variables in the formula.
- (b) Learners should be exposed to all the prescribed basic shapes and appropriate formulae for them. Once learners have gained confidence with working with the basic shapes, then teachers should consider alterations to the basic shapes.
- (c) Learners should be taught that when they compare objects in general, they should first express them in the same unit.

CHAPTER 3

TECHNICAL SCIENCES

The following report should be read in conjunction with the Technical Sciences question papers of the NSC November 2021 examinations.

3.1 PERFORMANCE TRENDS (2018–2021)

In 2021, 14 642 candidates sat for the Technical Sciences examination, 2 987 more candidates than in 2020.

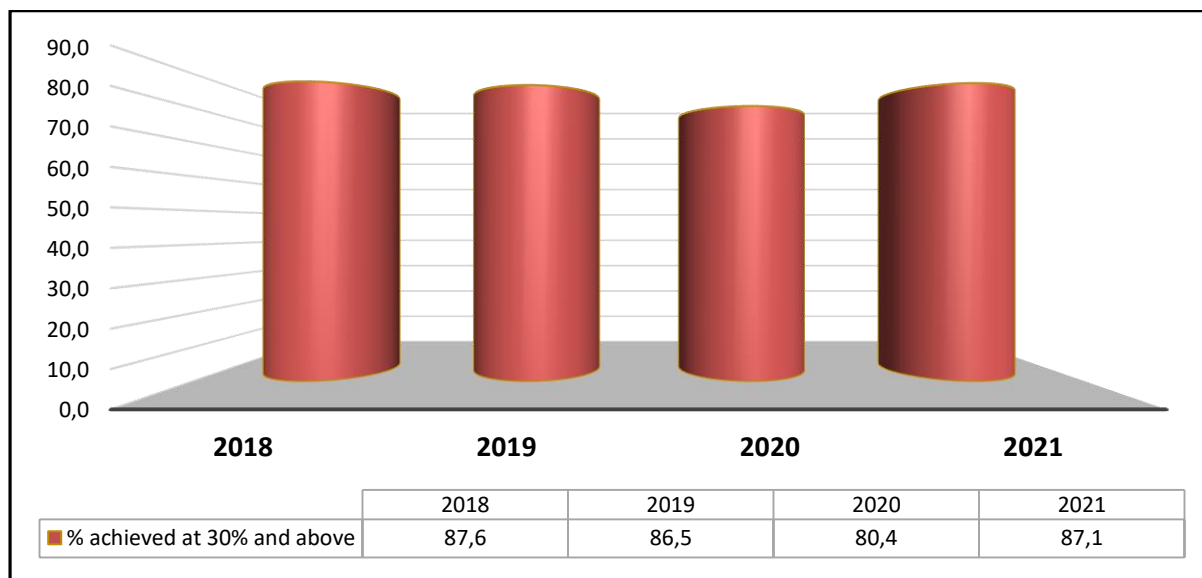
The performance of the candidates in 2021 shows a significant increase when compared to the performance in 2020. The pass percentage at 30% (Level 2) increased from 80,4% in 2020 to 87,1% in 2021.

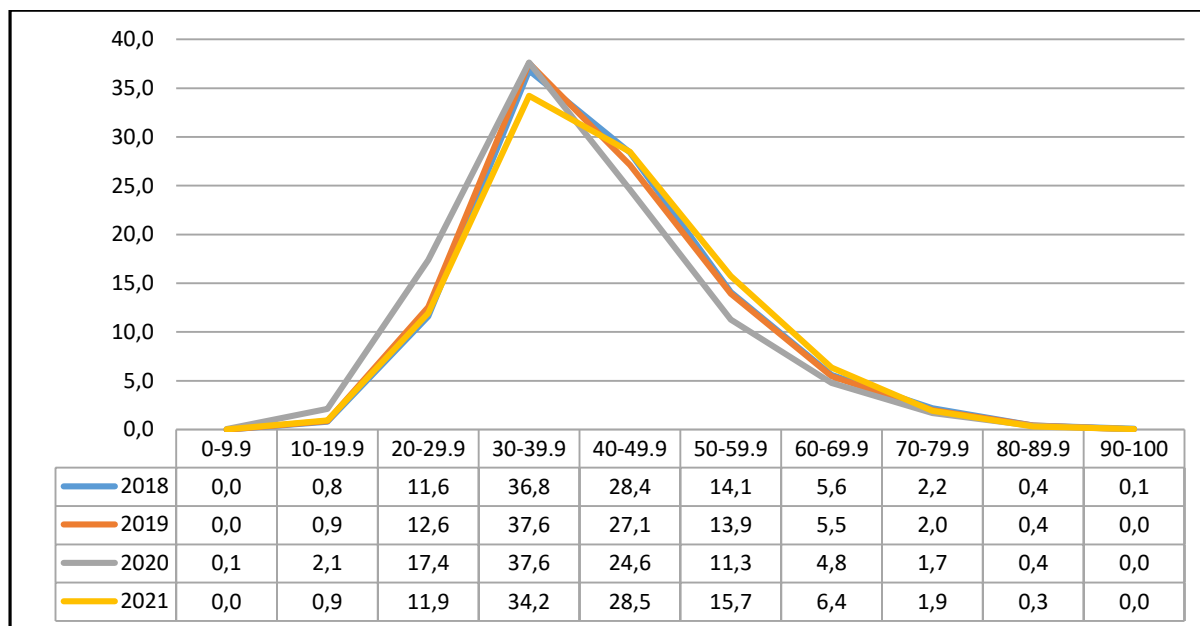
It was very encouraging that 24,3% of candidates achieved over 50% this year in comparison with 18,2% of candidates doing so in 2020. The percentage of distinctions (80% and above) decreased marginally from 0,4% in 2020 to 0,3% in 2021.

Table 3.1.1 Overall achievement rates in Technical Sciences

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	10 503	9 204	87,6
2019	10 862	9 401	86,5
2020	11 655	9 375	80,4
2021	14 642	12 758	87,1

Graph 3.1.1 Overall achievement rates in Technical Sciences (percentage)



Graph 3.1.2 Performance distribution curves in Technical Sciences (percentage)

There is much room for improvement in the performance of the candidates as the challenges surrounding conceptual understanding, mathematical skills, integration of topics, problem-solving skills and practical work are being addressed.

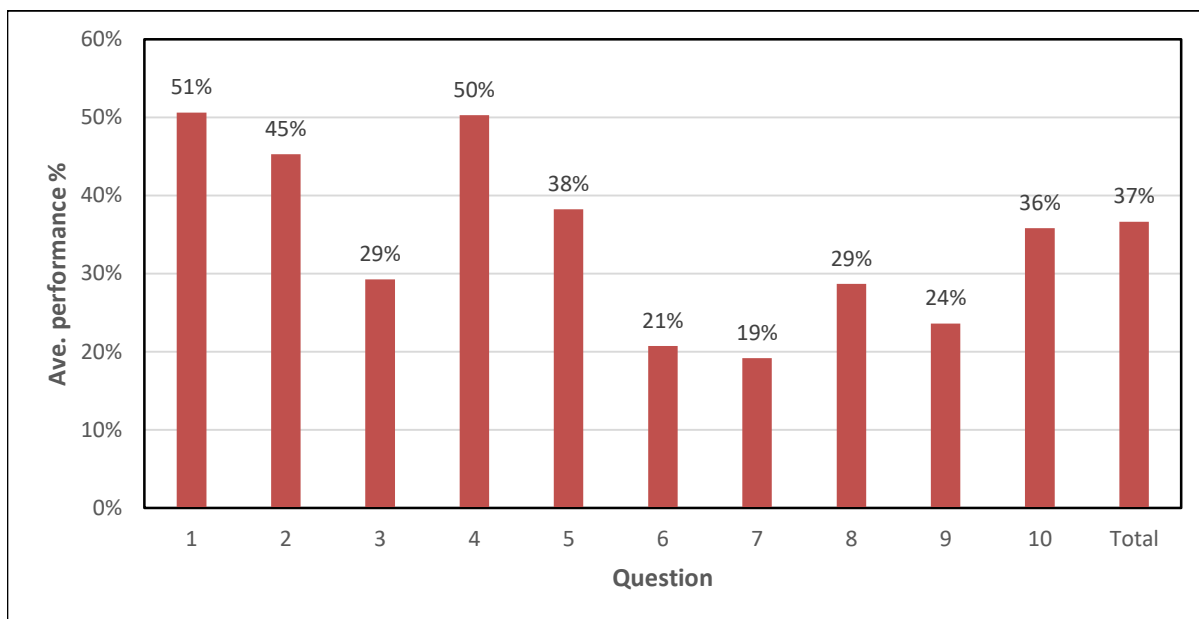
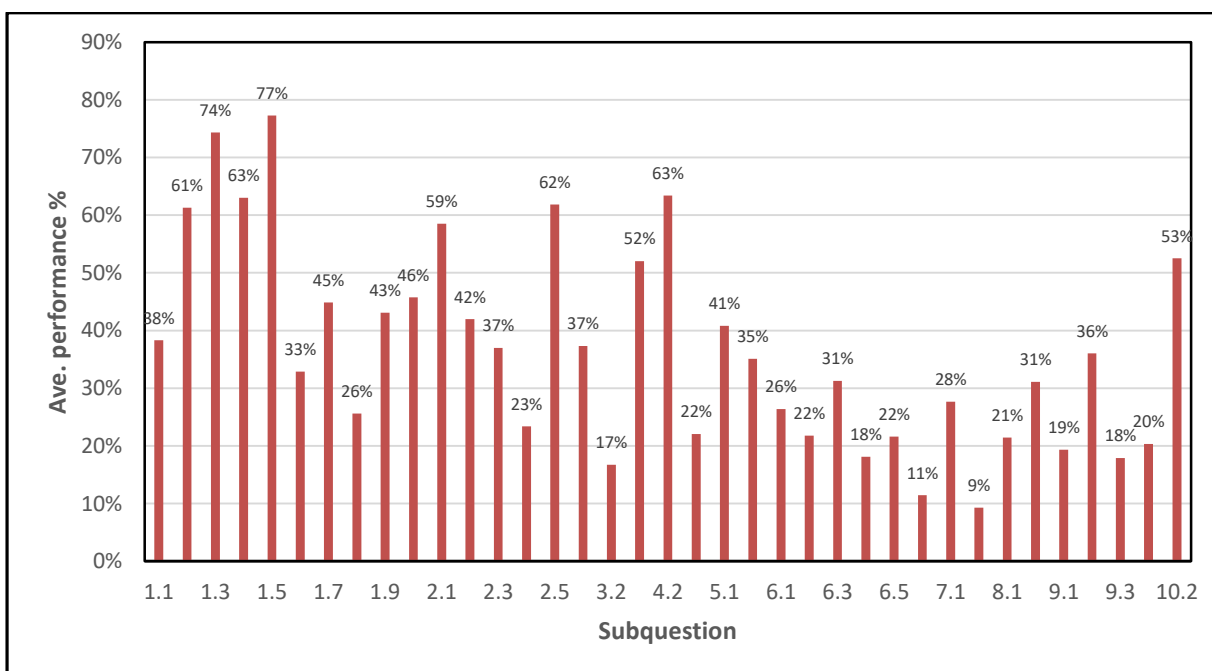
3.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 1

General comments

- The multiple-choice items in Q1 and the questions on Newton's First, Second and Third Laws of Motion (Q2), work, energy and power (Q4) were generally well answered.
- In general, Q3, Q6, Q7, Q8 and Q9 were poorly answered. Q3 examined momentum and impulse; Q6 focused on light; Q7 dealt with electromagnetic radiation; Q8 examined capacitors and capacitance and Q9 was on electric circuits.
- Recall questions are still posing a challenge to the candidates.
- Candidates showed a significant improvement in drawing and labelling free-body diagrams. However, some still struggled in this regard.
- Most candidates showed poor mathematical skills, such as understanding and using formulae and scientific notation as well as interpreting and representing direction in terms of a positive and negative sign.

3.3 DIAGNOSTIC QUESTION ANALYSIS OF 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 3.3.1 Average performance per question in Paper 1**Graph 3.3.2 Average performance per subquestion in Paper 1**

3.4 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- In Q1.1 candidates assumed that the direction of motion is the same as the applied force. They failed to realise that the net force determines the direction of motion.
- Most candidates showed poor mathematical skills in Q1.6 as they could not use the formula, $P = \frac{F}{A}$, to determine the unit of pressure.

- (c) In Q1.7 a significant number of candidates had difficulty in determining the path followed by light rays as they pass through a convex lens.
- (d) In Q1.8 majority of candidates could not use the right-hand rule to determine the direction of the magnetic field when current goes out of the page.
- (e) Candidates showed a poor understanding of the relationship between the resistance, current and brightness of the bulb for bulbs connected in series and parallel in Q1.9.
- (f) In Q1.10 a significant number of candidates had no idea of what the different components of generators and motors are as well as energy conversion taking place in these machines.

Suggestions for improvement

- (a) Learners must be taught the skills to answer the MCQ rather than relying on guesswork. They must be able to state a reason for eliminating incorrect options in multiple-choice questions.
- (b) Expose learners to multiple-choice-questions regularly through daily activities/informal tasks and short speed tests (± 10 minutes).
- (c) Learners must be taught the basics by ensuring that they know ALL the terminology (definitions, laws and principles) as stated in the CAPS and *Examination Guidelines*.
- (d) Teachers must teach and expose learners to questions from different cognitive demand from basic calculation to drawing and interpretation of graphs as well as reasoning/justification.
- (e) *Edukite* or *PhET*-simulations must be used to reinforce understanding of generators and motors. This can also be used to show the relationship between resistance, current and brightness of the bulbs in parallel and series circuits.

QUESTION 2: NEWTON'S LAW OF MOTION

Common errors and misconceptions

- (a) In Q2.1 and Q2.5.1 candidates omitted keywords when stating Newton's laws. Omissions were as follows:
 - In Q2.1 the keywords *rest*, *resultant (force)* and *uniform velocity* were omitted.
 - The keywords *simultaneously*, *equal magnitude* and *opposite direction* were omitted in Q2.5.1.
- (b) A notable number of candidates could not calculate the horizontal and vertical components of the force, 60 N applied at an angle of 30° , in Q2.2.1 and Q2.2.3. Common errors include:
 - Confusing the horizontal and vertical component, by:
 - Calculating the vertical component instead of the horizontal component and vice versa
 - Using $\cos 30^\circ$ instead of $\sin 30^\circ$ for the vertical component and $\sin 30^\circ$ instead of $\cos 30^\circ$ for the horizontal component
 - not writing the units in the final answer

- (c) In Q2.2.2 a significant number of candidates had difficulty in calculating the normal force when there is a force acting on object at an angle. Some of the common errors were mainly the use of incorrect formulae:
- To calculate the normal force, using $N = mg$ instead $N = mg - F \cdot \sin \theta$
 - To calculate the coefficient of kinetic friction using $f_s^{max} = \mu_s N$ instead of $f_k = \mu_k N$
- (d) Most candidates committed the following errors in Q2.3:
- Wrote the formula $F_{net} = ma$ as $F = mg$ or $F = ma$
 - Substituted 9.8 for acceleration, a
 - Could not determine F_{net} as they seemed to have no idea what horizontal force is acting on the object
 - Failed to choose/indicate a positive and a negative direction
 - Omitted the direction in the final answer and forfeited a mark for the final answer
- (e) In Q2.4 candidates were unable to explain how the vertical component of the applied force affect the magnitude of the normal when the angle between the horizontal and applied force is increased.
- (f) A significant number of candidates labelled applied force as tension as if a string or a rope was used to tow a caravan in Q2.5.2.

Suggestions for improvement

- (a) Learners must be exposed to recall questions like defining concepts, stating laws and principles without omitting keywords.
- Classrooms and laboratories must have print-rich materials with lists of definitions, principles and laws on the walls/notice boards.
 - Speed tests must be used to drill learners to recall definitions, laws and principles.
- (b) Drawing of free-body diagrams and identification of forces acting on an object must be drilled as it is a useful skill for problem-solving.
- (c) Teachers must emphasise the fact that the number of forces required correlates with mark allocation, e.g. Four forces are required if the mark allocation is 4.
- (d) Learners must be cautioned to avoid common errors in a free-body diagram like:
- Omitting the dot
 - Using a line instead of an arrow
 - Using dotted/broken lines
 - Drawing the number of forces that are not correlating with mark allocation
- (e) Emphasise the fact that vectors have magnitude and direction, therefore:
- Learners must choose a negative and positive direction in calculations involving vector quantities.
 - The final answer of calculations of vector quantities must have correct the value with units and direction.
- (f) Teachers must expose learners to questions across different cognitive levels including:
- Routine and multi-step calculations
 - Using laws, principles and equations to explain or justify answers
 - Questions involving scientific reasoning

QUESTION 3: IMPULSE AND CONSERVATION OF MOMENTUM**Common errors and misconceptions**

- (a) In Q3.1.1 and Q3.1.4 candidates omitted keywords like *product* and *total*.
- (b) Most candidates used the equation $\Delta p = mv_f - mv_i$ in Q3.1.2. Some candidates omitted the direction in the final answer.
- (c) Some of the common errors that candidates committed in Q3.1.3 were:
 - Using $p_{\text{before}} = p_{\text{after}}$ or $\sum Ek_i = \sum Ek_f$ instead of $\sum p_{\text{before}} = \sum p_{\text{after}}$
 - Omitting the SI unit or direction in the final answer
- (d) A significant number of candidates distinguished between elasticity and plasticity instead of elastic and inelastic collisions in Q3.1.4. Common mistakes include:
 - Omitting the keyword *total* or symbol $\sum$
 - Using calculations to show the difference between elastic and inelastic collision instead of stating the difference between the two
- (e) In Q3.2.1 most candidates used the formula $F_{\text{net}} \Delta t = \Delta p$ instead of Newton's First Law or inertia to explain how the seatbelt reduces injuries during collision.
- (f) Candidates had a challenge in realising that Impulse = Δp in Q3.2.2. They did not realise that Δp was given.
- (g) In Q3.2.3 most candidates calculated Δp instead of F_{net} . They also did not state whether the wall will withstand the impact of collision or not.

Suggestions for improvement

- (a) Learners must be taught how to define concepts and state principles without omitting keywords. Teachers must highlight keywords when teaching these concepts or principles.
- (b) Teachers must emphasise the fact that momentum is a vector quantity, therefore, learners must always choose a negative and positive direction in calculations involving momentum.
- (c) Teachers must expose learners to problems involving different practical applications of momentum and Newton's laws in road and motor vehicle safety.
- (d) Learners must be familiar with the equations in the data sheet. They must:
 - Be able to identify the relevant equation applicable to a specific problem
 - Use equations to explain relationships between different variables
- (e) Subject advisors must organise workshops to reinforce the teaching of momentum and impulse using practical examples.
- (f) PEDs and district officials must develop and give schools appropriate teacher and learner support material to strengthen the teaching and learning of momentum and impulse.

QUESTION 4: WORK AND ENERGY**Common errors and misconceptions**

- (a) In Q4.1.1 most candidates omitted the words *product*, *applied force* or *displacement* when defining work done.
- (b) A notable number of candidates omitted the SI units in the final answer in Q4.1.2. Other errors include:
- Omitting Δx in the formula for work done and substitution step
 - Failing to recognise that F is applied at an angle and substituting 60 for F instead of using the horizontal component of F , i.e. $60 \times \cos 25^\circ$
 - Stating the principle of conservation of linear momentum instead the principle of conservation of mechanical energy
 - Others omitted keywords like *total* or *sum* and *isolated system*
- (c) In Q4.3 a significant number of candidates did not realise that E_p calculated in Q4.2.2 and E_k calculated in Q4.2.2 were E_p and E_k at the top. They did not use these values to calculate E_p at the bottom.

Suggestions for improvement

- (a) Teachers must emphasise the use of keywords when teaching principles and concepts.
- (b) Learners must be exposed to the use of formula/data sheet in informal and formal activities.
- (c) Teach learners to identify the forces that are doing work on an object.
- (d) Teachers must emphasise the difference between *mechanical energy*, *kinetic energy*, *gravitational potential energy* as well as the *principle of conservation of mechanical energy* and *principle of conservation of linear momentum*.

QUESTION 5: ELASTICITY, HYDRAULICS AND VISCOSITY**Common errors and misconceptions**

- (a) In Q5.1.1 most candidates had difficulty in calculating the area. Some of the common mistakes included:
- Using $A = \ell \times b$ instead of $A = \pi r^2$ or $A = \frac{\pi d^2}{4}$
 - Failing to convert mm to m
 - Using the length of a diameter in the formula $A = \pi r^2$
 - Using the incorrect formula to calculate stress, i.e., $P = \frac{F}{A}$. or $\varepsilon = \frac{\Delta \ell}{L}$ instead of $\sigma = \frac{F}{A}$
 - Omitting the units in the final answer
- (b) In Q5.1.2 the majority of candidates had a challenge to realise that $\Delta \ell$ was given, so they substituted $3 - 0,0005$ for $\Delta \ell$. Some of their common mistakes include:
- Using the incorrect formula to calculate stress, i.e. $\sigma = \frac{F}{A}$ instead of $\varepsilon = \frac{\Delta \ell}{L}$
 - Including the SI unit in the final answer

- (c) Candidates could not use the values calculated in Q5.1.1 and Q5.1.2 to calculate Young's modulus of the wire in Q5.1.3.
- (d) In Q5.2.1 a significant number of candidates had no idea of what the pressure at a particular point is.
- (e) A substantial number of candidates could not answer Q5.2.2. Some of the incorrect responses included:
 - Using the incorrect formulae - $\rho = pgh$, $p = mv$, $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ and $\sigma = \frac{F}{A}$
 - Giving the incorrect SI units in the final answer
- (f) In Q5.2.3 most candidates calculated the area of the input piston instead of the area of the output pressure. They failed to recognise that the area of the input area was given in the leading statement.

Suggestions for improvement

- (a) Learners must be taught mathematical skills required with emphasis on scientific notation, conversion of units and the meaning of prefixes like *nano*, *giga*, *mega*, *milli*, etc. in calculations.
- (b) Teachers must give learners more practical problems where they can:
 - Use mathematical skills learned in (a).
 - Distinguish between stress, strain and pressure.
 - Know the formula used to calculate each of these variables (i.e. pressure, stress and strain).
- (c) Learners must be taught a skill to identify different variables including the unknown from the information on the question/leading statement or diagram. This will help them to select a correct formula to calculate the unknown.

QUESTION 6: REFRACTION & TOTAL INTERNAL REFLECTION

Common errors and misconceptions

- (a) In Q6.1 candidates omitted keywords *bending* or *from one medium to another*. Others defined *reflection* instead of *refraction*.
- (b) The phrases *angle of incidence* or *refracted ray* in Q6.2 were given as *critical angle* by most of the candidates.
- (c) In 6.3 a notable number of candidates had difficulty in stating the magnitude of a critical angle. Some wrote 30° or 45° as an answer instead of 90°.
- (d) A large number of candidates had no idea which ray undergoes total internal reflection in Q6.5. Some just wrote *R* instead of ray *QR*.
- (e) In Q6.6 a significant number of candidates had difficulty in stating the conditions required for total internal reflection to occur. Most of the candidates stated the uses of total internal reflection.

Suggestions for improvement

- (a) Learners must be taught definitions of all concepts as prescribed in the *CAPS* and the *Examination Guidelines* without omitting keywords in definitions.
- (b) Teachers must teach the concepts *reflection*, *refraction*, *critical angle* and *total internal reflection* thoroughly.
- (c) Practical activities and *PhET* simulations must be used to reinforce the understanding of the concepts in (b).
- (d) PEDs and schools must procure light kits required to do practical work of this section or teachers may download open source *Edukite* or *PhET*-simulation software.
- (e) PEDs and district officials must train teachers on the effective use of light kits and *Edukite* or *PhET*-simulations.

QUESTION 7: ELECTROMAGNETIC RADIATION (WAVES/SPECTRUM)

Common errors and misconceptions

- (a) In Q7.1.1 a notable number of candidates omitted keywords like *white*, *break up* or *component colours*. Some of them used the phrase *different colours* instead of *component colours*.
- (b) Most candidates could not identify the specific colours of the spectrum as required in Q7.1.2. A common incorrect response was *red* and *violet*.
- (c) In Q7.1.3 a significant number of candidates had difficulty in stating the property of light responsible for dispersion.
- (d) Candidates could not determine the relationship between a *wavelength* and *speed* of a wave in Q7.1.4.
- (e) In Q7.2.1 a notable number of candidates had a challenge in defining a *wave*. A common error was a *repetitive movement*.
- (f) Most candidates had difficulty recalling characteristics of electromagnetic waves in Q7.5. A significant number of candidates did not even attempt to answer this question.

Suggestions for improvement

- (a) Emphasise learning of definitions as they appear in the *CAPS* and *Examination Guidelines*.
- (b) Teachers must use light kits and *PhET*-simulations to reinforce the teaching and learning of *dispersion* and *electromagnetic waves/spectrum*.
- (c) Learners must be taught to use acronyms and rhymes to recall different colours of the spectrum like *ROYGBIV* and electromagnetic waves like *RMIVUXG*.
- (d) Teachers should give learners more activities involving the labelling of colours of the spectrum of visible light and electromagnetic waves.

QUESTION 8: ELECTRIC CIRCUITS AND POWER

Common errors and misconceptions

- (a) In Q8.1 a significant number of candidates showed little understanding of a difference between *capacitor* and *capacitance*. Some common mistakes included:
 - Omitting keywords like *amount*, *store* and *per unit volt*
 - Using *energy* instead of *charge*
- (b) In Q8.2 and Q8.3 candidates swapped the equations $C = \frac{Q}{V}$ and $C = \frac{\epsilon_0 A}{d}$ around. Some had difficulty in using unit conversion as well the relationship between the scientific notation and prefixes, e.g. 10^9 means *nano*. Others wrote incorrect SI units in the final answer.

Suggestions for improvement

- (a) Teach learners all concepts, definitions, terminology, laws and principles as defined or stated in CAPS and the *Examination Guidelines*.
- (b) Unit conversion, scientific notation and writing of an SI unit in the final answer must be revised thoroughly.
- (c) Teachers must drill calculator skills.
- (d) PEDs and district officials must organise regular Technical Sciences teacher development workshops.

QUESTION 9: ELECTRIC CIRCUITS AND POWER

Common errors and misconceptions

- (a) In Q9.1 most candidates omitted keywords like *rate* or *electric energy*. The responses showed that they were defining *power* as defined in *mechanics* not *electric power* as required.
- (b) In Q9.2 candidates struggled to identify the equation suitable to calculate resistance using the information provided on the leading statement. Some used the equations $R = \frac{V}{I}$ and $W = \frac{V^2 \Delta t}{R}$ for calculating resistance and were frustrated by having two unknown variables.
- (c) A notable number of candidates used the parallel resistors equation to calculate effective/total resistance of resistors in series in Q9.3. Some did not realise that to calculate potential difference across the $5\ \Omega$ resistor, one needs to use the current flowing in the circuit.

Suggestions for improvement

- (a) Teachers must teach learners the basic concepts of resistors, i.e. how to calculate the total resistance of resistor in series and in parallel.
- (b) Learners must be given informal activities to reinforce the fact that parallel resistors are current dividers and resistors in series are voltage dividers.
- (c) Teachers must revise Ohm's laws taught in lower grades.

QUESTION 10: GENERATORS AND TRANSFORMERS

Common errors and misconceptions

- (a) In Q10.1.1 most candidates had difficulty stating a phenomenon illustrated in the diagram.
- (b) In Q10.1.2 candidates stated Faraday's law instead of using it to state a relationship between the extent of the deflection of a needle, rate of change and induced emf.
- (d) A significant number of candidates could not give a reason why this transformer is a step-down transformer in Q10.2.1. They failed to refer to the *number of windings* and voltage in the primary and secondary coil.
- (e) In Q10.2.2 most candidates substituted incorrectly or wrote down the formula for a transformer incorrectly instead of copying it directly from the formula sheet. Some had difficulty of making the *number of windings* in the primary coil a subject of the formula.

Suggestions for improvement

- (a) Teachers must teach learners terminology as they appear in the *CAPS* and *Examination Guidelines*.
- (b) *Edukite* or *PhET*-simulations must be used to enhance the understanding of the principle of electromagnetic induction as well as Faraday's law and Lenz' law.
- (c) The difference between a *motor* and a *generator*, as well as the difference between an AC and a DC motor/generator must be explained thoroughly.
- (d) Teachers must emphasise the writing of the correct formula, substitution and the need to have units in the final answer.

3.5 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

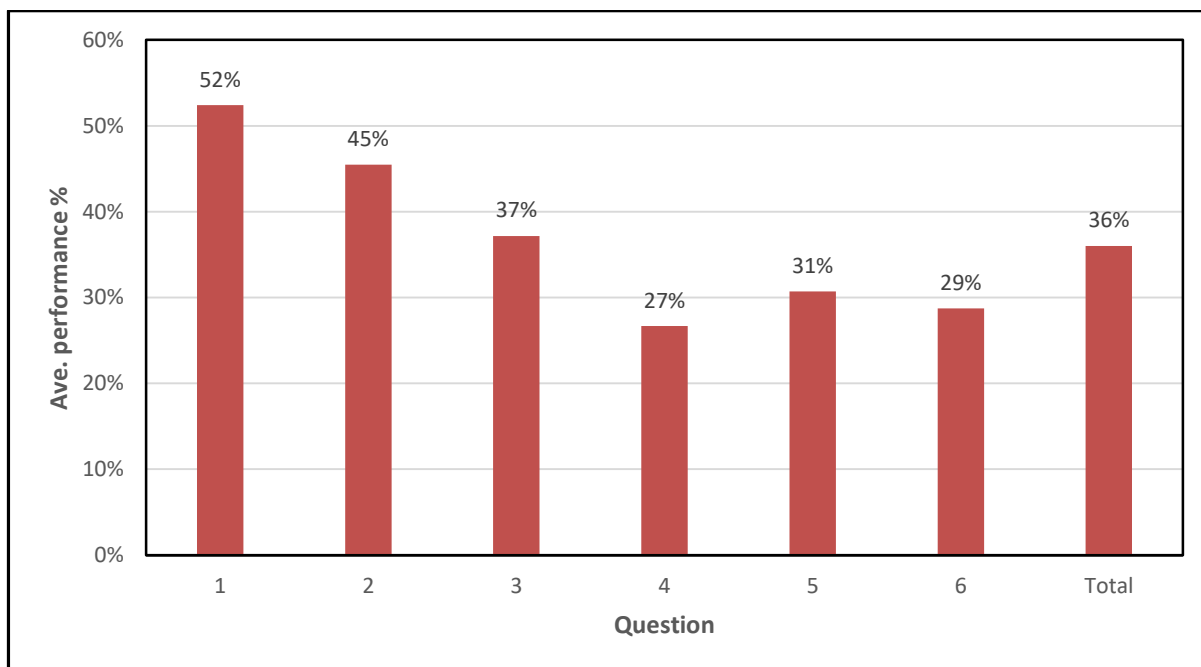
General comments

- (a) Questions on definitions were poorly answered.
- (b) Candidates struggled with Question 4 (Reactions of organic molecules), Question 5 (Electrolytic cell) and Question 6 (Galvanic cell).
- (c) Writing half-reactions and net ionic cell reactions proved to be a challenge for candidates.
- (d) The interpretation and the use of the Table of Standard Reduction Potentials posed a challenge to most of the candidates.
- (e) The types of isomers proved to be a problem for candidates.
- (f) Candidates' performances were poor in questions which required motivation using scientific reasoning.

3.6 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 2

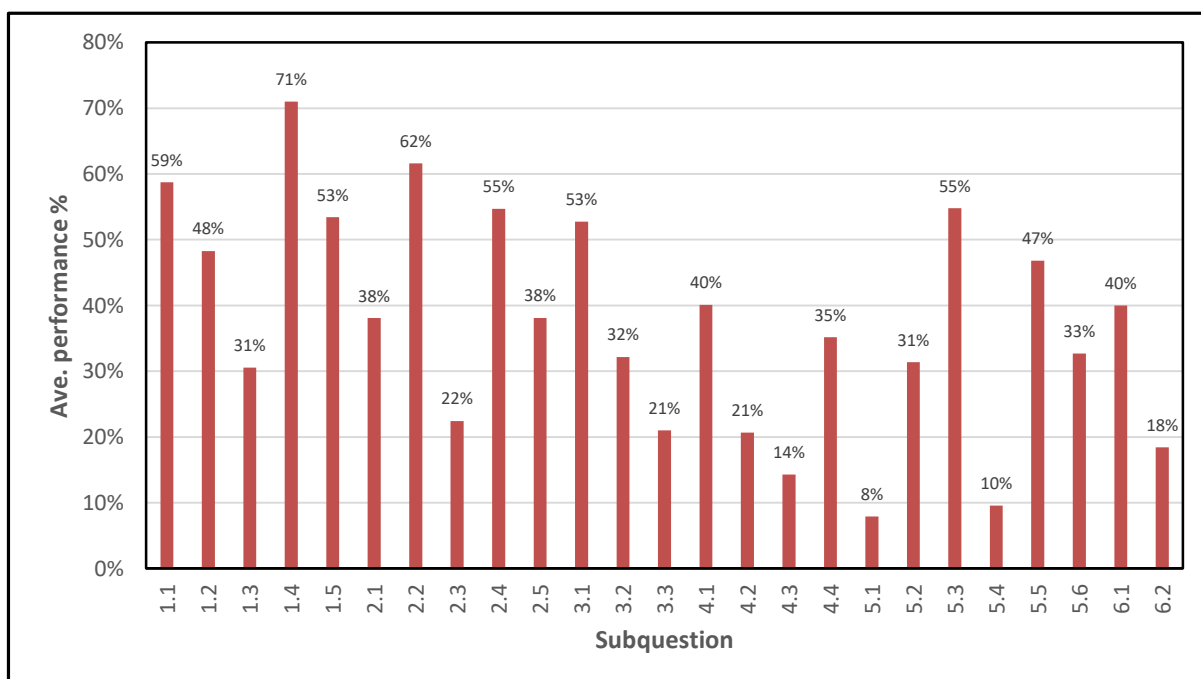
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 3.6.1 Average performance per question in Paper 2



Q	Topics	Q	Topics
1	Multiple-choice Questions	4	Reactions of Organic Compounds
2	Naming of Organic Molecules and Structures	5	Electrolytic Cell
3	Physical Properties of Organic Molecules	6	Galvanic Cell

Graph 3.6.2 Average performance per subquestion in Paper 2



3.7 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) In Q1.1 candidates could not correctly identify the functional group, especially when there were similarities in the structure of the functional group, e.g. ketones and aldehydes.
- (b) Candidates could not identify the compound with the lowest vapour pressure even though boiling points were given in Q1.2. They could not draw inference from the relationship between the boiling point and vapour pressure.
- (c) In Q1.3 a significant number of candidates failed to recall the definition of oxidation in terms of electron transfer and oxidation numbers.
- (d) Most candidates could not identify the electrode that gains and the one that loses mass between an anode and a cathode in a galvanic cell in Q1.5.

Suggestions for improvement

- (a) Teachers should explain the difference between the different homologous series by using their functional groups.
- (b) Teachers must thoroughly explain that when given a series of values for the boiling point or melting point, the highest negative value would be the lowest in terms of its magnitude on the numerical scale. These values should also be linked to and taught in accordance with physical properties.
- (c) Teachers need to explain the relationship between the different physical properties of organic molecules, e.g. melting point, boiling point and vapour pressure.
- (d) The difference between oxidation and reduction should be thoroughly explained in terms of electron transfer and oxidation numbers.
- (e) Learners must be guided to eliminate the wrong answers through regular practice and assessment. Use the practice of scientific argumentation among learners to identify incorrect multiple-choice distractors.

QUESTION 2: NAMING OF ORGANIC MOLECULES AND STRUCTURAL FORMULAE

Common errors and misconceptions

- (a) In Q2.1 candidates omitted the word 'only' when defining *hydrocarbon*. There was the incorrect use of words that changed the context of the definition, e.g. 'The carbon atom that is bonded to hydrogen atom only'.
- (b) The most common mistakes committed in Q 2.2.1 when drawing the structural formula of 1-chlorobutane include the following:
 - A bond indicated between C and l for chlorine
 - The omission of bonds or hydrogen atoms

- Using double bonds between the carbon atoms
 - The chlorine atom often placed on the second carbon of the hydrocarbon compound instead of the first
- (c) Common errors committed by candidates when drawing structural formula for butan-1-ol in Q2.2.2 are as follows:
- 'ol' was used instead of -O-H.
 - When the correct functional group was used, it was not clear which of the atoms between O and H was bonded to the carbon atom.
 - Had two bonds for hydrogen as -C-H-O instead of -C-O-H.
 - Drawing a structural formula of a carboxylic acid rather than of an alcohol.
- (d) In Q2.3 candidates could not identify and give the IUPAC name of the ester when the structural formula was given.
- (e) Most candidates could not identify the *homologous series* of the given molecules from recognition of their *functional groups* in Q2.4.1 and Q2.4.2.
- (f) In Q2.5.1 candidates used the phrase '*they are compounds having the same general formula but different structures*' instead of defining *structural isomers* as '*organic compounds having the same molecular formula but different structural formula*'.
- (g) Candidates struggled to identify the type of structural isomers of compounds B (ester) and D (carboxylic acid) in Q2.5.2.

Suggestions for improvement

- (a) Teachers must emphasise the inclusion of the key words when defining concepts. Short informal tests on definitions, stating laws and principles should be written. Greater emphasis should be placed on the learning of definitions listed in the CAPS and the *Examination Guidelines*.
- (b) Teachers must emphasise the link between the functional group and homologous series of molecules. The structural differences between functional groups should be reinforced by using consolidation activities, with specific reference to the drawing of structural formulae.
- (c) Drawing of structural formula of the functional groups and compounds in different homologous series should be assessed informally and formally. Learners should check whether each carbon atom has four bonds and that all hydrogen atoms are included.
- (d) The bond between the Oxygen and Hydrogen should be indicated when drawing the structural formula of the alcohols.
- (e) The IUPAC naming rules of organic compounds must be emphasised, i.e. a correct prefix must be given and a number, comma and hyphen should be placed correctly. Emphasise the fact that a hyphen is only used between a letter and a number in the IUPAC name and a comma is only placed between two numbers when having multiple locations of additional attachments to the parent chain.
- (f) Learners must be assessed on different structural isomers, i.e. chain, functional and position in terms of defining, identifying and drawing them.
- (g) The use of audio-visual aids when revising organic chemistry is encouraged.

QUESTION 3: PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

Common errors and misconceptions

- (a) Candidates failed to correctly identify the type of intermolecular forces between alkane molecules in Q3.1.1. Some wrote Van der Waals forces instead of being specific by writing London forces.
- (b) In Q 3.1.2 candidates could not identify a compound with stronger intermolecular forces between butane and methylpropane.
- (c) In Q3.1.3 candidates failed to recognise and explain that branching or chain length is a factor that had an influence on the strength of the intermolecular forces when comparing butane and methylpropane. Some did not compare these compounds when responding to the question.
- (d) Candidates struggled to give reasons why the comparison of the boiling points of butane and butan-1-ol is fair in Q3.2.1.
- (e) Candidates failed to explain why butan-1-ol (alcohol) had a higher boiling point than butane (alkane) in Q3.2.3. They could not identify correct type of intermolecular forces and to compare the strength of the intermolecular forces of the alkanes and alcohols.
- (f) Most candidates could not arrange the given compounds in order of decreasing vapour pressure through identification of the type and strength of their intermolecular forces in Q3.3.

Suggestions for improvement

- (a) Teachers must emphasise the importance of being specific about the type of intermolecular forces and the strength of intermolecular forces acting on organic compounds from different homologous series.
- (b) All factors, e.g. chain length, branching, homologous series/type of functional group, type of intermolecular forces, etc., that influence the strength of the intermolecular forces should be explained thoroughly and when to use them.
- (c) When explaining the impact of the physical properties of organic compounds, learners must be encouraged to give their explanation in point form addressing structure, relationship and energy rather than in a paragraph.
- (d) Learners must be guided on how to use chain length, type of intermolecular forces, strength of the intermolecular forces and energy to explain trends in physical properties of organic compounds. Emphasis should be on the comparison between the given compounds.
- (e) Teachers must train learners to pay attention to the mark allocation of a question, which will inform them regarding the extent to which the answer should be given.
- (f) Learners must be able to identify the factor that determines the strength of the intermolecular forces of a specific question.
- (g) Learners must mention compounds when comparing compounds and should be specific about the factors which are compared rather than being too general.

- (h) Teachers must emphasise the relationship of physical properties and the impact they have on each other.
- (i) Teachers must guide learners on how to articulate their responses in such a way that it encompasses all desired aspects about physical properties of organic compounds in informal (classwork and homework) and formal tasks.

QUESTION 4: REACTIONS OF ORGANIC COMPOUNDS

Common errors and misconceptions

- (a) Candidates could not analyse the given reactions so that they could name them in Q4.1.1 and Q4.1.2.
- (b) Candidates failed to name the catalyst needed for hydrogenation of propene in Q4.2.1.
- (c) In Q4.2.2 candidates struggled to recall the reaction condition needed for the substitution reaction of an alcohol with hydrogen bromide. The common incorrect response was excess water instead of no water, and mild temperature instead of mild heat.
- (d) In Q4.3.1 some candidates used molecular formulae instead of structural formulae for the reaction of propane with bromine to form 2-bromopropane. Those who managed to use structural formula made the following common mistakes:
 - Wrong symbols used; Br instead of Br-Br and writing bromine as br or BR
 - Omission of the arrow to separate reactants from the products
 - Drew the structural formula of 1-bromopropane instead of 2-bromopropane
 - H₂O was not included as one of the products
 - Drew the structural formula of the major product without the reactants and the arrow
- (e) In Q4.3.2 candidates failed to recall the products for the combustion of alkanes.
- (f) Candidates had difficulty in naming the process that is used to improve the conductivity of semiconductors in Q4.4.1.
- (g) Candidates defined an intrinsic semiconductor as a conductor in its pure form, instead of a semiconductor in its pure form.
- (h) In Q4.4.3 most candidates struggled to distinguish between an n-type semiconductor and a p-type semiconductor. The word 'carriers' was omitted. They stated that an n-type semiconductor is negative and the p-type semiconductor is positive.

Suggestions for improvement

- (a) Teachers must emphasise the different types of reactions which include combustion/oxidation, substitution and addition as well as their reaction conditions.
- (b) Teachers must explain that saturated compounds will undergo substitution reaction while unsaturated compounds will undergo addition reaction.
- (c) Emphasise the difference between molecular, structural and condensed structural formulae. The correct scientific symbols must be used when writing reactions.

- (d) It should be clearly explained that products in any combustion reaction of the hydrocarbons will be CO_2 and H_2O . Use simulations and videos to explain combustion reactions for learners to gain a deeper understanding of the concept.
- (e) The difference between doping as a process and the definition should be thoroughly explained.
- (f) Interpretation and analysis of questions should be addressed so that learners respond to the questions accordingly.
- (g) Teachers must emphasise definition of concepts.
- (h) Teach the concepts of n-type and a p-type semiconductors using Lewis structures to show the formation of excess negative charge carriers and positive hole. It is advised that teachers use computational simulations when teaching *doping* in electronic properties of matter. This will allow learners to make a clear distinction between the n-type and p-type semiconductors and gain a deeper understanding of the concept.

p-type	n-type
Doped with Group III/trivalent elements	Doped with group 5/pentavalent elements
Impurities added create vacancy of electrons(holes)	Impurities added provide extra electrons
Electrons are minority charge carriers and holes are the majority charge carriers	Electrons are majority charge carriers and holes are minority charge carriers

QUESTION 5: ELECTROLYTIC CELL

Common errors and misconceptions

- (a) Majority of the candidates could not give the name of the cations in Q5.1.1 and of anions in Q5.1.2 of the electrolyte even though the formula of these ions were given in the diagram. They wrote copper instead of copper (II) ions and chlorine ions instead of chloride ions. Some learners gave the symbol of the ions instead of the names.
- (b) In Q5.2.1 and Q5.2.2 most candidates swapped the polarity of the *anode* and the *cathode*. Some candidates gave ions as representation of the electrodes instead of stating whether the electrode was the positive or negative.
- (c) In Q5.3 some candidates defined oxidation as a substance that loses electrons or the loss of electrodes instead of referring to it as loss of electrons.
- (d) Most candidates wrote the half-reaction of copper ($\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$) instead of chlorine ($2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$) in Q5.4 for the reaction occurring at the positive electrode. Some used double arrows and omitted ions.
- (e) Candidates confused the definition of *reducing agent* with that of *oxidation* in Q5.5. They defined reducing agent as loss of electrons or as a process that undergoes oxidation, instead of '*a substance that is oxidised or loses electrons*'.
- (f) In Q5.6 candidates failed to follow instructions and drew a galvanic cell instead of an electrolytic cell. Common mistakes were as follows:

- Electrodes were not labelled as spoon and silver but labelled as anode and cathode or had incorrect labels.
- CuCl_2 or silver chloride was used as an electrolyte instead of silver nitrate or silver acetate.
- The spoon to be electroplated was connected to the positive terminal and the silver electrode at the negative terminal of the battery.

Suggestions for improvement

- The difference between cations and anions, and the names of the specific ions of any electrolyte should be clearly explained. For copper, specify whether it is copper (I) ions or copper (II) ions when giving the name of the ions.
- Ensure that there is a clear distinction between the anode and the cathode and explain how the electrodes are polarised in electrolytic cells.
- Definitions, with the emphasis on the key words, and the difference between *reducing agent*, *oxidising agent*, *oxidation* and *reduction* should be addressed.
- Learners should be taught to use the Table of Standard Reduction Potentials to write oxidation and reduction half-reactions, to identify the oxidising and reducing agents and to write the overall net cell reactions.

QUESTION 6: GALVANIC CELL

Common errors and misconceptions

- In Q6.1.1 some candidates identified the type of cell as an electrochemical cell instead of galvanic or voltaic cell.
- Candidates failed to use the Table of Standard Reduction Potential to write the net ionic reaction of the Zn-Cu cell in Q6.1.2. Some wrote it incorrectly as:
 $\text{Zn}^{2+} + \text{Cu} \rightarrow \text{Zn} + \text{Cu}^{2+}$ or wrote the cell notation, omitted ions and used double arrows.
- In Q 6.1.3 candidates:
 - Struggled to calculate the emf the zinc-copper cell
 - Used unconventional abbreviations or details concerning subscripts or superscripts have been omitted
 - Had no units in the final answer
 - Swopped the E° values of the cathode and the anode
- Most candidates found it difficult to identify the reaction which is spontaneous and to use the Table of Standard Reduction Potential to explain in Q6.2.1 and Q6.2.2.

Suggestions for improvement

- Teachers must differentiate between the two types of electrochemical cells which are the galvanic and the electrolytic cell.
- Teachers should ensure that learners understand how to use the Table of Standard Reduction Potentials to write half-reactions and the net cell reaction. The table should also be used to predict the spontaneity of a reaction by referring to the oxidising or reducing ability of the reactants.

- (c) Learners should be able to identify and compare the strength of the reducing and the oxidising agents using the Table of Standard Reduction Potentials.
- (d) Learners should be exposed to what is in the data sheet and how to use it. Teachers should ensure that learners can use the Table of Standard Reduction Potentials to get the correct values to be used in the calculation of the emf of the cell.
- (e) Much emphasis should be placed on the importance of copying formulae correctly from the data sheet, together with ensuring that final values calculated are furnished with an appropriate unit.
- (f) Learners should be reminded that, when using formulae, marks will only be credited for a formula if the values are correctly substituted into the formula.
- (g) Practical work (experiment) of the galvanic cell should be infused in lessons.

CHAPTER 4

CIVIL TECHNOLOGY

4.1 CIVIL SERVICES

The following report should be read in conjunction with the Civil Services question paper of the November 2021 examinations.

4.1.1 PERFORMANCE TRENDS (2018–2021)

In 2021, 627 candidates sat for the Civil Services examination, 26 more candidates than in 2020.

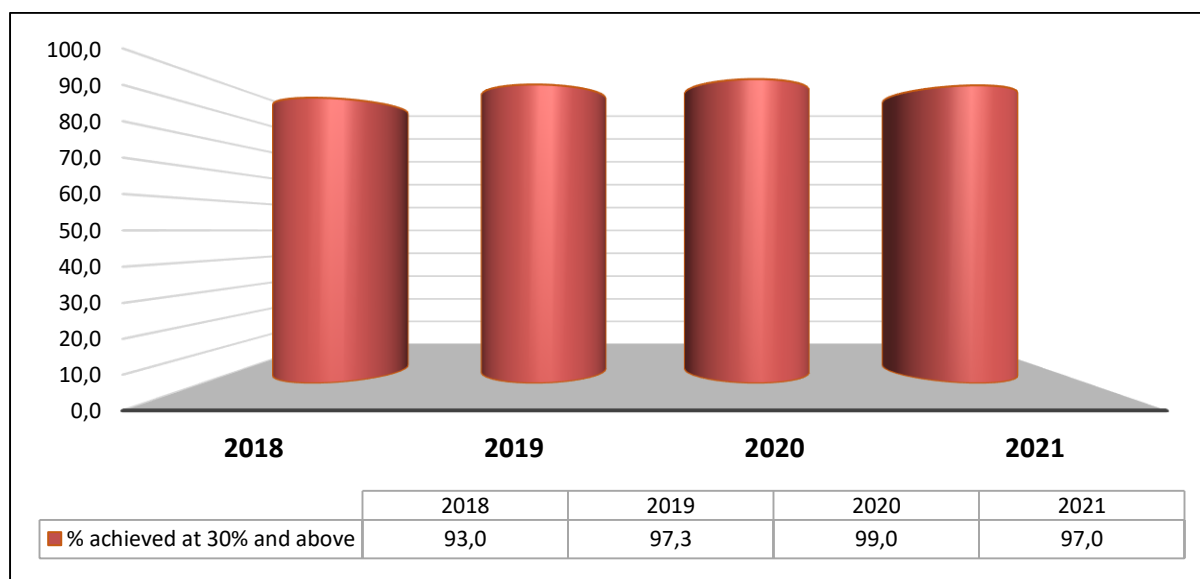
The performance of the candidates in 2021 shows a slight decline when compared to the performance in 2020. The pass percentage at 30% (Level 2) dropped from 99,0% in 2020 to 97,0% in 2021. It was disappointing that 61,3% of candidates achieved over 50% this year in comparison to 66,8% of candidates doing so in 2020.

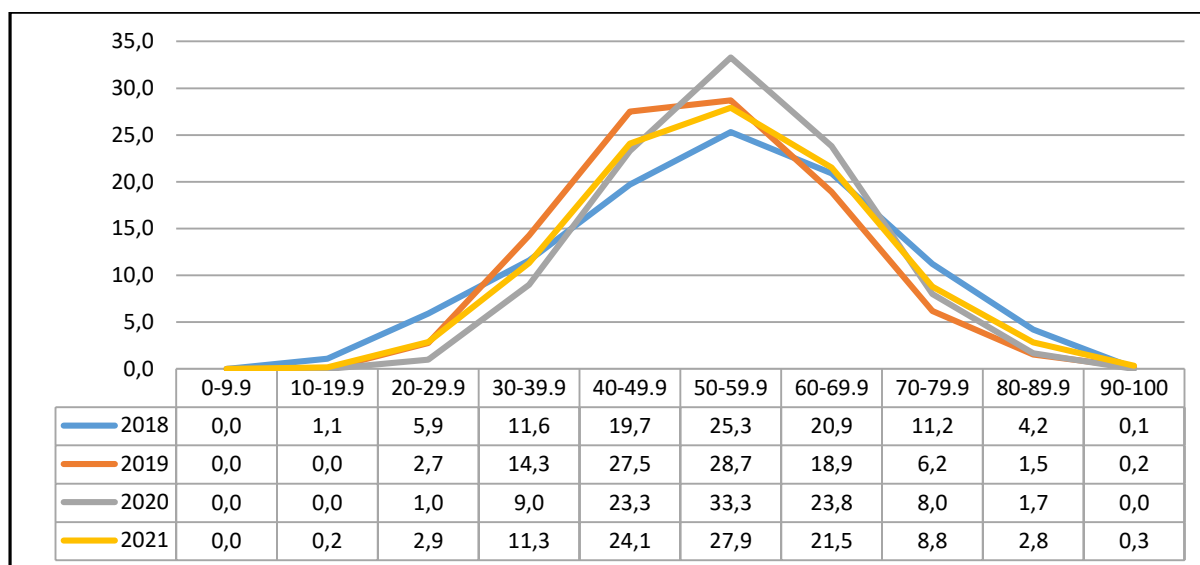
The percentage of distinctions (80%; Level 7) increased marginally from 1,7% in 2020 to 3,1% in 2021. This translates to an increase in the number of distinctions from 10 to 19.

Table 4.1.1 Overall achievement rates in Civil Services

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	795	739	93,0
2019	582	566	97,3
2020	601	595	99,0
2021	627	608	97,0

Graph 4.1.1(a) Overall achievement rates in Civil Services (percentage)



Graph 4.1.1(b) Performance distribution curves in Civil Services (percentage)

4.1.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE CIVIL SERVICES PAPER

General comments

- (a) It was noted that many candidates did not start each question on a new page as indicated in the instructions.
- (b) Many candidates experienced difficulty with subject-specific and academic terminology.
- (c) Poor drawing and interpretation skills were evident. There was poor distinction between line diagrams, sketches, pictorial views and scale drawings. Many scale drawings were not done using drawing equipment.
- (d) From the responses in the scripts, it is evident that the candidates lacked practical exposure and experience.
- (e) A significant number of candidates were not credited with marks because they failed to label their drawings.
- (f) Candidates experienced challenges to express themselves when responding to questions which required them to describe or explain.
- (g) Matching-items and multiple-choice questions were left unanswered by some candidates, and they were not credited as a result.
- (h) Many candidates found it difficult to explain practical applications theoretically.
- (i) In a question that counted 2 marks, a significant number of candidates provided only one response instead of two.
- (j) It was observed that the performance of the candidates was poorest in the topics indicated last on the ATP. A possible reason for the poor performance may be that at the end of the year, teachers are under pressure to complete the ATP and do not spend enough time on teaching these topics.

4.1.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN CIVIL SERVICES

QUESTION 1: OHSA, MATERIALS, TOOLS, EQUIPMENT AND JOINING

Common errors and misconceptions

- (a) In Q1.1 (5 marks) candidates had difficulty in the *matching-items* question to link the appropriate descriptions with the items provided. A number of candidates were not able to respond in the required manner. They had to demonstrate deeper insight in the properties and principles applied in materials rather than the mere identification and use thereof. Many candidates were also not familiar with the correct subject terminology that was used in the question.
- (b) In Q1.2.1 and Q1.2.3 (4 marks) candidates were not able to respond well to the question relating to the specifications that scaffolding should adhere to before it is used and while working on scaffolding.
- (c) In Q1.4 (2 marks) candidates named the safety precautions for a worker working on a trestle scaffold and not the regulations regarding the safe use of trestle scaffolds.
- (d) In Q1.6 (3 marks) some candidates could not explain in logical steps how a bolt and nut can be used to join two metal plates.
- (e) In Q1.7 (2 marks) many candidates were not able to respond with the correct answer by completing the sentences given in the question. Instead, the candidates wrote general uses and aspects of how to care for the multi detector. They were not credited for this interpretation.

Suggestions for improvement

- (a) It is recommended that teachers ensure that learners fully understand the concepts related to materials instead of rote learning. It is important that learners work physically with materials to become familiar with them and acquire the knowledge of the properties and uses of different materials.
- (b) A glossary of academic terminology must be compiled and given to learners and must be used throughout the presentation of lessons. The meaning of each of these terms should be clearly explained to the learners.
- (c) It is imperative that labels be indicated on all drawings.
- (d) Learners must be taught to explain or describe concepts in a logical manner, e.g. *Explain how to use a bolt and nut to join two metal plates.*
- (e) Multiple-choice and matching-item questions must be attempted.
- (f) It is recommended that before learners start with scale drawings, they study them by doing the drawings freehand until they know all the parts and the sequence to be followed.
- (g) The mark allocation per question is indicative of the number of facts required in response to the question.

- (h) It is important that all topics be sufficiently covered before the preparatory examinations commence.
- (i) Teachers should not only rely on activities that are in the textbooks. Alternative questions that address the expected outcomes should be developed to cover all cognitive levels. These are listed in the CAPS for all the topics.
- (j) Learners must be aware that the relevant unit of measurement must be indicated in their answers.
- (k) It would be beneficial for learners if they were taught to read the question carefully and to isolate the exact aspect, within the topic, that should form the basis of their response. Learners recognise certain words and make their own conclusions without really taking cognisance of the question that is asked
- (l) If learners do not adhere to the instructions in the question, they may lose marks, e.g. if the question requires a line diagram and the candidate responds with a drawing, showing all details of the object, (s)he has not adhered to the instructions.
- (m) Learners must be aware that if they draw another drawing than the one asked in the question, no marks will be awarded for the incorrect drawing or part thereof.
- (n) It is recommended that if teachers complete the Grade 11 ATP in good time, they should start preparing learners for those topics that are placed last in the Grade 12 ATP.
- (o) Teachers and learners should take note that the assessment criteria in the answer sheets do not indicate all the aspects and mark allocations of the drawings required. The table on the left is an example of details that will appear in the question paper. The table on the right reflects details in the marking guideline. This implies that learners should know all the parts and dimensions of all required drawings.

ASSESSMENT CRITERIA	MARK	CM
Correctness of drawing	8	
One label with dimensions	2	
TOTAL:	10	

ASSESSMENT CRITERIA	MARK
Correctness of drawing:	
Rafters	2
King post	1
Tie beam	1
Queen posts	2
Struts	2
Wall plates	2
TOTAL:	10

- (p) More emphasis should be placed on the use of practical demonstrations of the application of different joining fixtures. Learners should be given the opportunity to practically use each of the prescribed joining fixtures during practical periods.

QUESTION 2: GRAPHICS AS METHOD OF COMMUNICATION

Common errors and misconceptions

- (a) Many candidates experienced challenges in reading and interpreting the floor plan and elevation and they were unable to identify, draw and interpret drawing symbols.
- (b) The use of the correct subject terminology seems to be a challenge for many candidates. When candidates are asked to identify features or objects from the drawings, they used layman's terminology or they gave explanations.

- (c) Candidates made use of symbols that are found in computer-aided drawings and not the SANS approved symbols that are required in the question paper. Candidates lost valuable marks because of this.
- (d) Poor performance by candidates was noted in Q2.2 (1 mark). The identification of the person who is responsible to verify levels and measurements on the site posed challenges to them.
- (e) In Q2.12 (1 mark) some candidates identified the municipal sewerage connection only as a manhole.
- (f) Many candidates did not indicate the unit next to the dimension in Q2.14 (1 mark), and were, therefore, not credited for the answer.
- (g) Poor performance by candidates was noted in Q2.15 (1 mark) and Q2.17 (1 mark). Candidates failed to identify the site numbers on a specific side of the site plan.
- (h) In Q2.18 (2 marks) most candidates correctly identified errors on the floor plan.
- (i) There was a noticeable decline in responses. Candidates could not correctly deduce dimensions from the site plan and calculate the omitted dimension in Q2.29 (6 marks).

Suggestions for improvement

- (a) Actual building plans should be used during teaching to familiarise learners with the interpretation of these items.
- (b) A lot of attention should be given to the correct subject terminology when explaining content to learners. Learners should always be corrected when they respond using the wrong terminology when interacting in the classroom.
- (c) Teachers should ensure that learners are aware of the fact that there are many symbols found in the construction field, but only SANS approved symbols are accepted in this subject.
- (d) More analytical questions and worksheets, similar to Q2, should be completed in class focusing on the correct terminology for each part on the drawings.
- (e) The correct use of subject terminology should be emphasised to ensure learners avoid the unnecessary loss of marks through the use of incorrect terms.
- (f) It is recommended that teachers emphasize the importance of indicating units next to any measurement and answers of calculations to ensure that learners do not lose any marks that are easy to score.
- (g) It is recommended that teachers differentiate between the elevations of a building and the views in orthographic drawings during teaching and also explain the correct use of the terminology in the correct context.
- (h) Teachers should not only teach learners what they see in the building plans, but also to identify/recognise all detail that should be indicated in a building plan as well as how to analyse and identify errors or omissions.
- (i) Learners should be exposed to more calculations involving area, perimeter and lengths of walls to ensure that they have mastered the mathematical concepts.

QUESTION 3: CONSTRUCTION ASSOCIATED WITH CIVIL SERVICES, OHSA AND QUANTITIES

Common errors and misconceptions

- (a) Q3.1 (2 marks) was poorly answered by most candidates. They were not familiar with the correct terminology and equipment *respirator* and wrote *mask* instead, for which they were not credited.
- (b) In Q3.2 (2 marks) most candidates were not able to describe two aspects that must be determined when setting out and excavating trenches for sewer pipes.
- (c) Many candidates had difficulty with identifying the concrete ring manhole and describing the process for installing the base of this manhole as required in Q3.4 (5 marks). It seems candidates had not been exposed to the specific practical aspects of the building of this item.
- (d) In Q3.7 (8 marks) the majority of candidates demonstrated a poor understanding of the basic concepts in the calculation of the quantity of bricks, and the correct use of the dimension sheet.
- (e) In Q3.8 (9 marks) many candidates were not familiar with the brick bond tested and were not able to correctly project and draw the second course of the given wall.

Suggestions for improvement

- (a) It is recommended that teachers emphasise the correct terminology related to equipment during teaching and informal assessment.
- (b) It is advised that aspects pertaining to the setting out and excavation of trenches for sewerage pipes be coupled with a practical demonstration in the L-shaped sand pit that should be available at all schools offering Civil Services. Pictures and video clips can be used to enhance understanding of the setting-out of trenches in a real-life context.
- (c) It will be beneficial to learners if they can be exposed to the practical installation of concrete ring manholes. If a physical demonstration is not possible, video clips and pictures can be used very effectively to demonstrate this procedure.
- (d) Subject advisors should conduct workshops on the calculation of quantities. It is recommended that teachers first explain the concept of the specific items for which the quantities should be calculated before explaining the actual calculation. It will be beneficial to learners if they were given more exercises on the calculation of quantities of each item than the one example in the textbook. These additional exercises should form part of the teacher's lesson preparation.
- (e) It will be beneficial to learners if they are exposed to the practical dry packing of the different brick bonds. Learners should also perform freehand drawings of the different brick bonds indicating the sizes of the different bricks used.

QUESTION 4: COLD AND HOT-WATER SUPPLY, TOOLS, EQUIPMENT AND MATERIALS

Common errors and misconceptions

- (a) In Q4.1 (8 marks) many candidates had difficulty with matching the correct description from the matching column question with the item listed in the opposite column. Candidates had to demonstrate deeper insight in the parts and working principles of valves, rather than the mere identification and use of valves. It is evident that they were not fully equipped to respond in the required manner.
- (b) The majority of candidates were not able to respond to the methods used to prevent electrolytic reaction in Q4.2.
- (c) In Q4.5 (2 marks) most candidates were not familiar with the principle on which an electronic water-saving shower head works and confused it with pre-set water providing devices.
- (d) Many candidates demonstrated a poor understanding of the symbols that are used in plumbing and were not able to correctly draw the symbols as required in Q4.6.
- (e) In Q4.8 most candidates had difficulty with explaining what an *Airlock* and *Water hammer* were.
- (f) Most candidates were not familiar with the correct name of the tool and the use of the different parts of the machine in Q4.11 (3 marks).

Suggestions for improvement

- (a) More emphasis should be placed on the practical disassembly, reassembly and installation of valves to enable learners to see the different parts of the valves and the purpose of each part.
- (b) It will be beneficial to learners if they could be shown the outcomes of electrolytic reaction. It is advised that teachers use small sections of different types of pipes to physically explain the concepts of *similar* and *dissimilar* pipes as used in the reference material.
- (c) It is recommended that teachers differentiate between the different water-saving devices using a table so that learners can clearly identify the differences between them.
- (d) Learners will benefit if informal assessment tasks are conducted on a regular basis during each term to test the identification and drawing of the symbols used in plumbing.
- (e) A practical demonstration will help to develop a better understanding of the different faults that may occur in hot and cold-water systems.
- (f) The challenge with terminology can be addressed by ensuring that correct subject terminology is used by the teacher while teaching and by learners when doing class and homework activities. Teaching in the language of teaching and learning is a critical factor in the ability of the learners to comprehend and correctly respond to questions.

QUESTION 5: GRAPHICS AS MEANS OF COMMUNICATION, ROOF WORK AND STORM WATER

Common errors and misconceptions

- (a) In Q5.2 (9 marks) most candidates were not able to draw the front elevation of a PVC gutter with all the required accessories on the given fascia board as expected.
- (b) Poor performance was evident in the drawing of the development of the cylindrical pipe elbow in Q5.3 (19 marks). Many candidates either developed the wrong section of pipe or did not attempt the question at all.
- (c) Many candidates did not project the development from the given view but instead drew the development in the open space available on the side of the answer sheet. If candidates did not project the development from the given view, as indicated in the instructions, they were not credited with the three marks for those projection lines. Candidates who developed the wrong pipe were only credited with the first three marks for dividing the circle into twelve equal parts and the upward projection lines.

Suggestions for improvement

- (a) It will benefit learners if a PVC gutter with gutter clips, gutter outlet, stop ends and a down pipe can be erected in the workshop so that learners can be exposed to this topic in a real-life context.
- (b) Workshops on the development of cones and pipes, conducted by subject specialists, will benefit teachers. Making paper or cardboard models of the developments listed in the CAPS will assist learners in their understanding of these concepts. The Grade 10 and 11 PAT can also be used to develop the skills of learners on this topic. A possible reason for the poor performance in this topic can be that Civil Technology teachers rely on the EGD teachers to teach this topic and do not teach and give enough examples to learners to draw in the Civil Technology class.
- (c) More emphasis should be placed on the adherence to instructions in the questions. Many candidates lost easy-to-score marks by not adhering to the instructions in the questions.

QUESTION 6: SEWERAGE, SANITARY FITTINGS AND JOINING

Common errors and misconceptions

- (a) In Q6.3 most candidates were not familiar with the correct name of the compression ring/ferrule in the compression T coupling and were not able to explain the function of the compression ring.
- (b) The majority of candidates were not familiar with the regulations pertaining to the laying of pipes for sanitary fittings in Q6.5.
- (c) In Q6.6 many candidates had difficulty with explaining the difference between the functions of chamber A and B of a septic tank.
- (d) Many candidates had difficulty with the drawing of the sewerage layout that was required in Q6.8 (13 marks). A possible reason may be that candidates were not exposed to the practical application of the design and layout of a sewerage system according to drainage principles and regulations. The correct flow direction of branch

pipes, the correct connection of two sewer lines and the positioning of the rodding eyes posed the biggest challenge to candidates in this question.

Suggestions for improvement

- (a) It will benefit learners to physically use the prescribed joints and to be exposed to a sectional view of the real joints. This will enhance their understanding of the different joints and develop their skills in the drawing of these items.
- (b) It is recommended that learners be given the opportunity in class to explain the regulations pertaining to the laying of pipes for sanitary fitments, in the language of teaching and learning, to develop their ability to express themselves in a logical manner.
- (c) It will benefit learners if teachers practically demonstrated the working principles and purpose of septic tanks.
- (d) Subject advisors should conduct workshops on the design and installation of a sewerage system by taking teachers on a site excursion around a school to show them the different parts of a sewerage system. This will assist teachers with understanding the function and position of each component before going into a classroom to demonstrate to their learners how to design and draw the layout of a sewerage system. Teachers might find that replicating the strategy of a real-life tour of the school will enhance learners' understanding of the details of this topic.

4.2 CONSTRUCTION

The following report should be read in conjunction with the Construction question paper of the November 2021 Examinations.

4.2.1 PERFORMANCE TRENDS (2018–2021)

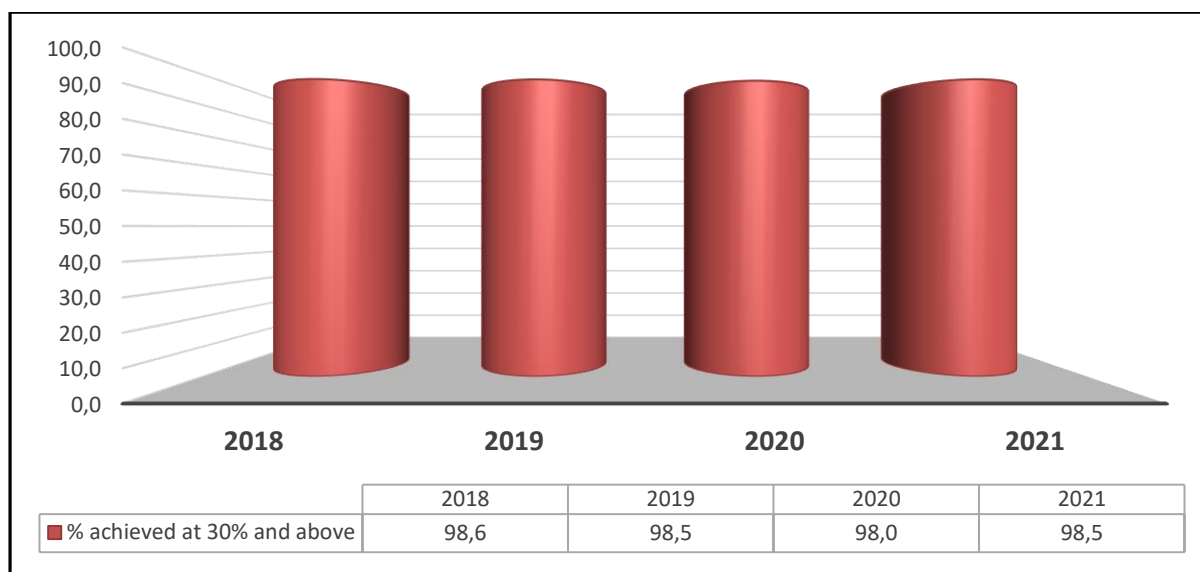
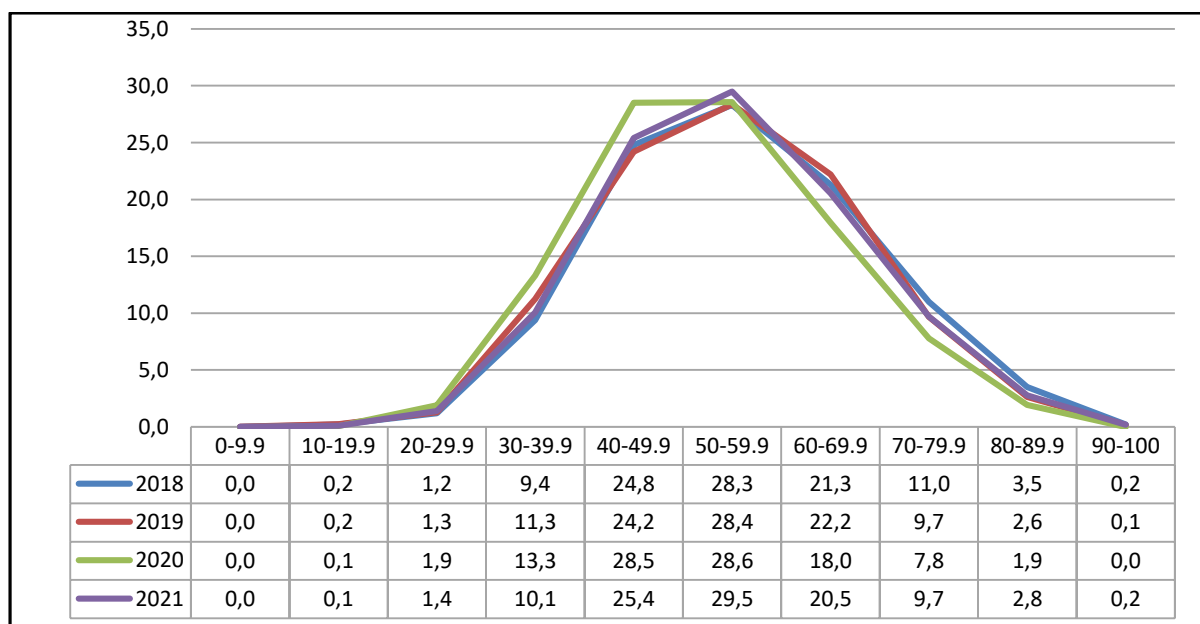
In 2021, 4 474 candidates sat for the Construction examination. The number of candidates increased by 892 in 2021.

The performance of the candidates in 2021 was close to the performance of learners in 2020. The pass percentage at 30% and above increased slightly from 98,0% in 2020 to 98,5% in 2021. It was encouraging that 62,7% of candidates achieved over 50% this year in comparison to 56,3% of candidates doing so in 2020.

The percentage of distinctions (80% and above) increased marginally from 1,9% in 2020 to 3,0% in 2021. This translates to an increase in the number of distinctions from 68 in 2020 to an impressive 134 in 2021.

Table 4.2.1 Overall achievement rates in Construction

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	4 350	4 288	98,6
2019	3 492	3 438	98,5
2020	3 582	3 511	98,0
2021	4 474	4 406	98,5

Graph 4.2.1(a) Overall achievement rates in Construction (percentage)**Graph 4.2.1(b) Performance distribution curves in Construction (percentage)**

4.2.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE CONSTRUCTION PAPER

General Comments

- (a) It was noted that many candidates did not start each question on a new page as indicated in the instructions.
- (b) A large number of candidates experienced difficulty with subject-specific and academic terminology.
- (c) Poor drawing and interpretation skills were evident. There was poor distinction between line diagrams, sketches, pictorial views and scale drawings. Many scale drawings were not done using drawing equipment.

- (d) From the responses in the scripts, it is evident that the candidates lacked practical exposure and experience.
- (e) A significant number of candidates were not credited with marks because they failed to label their drawings.
- (f) Candidates experienced challenges to express themselves when responding to questions which required them to describe or explain.
- (g) Matching-items and multiple-choice questions were left unanswered by some candidates, and they were not credited as a result.
- (h) Many candidates found it difficult to explain practical applications theoretically.
- (i) In a question that counted 2 marks, a significant number of candidates provided only one response instead of two.
- (j) It was observed that the performance of the candidates was poorest in the topics indicated last on the ATP. A possible reason for the poor performance may be that at the end of the year, teachers are under pressure to complete the ATP and do not spend enough time on teaching these topics.

4.2.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN CONSTRUCTION

QUESTION 1: OHSA, MATERIALS, TOOLS, EQUIPMENT AND JOINING

Common errors and misconceptions

- (a) In Q1.1 (5 marks) candidates had difficulty in the *matching-items* question to link the appropriate descriptions with the items provided. A number of candidates were not able to respond in the required manner. They had to demonstrate deeper insight in the properties and principles applied in materials rather than the mere identification and use thereof. Many candidates were also not familiar with the correct subject terminology that was used in the question.
- (b) In Q1.2.1 and Q1.2.3 (4 marks) candidates were not able to respond well to the question relating to the specifications that scaffolding should adhere to before it is used and while working on scaffolding.
- (c) In Q1.4 (2 marks) candidates named the safety precautions for a worker working on a trestle scaffold and not the regulations regarding the safe use of trestle scaffolds.
- (d) In Q1.6 (3 marks) some candidates could not explain in logical steps how a bolt and nut can be used to join two metal plates.
- (e) In Q1.7 (2 marks) many candidates were not able to respond with the correct answer by completing the sentences given in the question. Instead, the candidates wrote general uses and aspects of how to care for the multi detector. They were not credited for this interpretation.

Suggestions for improvement

- (a) It is recommended that teachers ensure that learners fully understand the concepts related to materials instead of rote learning. It is important that learners work physically with materials to become familiar with them and acquire the knowledge of the properties and uses of different materials.
- (b) A glossary of academic terminology must be compiled and given to learners and must be used throughout the presentation of lessons. The meaning of each of these terms should be clearly explained to the learners.
- (c) It is imperative that labels be indicated on all drawings.
- (d) Learners must be taught to explain or describe concepts in a logical manner, e.g. *Explain how to use a bolt and nut to join two metal plates.*
- (e) Multiple-choice and matching-item questions must be attempted.
- (f) It is recommended that before learners start with scale drawings, they study them by doing the drawings freehand until they know all the parts and the sequence to be followed.
- (g) The mark allocation per question is indicative of the number of facts required in response to the question.
- (h) It is important that all topics be sufficiently covered before the preparatory examinations commence.
- (i) Teachers should not only rely on activities that are in the textbooks. Alternative questions that address the expected outcomes should be developed to cover all cognitive levels. These are listed in the CAPS for all the topics.
- (j) Learners must be aware that the relevant unit of measurement must be indicated in their answers.
- (k) It would be beneficial for learners if they were taught to read the question carefully and to isolate the exact aspect, within the topic, that should form the basis of their response. Learners recognise certain words and make their own conclusions without really taking cognisance of the question that is asked
- (l) If learners do not adhere to the instructions in the question, they may lose marks, e.g. if the question requires a line diagram and the candidate responds with a drawing, showing all details of the object, (s)he has not adhered to the instructions.
- (m) Learners must be aware that if they draw another drawing than the one asked in the question, no marks will be awarded for the incorrect drawing or part thereof.
- (n) It is recommended that if teachers complete the Grade 11 ATP in good time, they should start preparing learners for those topics that are placed last in the Grade 12 ATP.

- (o) Teachers and learners should take note that the assessment criteria in the answer sheets do not indicate all the aspects and mark allocations of the drawings required. The table on the left is an example of details that will appear in the question paper. The table on the right reflects details in the marking guideline. This implies that learners should know all the parts and dimensions of all required drawings.

ASSESSMENT CRITERIA	MARK	CM
Correctness of drawing	8	
One label with dimensions	2	
TOTAL:	10	

ASSESSMENT CRITERIA	MARK
Correctness of drawing:	
Rafters	2
King post	1
Tie beam	1
Queen posts	2
Struts	2
Wall plates	2
TOTAL:	10

- (p) More emphasis should be placed on the use of practical demonstrations of the application of different joining fixtures. Learners should be given the opportunity to practically use each of the prescribed joining fixtures during practical periods.

QUESTION 2: GRAPHICS AS METHOD OF COMMUNICATION

Common errors and misconceptions

- Many candidates experienced challenges in reading and interpreting the floor plan and elevation and they were unable to identify, draw and interpret drawing symbols.
- The use of the correct subject terminology seems to be a challenge for many candidates. When candidates are asked to identify features or objects from the drawings, they used layman's terminology or they gave explanations.
- Candidates made use of symbols that are found in computer-aided drawings and not the SANS approved symbols that are required in the question paper. Candidates lost valuable marks because of this.
- Poor performance by candidates was noted in Q2.2 (1 mark). The identification of the person who is responsible to verify levels and measurements on the site posed challenges to them.
- In Q2.12 (1 mark) some candidates identified the municipal sewerage connection only as a manhole.
- Many candidates did not indicate the unit next to the dimension in Q2.14 (1 mark), and were, therefore, not credited for the answer.
- Poor performance by candidates was noted in Q2.15 (1 mark) and Q2.17 (1 mark). Candidates failed to identify the site numbers on a specific side of the site plan.
- In Q2.18 (2 marks) most candidates correctly identified errors on the floor plan.
- There was a noticeable decline in responses. Candidates could not correctly deduce dimensions from the site plan and calculate the omitted dimension in Q2.29 (6 marks).

Suggestions for improvement

- (a) Actual building plans should be used during teaching to familiarise learners with the interpretation of these items.
- (b) A lot of attention should be given to the correct subject terminology when explaining content to learners. Learners should always be corrected when they respond using the wrong terminology when interacting in the classroom.
- (c) Teachers should ensure that learners are aware of the fact that there are many symbols found in the construction field, but only SANS approved symbols are accepted in this subject.
- (d) More analytical questions and worksheets, similar to Q2, should be completed in class focusing on the correct terminology for each part on the drawings.
- (e) The correct use of subject terminology should be emphasised to ensure learners avoid the unnecessary loss of marks through the use of incorrect terms.
- (f) It is recommended that teachers emphasize the importance of indicating units next to any measurement and answers of calculations to ensure that learners do not lose any marks that are easy to score.
- (g) It is recommended that teachers differentiate between the elevations of a building and the views in orthographic drawings during teaching and also explain the correct use of the terminology in the correct context.
- (h) Teachers should not only teach learners what they see in the building plans, but also to identify/recognise all detail that should be indicated in a building plan as well as how to analyse and identify errors or omissions.
- (i) Learners should be exposed to more calculations involving area, perimeter and lengths of walls to ensure that they have mastered the mathematical concepts.

QUESTION 3: ROOFS, STAIRCASES AND JOINING

Common errors and misconceptions

- (a) Question 3.1 (1 mark) was answered very poorly. Candidates were not familiar with the different balustrade patterns.
- (b) It was observed that most candidates did not answer Q 3.3 (1 mark) and could not recall the minimum distance between a pitch line and the handrail of a staircase.
- (c) Q3.7 (1 mark) appeared to be challenging for most candidates. Candidates could not name one type of cast-in anchor.
- (d) Candidates struggled to draw the components of a closed-couple roof truss to scale in Q3.14 (8 marks). Candidates did not adhere to or apply the prescribed scale. If the candidate drew the wrong roof truss, he or she was not awarded any marks.

Suggestions for Improvement

- (a) Samples of the different balustrade patterns could be displayed in the classroom so that learners could identify and name these different patterns on a few occasions,

especially during revision. Learners remember content better if they see it physically and not just in the textbook.

- (b) Simulation tasks work very well for learners to identify and know the different parts and specifications of staircases. If time allows, it will benefit the learners if they could build (even according to a smaller scale) their own staircase.
- (c) Because learners cover joining methods in Grade 10 and 11, they tend to get complacent and assume that they know the content. Teachers must make sure that they give these chapters the necessary attention in Grade 12.
- (d) It is recommended that teachers provide learners with more exercises on the drawing of roof trusses for learners to develop their drawing skills and in understanding the different types of roof trusses.

QUESTION 4: EXCAVATIONS, FORMWORK, TOOLS AND EQUIPMENT AND MATERIALS

Common errors and misconceptions

- (a) Q4.4.1 (2 marks) expected the candidate to name two members that were omitted in the figure and required the candidate to predict the likely consequence of omitting these members during excavations. Candidates answered the first part of this question well, but most candidates neglected to answer the second part of the question.
- (b) Many candidates drew the shuttering in Q4.4.2 (5 marks) oblique and not two-dimensional. Many candidates understood the concept but experienced challenges in drawing a two-dimensional drawing. It seems that the candidates did not understand what the different drawing methods are.
- (c) Candidates could not identify the type of formwork in Q4.6.1 (1 mark). Many candidates gave an explanation but could not use the correct terminology.
- (d) The word *respectively* in Q4.8 (2 marks) posed a challenge to many candidates. Candidates did not know what the different verbs or instructions meant, and although they knew the content, they could not respond accurately to some of the questions.
- (e) Q4.10 (2 marks) was not answered as well as expected. Candidates could not respond to the two categories of metals. Candidates listed types of metals that fall within both the categories of ferrous and non-ferrous metals instead of the two categories.

Suggestions for improvement

- (a) All formal and informal tasks should be set according to the same standard as the NSC question papers and according to the examination guidelines. Learners should be exposed to these types of questions on a regular basis.
- (b) The different drawing principles and methods should be explained to learners in the classroom, so that they are able to respond with the correct type of drawing during examinations. During formal or informal tasks, marks should not be awarded to learners for the incorrect drawings.
- (c) The correct terminology should be used during teaching and learning, so that learners can respond accurately to these types of questions.

- (d) All the different verbs and instructions that are used in the question papers should be explained to learners so that they can understand what the questions expect from them and how to respond.
- (e) Samples of the different metals can be used very effectively to practically demonstrate, not only the properties and uses of thereof, but also to divide them into the different categories for learners to be able to understand all the required aspects of these materials.

QUESTION 5: PLASTER AND SCREED, BRICKWORK AND GRAPHICS AS MEANS OF COMMUNICATION

Common Errors and Misconceptions

- (a) In Q5.1.3 (1 mark) many candidates were not familiar with different admixtures for the material.
- (b) Q5.2.1 to Q5.2.3 (3 marks) required the candidate to explain different terminology. Many candidates were not equipped to explain the terminology accurately.
- (c) Question 5.4.2 (1 mark) seemed to be challenging for many candidates. It appeared that candidates did not understand the verb *describe* and instead of *describing* where weep holes were positioned, they gave the functions of the weep holes.
- (d) Only a limited number of candidates were able to draw the horizontal section of a steel door frame in Q5.5 (4 marks). If the drawing was rotated, candidates were not awarded any marks.

Suggestions for Improvement

- (a) Materials is a topic that is covered in Grade 10 and 11, and it seems to be neglected in Grade 12. All topics should be covered as prescribed by the ATP for Grade 12.
- (b) Terminology should be high priority during teaching and learning. Learners need to know and be able to explain the different terminology before they can advance to the practical implementation of a certain topic.
- (c) It will be beneficial to learners if teachers ensure that learners understand the different types of questions and what the ideal responses would be to those questions.
- (d) More emphasis should be placed on the different orientations of sectional drawings for door frames.

QUESTION 6: REINFORCEMENT IN CONCRETE, FOUNDATIONS, CONCRETE FLOOR AND QUANTITIES

Common errors and misconceptions

- (a) Q 6.2, Q6.3 and Q6.8 (5 marks) seemed to be challenging for most candidates. The required responses were dimensions while candidates only focused on identifying parts and were not equipped to give more detail.
- (b) In Q6.5 (9 marks) candidates had difficulty with drawing a detailed drawing of the vertical sectional view through a rib and block floor.

- (c) Q 6.6.1 and 6.6.2 (1 mark each) were placed between two drawing questions. Many candidates neglected to answer these questions.
- (d) Q 6.6.3 required the candidates to draw the reinforcing of the circled part on an answer sheet. Many candidates experienced challenges with drawing the reinforcing in the indicated section.
- (e) Doing basic calculations posed a serious challenge to candidates. Many candidates could not calculate the correct area of the floor, the volume of concrete or the number of tiles needed in Q6.9.1 and Q6.9.2 (10 marks). Most candidates could not use the dimension paper, in the answer sheet for Q6.9, correctly.

Suggestions for improvement

- (a) Learners should be encouraged not to limit their studies to merely identifying parts, but to also be able to know the measurements or dimensions of these parts.
- (b) It is recommended that these types of drawings be done in class. Visits to construction sites would be an excellent way to demonstrate such installations since it would be difficult to demonstrate at school. If that is not possible, there are different videos available on the internet that can be used to demonstrate these installations.
- (c) Learners should make sure that they answer all the questions and number them according to the numbering system used in the question paper.
- (d) Reinforcing is covered in Grades 10, 11 and 12. Learners should be exposed to the different methods of asking questions on the same content and not only examples from previous NSC question papers.
- (e) More exercises on the calculation of quantities of materials for a building should be given to learners to develop a better understanding of the topic. These calculations should always be done on dimension paper so that learners become familiar with this process in preparing for examinations. Arrangements could be made with the mathematics teacher to also focus on the different formulae used in the technology subjects to ensure a concrete understanding of these concepts.

4.3 WOODWORKING

The following report should be read in conjunction with the Woodworking question paper of the November 2021 Examinations.

4.3.1 PERFORMANCE TRENDS (2018–2021)

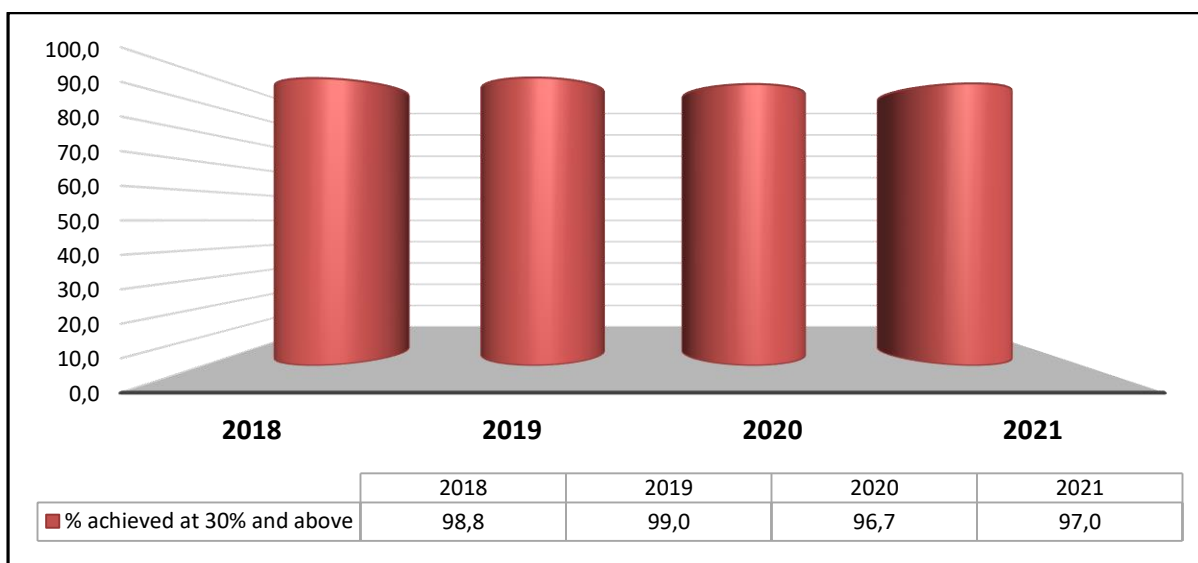
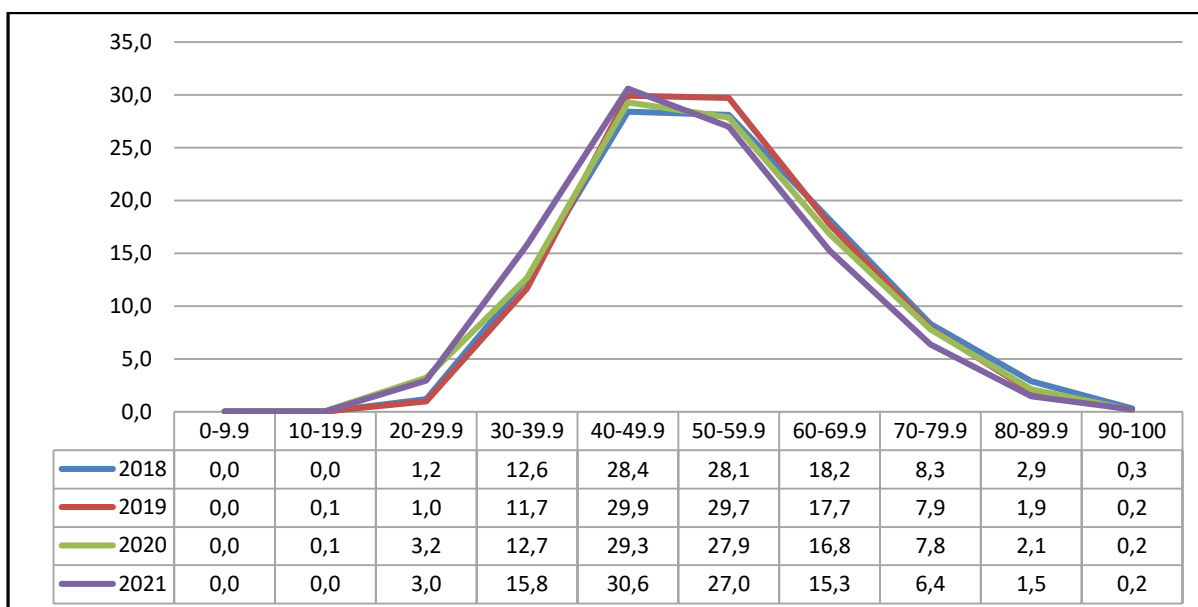
In 2021, 2 366 candidates sat for the Woodworking examination, i.e. the number of candidates increased by 529 in 2021.

The performance of the candidates in 2021 was almost similar to the performance of learners in 2020. The pass percentage at 30% and above increased slightly from 96,7% in 2020 to 97,0% in 2021. The percentage of candidates who obtained 50% and above stood at 50,4% for 2021. This was a decline from 54,8% in 2020.

The percentage of distinctions (80% and above) decreased marginally from 2,3% in 2020 to 1,7% in 2021. Given the bigger cohort, the number of distinctions decreased from 42 in 2020 to 40 in 2021.

Table 4.3.1 Overall achievement rates in Woodworking

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	2 606	2 574	98,8
2019	1 946	1 926	99,0
2020	1 837	1 777	96,7
2021	2 366	2 294	97,0

Graph 4.3.1(a) Overall achievement rates in Woodworking (percentage)**Graph 4.3.1 (b) Performance distribution curves in Woodworking (percentage)**

4.3.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE WOODWORKING PAPER

General Comments

- (a) It was noted that many candidates did not start each question on a new page as indicated in the instructions.
- (b) A large number of candidates experienced difficulty with subject-specific and academic terminology.
- (c) Poor drawing and interpretation skills were evident. There was poor distinction between line diagrams, sketches, pictorial views and scale drawings. Many scale drawings were not done using drawing equipment.
- (d) From the responses in the scripts, it is evident that the candidates lacked practical exposure and experience.
- (e) A significant number of candidates were not credited due to a failure to indicate labels.
- (f) Candidates experienced challenges to express themselves when responding to questions which required them to describe or explain.
- (g) Matching-items and multiple-choice questions were left unanswered by some candidates, and they were not credited as a result.
- (h) Many candidates found it difficult to explain practical applications theoretically.
- (i) In a question that counts 2 marks, a significant number of candidates provided only one response instead of two.
- (j) It was observed that the performance of the candidates was poorest in the topics indicated last on the ATP. A possible reason for the poor performance may be that at the end of the year, teachers are under pressure to complete the ATP and do not spend enough time on teaching these topics.

4.3.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN WOODWORKING

QUESTION 1: OHSA, MATERIALS, TOOLS, EQUIPMENT AND JOINING

Common errors and misconceptions

- (a) In Q1.1 (5 marks) candidates had difficulty in the *matching-items* question to link the appropriate descriptions with the items provided. A number of candidates were not able to respond in the required manner. They had to demonstrate deeper insight in the properties and principles applied in materials rather than the mere identification and use thereof. Many candidates were also not familiar with the correct subject terminology that was used in the question.
- (b) In Q1.2.1 and Q1.2.3 (4 marks) candidates were not able to respond well to the question relating to the specifications that scaffolding should adhere to before it is used and while working on scaffolding.

- (c) In Q1.4 (2 marks) candidates named the safety precautions for a worker working on a trestle scaffold and not the regulations regarding the safe use of trestle scaffolds.
- (d) In Q1.6 (3 marks) some candidates could not explain in logical steps how a bolt and nut can be used to join two metal plates.
- (e) In Q1.7 (2 marks) many candidates were not able to respond with the correct answer by completing the sentences given in the question. Instead, the candidates wrote general uses and aspects of how to care for the multi detector. They were not credited for this interpretation.

Suggestions for improvement

- (a) It is recommended that teachers ensure that learners fully understand the concepts related to materials instead of rote learning. It is important that learners work physically with materials to become familiar with them and acquire the knowledge of the properties and uses of different materials.
- (b) A glossary of academic terminology must be compiled and given to learners and must be used throughout the presentation of lessons. The meaning of each of these terms should be clearly explained to the learners.
- (c) It is imperative that labels be indicated on all drawings.
- (d) Learners must be taught to explain or describe concepts in a logical manner, e.g. *Explain how to use a bolt and nut to join two metal plates.*
- (e) Multiple-choice and matching-item questions must be attempted.
- (f) It is recommended that before learners start with scale drawings, they study them by doing the drawings freehand until they know all the parts and the sequence to be followed.
- (g) The mark allocation per question is indicative of the number of facts required in response to the question.
- (h) It is important that all topics be sufficiently covered before the preparatory examinations commence.
- (i) Teachers should not only rely on activities that are in the textbooks. Alternative questions that address the expected outcomes should be developed to cover all cognitive levels. These are listed in the CAPS for all the topics.
- (j) Learners must be aware that the relevant unit of measurement must be indicated in their answers.
- (k) It would be beneficial for learners if they were taught to read the question carefully and to isolate the exact aspect, within the topic, that should form the basis of their response. Learners recognise certain words and make their own conclusions without really taking cognisance of the question that is asked
- (l) If learners do not adhere to the instructions in the question, they may lose marks, e.g. if the question requires a line diagram and the candidate responds with a drawing, showing all details of the object, (s)he has not adhered to the instructions.

- (m) Learners must be aware that if they draw another drawing than the one asked in the question, no marks will be awarded for the incorrect drawing or part thereof.
- (n) It is recommended that if teachers complete the Grade 11 ATP in good time, they should start preparing learners for those topics that are placed last in the Grade 12 ATP.
- (o) Teachers and learners should take note that the assessment criteria in the answer sheets do not indicate all the aspects and mark allocations of the drawings required. The table on the left is an example of details that will appear in the question paper. The table on the right reflects details in the marking guideline. This implies that learners should know all the parts and dimensions of all required drawings.

ASSESSMENT CRITERIA	MARK	CM
Correctness of drawing	8	
One label with dimensions	2	
TOTAL:	10	

ASSESSMENT CRITERIA	MARK
Correctness of drawing:	
Rafters	2
King post	1
Tie beam	1
Queen posts	2
Struts	2
Wall plates	2
TOTAL:	10

- (p) More emphasis should be placed on the use of practical demonstrations of the application of different joining fixtures. Learners should be given the opportunity to practically use each of the prescribed joining fixtures during practical periods.

QUESTION 2: GRAPHICS AS METHOD OF COMMUNICATION

Common errors and misconceptions

- (a) Many candidates experienced challenges in reading and interpreting the floor plan and elevation and they were unable to identify, draw and interpret drawing symbols.
- (b) The use of the correct subject terminology seems to be a challenge for many candidates. When candidates are asked to identify features or objects from the drawings, they used layman's terminology or they gave explanations.
- (c) Candidates made use of symbols that are found in computer-aided drawings and not the SANS approved symbols that are required in the question paper. Candidates lost valuable marks because of this.
- (d) Poor performance by candidates was noted in Q2.2 (1 mark). The identification of the person who is responsible to verify levels and measurements on the site posed challenges to them.
- (e) In Q2.12 (1 mark) some candidates identified the municipal sewerage connection only as a manhole.
- (f) Many candidates did not indicate the unit next to the dimension in Q2.14 (1 mark), and were, therefore, not credited for the answer.
- (g) Poor performance by candidates was noted in Q2.15 (1 mark) and Q2.17 (1 mark). Candidates failed to identify the site numbers on a specific side of the site plan.
- (h) In Q2.18 (2 marks) most candidates correctly identified errors on the floor plan.

- (i) There was a noticeable decline in responses. Candidates could not correctly deduce dimensions from the site plan and calculate the omitted dimension in Q2.29 (6 marks).

Suggestions for improvement

- (a) Actual building plans should be used during teaching to familiarise learners with the interpretation of these items.
- (b) A lot of attention should be given to the correct subject terminology when explaining content to learners. Learners should always be corrected when they respond using the wrong terminology when interacting in the classroom.
- (c) Teachers should ensure that learners are aware of the fact that there are many symbols found in the construction field, but only SANS approved symbols are accepted in this subject.
- (d) More analytical questions and worksheets, similar to Q2, should be completed in class focusing on the correct terminology for each part on the drawings.
- (e) The correct use of subject terminology should be emphasised to ensure learners avoid the unnecessary loss of marks through the use of incorrect terms.
- (f) It is recommended that teachers emphasize the importance of indicating units next to any measurement and answers of calculations to ensure that learners do not lose any marks that are easy to score.
- (g) It is recommended that teachers differentiate between the elevations of a building and the views in orthographic drawings during teaching and also explain the correct use of the terminology in the correct context.
- (h) Teachers should not only teach learners what they see in the building plans, but also to identify/recognise all detail that should be indicated in a building plan as well as how to analyse and identify errors or omissions.
- (i) Learners should be exposed to more calculations involving area, perimeter and lengths of walls to ensure that they have mastered the mathematical concepts.

QUESTION 3: CASEMENTS, CUPBOARDS, WALL-PANELLING AND QUANTITIES

Common errors and misconceptions

- (a) In Q3.1 (6 marks) many candidates had difficulty with identifying the parts of the casement, stating the purpose of the *drip groove* and explaining the term *fanlight*.
- (b) Most candidates were not equipped to correctly calculate the dimensions of the required parts and to correctly complete the cutting list for the cupboard in Q3.2.1 (7 marks).
- (c) In Q3.2.2 (11 marks) it was evident from the responses of many candidates that they were unable to draw the sectional view of the cupboard correctly and indicate the hatching of the sectioned parts correctly.
- (d) The majority of the candidates were not equipped to project and draw to the given scale the front view of the wall panelling in Q3.3 (6 marks).

Suggestions for improvement

- (a) It is recommended that an old casement with a fanlight, which is not being used, should be cut and the relevant sections shown to the learners in class. The learners should then make drawings of what they see in the model.
- (b) Subject advisors should conduct workshops on the calculation of quantities. More exercises on the calculation of quantities of materials should be given to learners. It is advisable that learners be taught to read and interpret drawings and to use the correct method to compile a cutting list.
- (c) It will be beneficial to learners to be exposed to more practical examples of cupboards with doors, shelves and drawers from which they can draw the cupboards. In this way, they can see and understand the composition of the structure of the cupboard.
- (d) It will be beneficial to candidates if teachers required learners to draw the front, top and side views of the wall panelling during class and homework activities to equip them with the necessary skills to respond to this type of question.

QUESTION 4: ROOFS, CEILINGS, TOOLS AND EQUIPMENT, AND MATERIALS

Common errors and misconceptions

- (a) In Q4.1 (8 marks) the majority of the candidates were not sufficiently equipped to select the correct description of the roof members to match the items listed in column A.
- (b) Most candidates had difficulty with explaining the safe handling of the tools in terms of the specified criteria in Q4.2 (2 marks), Q4.3 (2 marks) and Q4.4 (1 mark). Instead, candidates listed general aspects regarding the safe handling of the tools and were not credited as a result.
- (c) In Q4.5.1 (1 mark) many candidates were not able to identify the metal T strip and only indicated metal strip or cover strip.
- (d) The majority of candidates were not able to differentiate between the different roof members of the different types of roof trusses and the correct names and functions of these parts in Q4.6 to Q4.11 (9 marks).
- (e) In Q4.12 (6 marks) the majority of candidates were not able to rearrange the given steps to be followed to lay concrete roof tiles in the correct sequence.
- (f) Most candidates were not able to respond correctly to the types of varnish finishes and the effect that spilled water may have on a waxed surface in Q4.13 to Q4.15.

Suggestions for improvement

- (a) It will be beneficial to learners if they are exposed to more drawings of roofs and the members which comprise each type of roof.
- (b) Learners should be given more practical exposure to all the listed tools and equipment prescribed in the CAPS to familiarise themselves with the parts, proper use, care and safety of machines.

- (c) It will be beneficial to learners if they are taught to look critically at objects and parts of structures and to always use the correct subject terminology when responding to a question.
- (d) Candidates did not understand the different roof trusses and the members of each truss in relation to one another. It seems that learners were taught each truss in isolation and were, therefore, not equipped to respond well to the questions in the question paper. It would be beneficial to look at how a combination of roof trusses is used in the roof structure.
- (e) More emphasis should be placed on the correct procedures to be followed when installing roof covering.
- (f) A challenge could be that learners were not practically exposed to the different varnish finishes and the type of protection each type provides to wood.

QUESTION 5: CENTERING, FORMWORK, SHORING AND GRAPHICS AS MEANS OF COMMUNICATION

Common errors and misconceptions

- (a) Many candidates were not able to select the correct answer from the given options in the multiple-choice questions regarding the different types of shores and parts of the shores in Q5.1 (5 marks).
- (b) In Q5.2 (5 marks) some candidates were not able to respond correctly to the shapes of the arches and were not able to correctly calculate the rise of the arch from the given span.
- (c) Most candidates responded well to question Q5.3 (9 marks). However, some candidates drew the full drawing instead of a line diagram as the question required and lost 5 marks as a result.
- (d) In Q5.4 (11 marks) many candidates were not able to draw a vertical section through the formwork for a beam and attached floor correctly.

Suggestions for improvement

- (a) A challenge could be that candidates were not practically exposed to shoring and do not understand this concept.
- (b) It is advised that learners should be exposed to more drawings of the different arches and also be taught how to calculate the rise of an arch if the span is given.
- (c) It will benefit candidates if they read the instructions in the question carefully and follow the instructions to the letter to ensure that they can obtain maximum marks.
- (d) A model should be made in the workshop for all concrete structures requiring formwork that are listed in the CAPS. It must be explained to learners why each component of the formwork is placed at a particular point, its correct name and the purpose that the component serves.

QUESTION 6: SUSPENDED FLOORS, STAIRCASES, IRONMONGERY, DOORS AND JOINING

Common errors and misconceptions

- (a) In Q6.2 (8 marks) very few candidates were able to draw the haunched mortice and tenon joint correctly.
- (b) Most candidates were not able to draw the floor joist with the truss hanger secured to the wall in Q6.3 (3 marks) correctly. Instead, many candidates redrew the incomplete drawing that was provided in answer sheet 6.5.
- (c) In Q6.4 (5 marks) many candidates could not differentiate correctly by means of two-dimensional drawings, between a straight flight of stairs with a landing and a stairwell with half a landing. Candidates were not credited if they drew three dimensional drawings, as the question required two-dimensional drawings.
- (d) The majority of candidates were not able to draw the supporting structure of a suspended timber floor in Q6.5 (10 marks) correctly. A challenge could be that learners were not exposed to the practical construction of a suspended timber floor and may not have drawn scale drawings of this floor during teaching and learning during the year.
- (e) In Q6.6 (8 marks) the majority of candidates were not able to correctly draw the horizontal section through the frame stile and raised and fielded panel of a door with a sidelight. Most candidates drew a raised panel instead of a raised and fielded panel. The majority of candidates left this question unanswered.

Suggestions for improvement

- (a) A challenge could be that candidates did not read the question properly and misinterpreted the instructions that indicated that the drawing shows an incomplete view of a haunched mortice and tenon joint. It will be beneficial to candidates if they read the instructions in the question carefully and followed the instructions to the letter to ensure that they could obtain maximum marks.
- (b) Practical demonstrations can be used to enhance the understanding of learners on the different methods that can be used to secure floor joists for upper-level suspended floors to a wall.
- (c) The use of a model of a suspended timber floor showing all components, including the supporting piers, will assist learners in gaining a better understanding of a suspended timber floor.
- (d) A model of an entrance door with a side light and raised and fielded panels can be made in the workshop. Learners should draw horizontal and vertical sectional drawings of this door with raised panels as well as raised and fielded panels.

CHAPTER 5

ELECTRICAL TECHNOLOGY

5.1 DIGITAL ELECTRONICS

The following report should be read in conjunction with the Digital Electronics question paper of the November 2021 examinations.

5.1.1 PERFORMANCE TRENDS (2018–2021)

This was the fourth time that this subject was offered as an NSC examination subject. There was a decrease of 51 candidates in this subject in 2021. The results reflect a marginal decline in the pass rate at 30% (Level 2) to 94,6%.

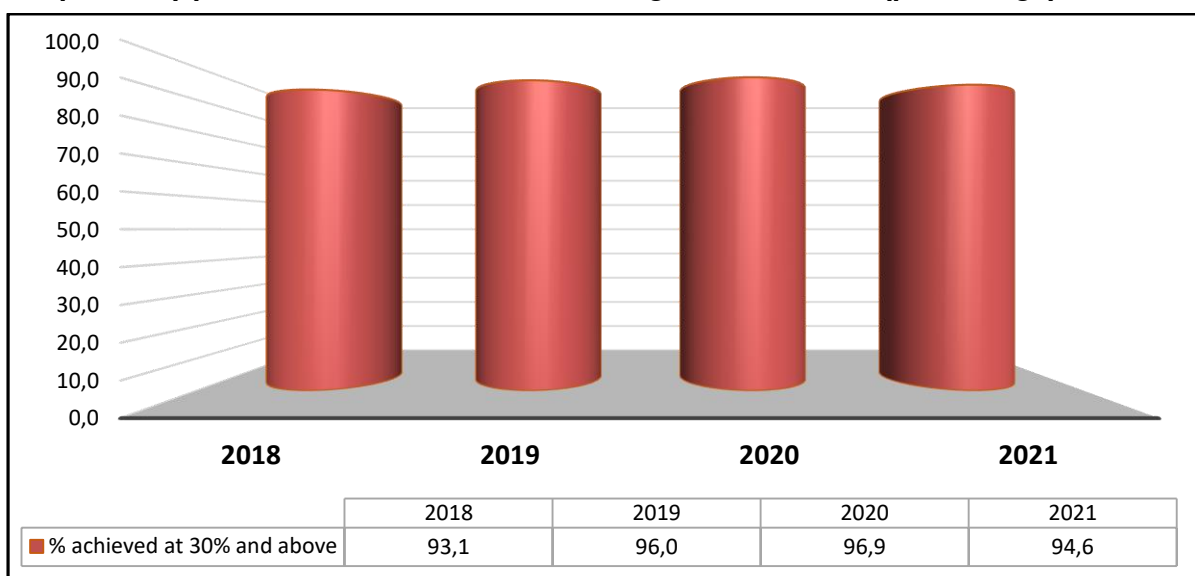
However, it was encouraging that 41,1% of candidates achieved over 50% this year in comparison to 38,8% of candidates doing so in 2020.

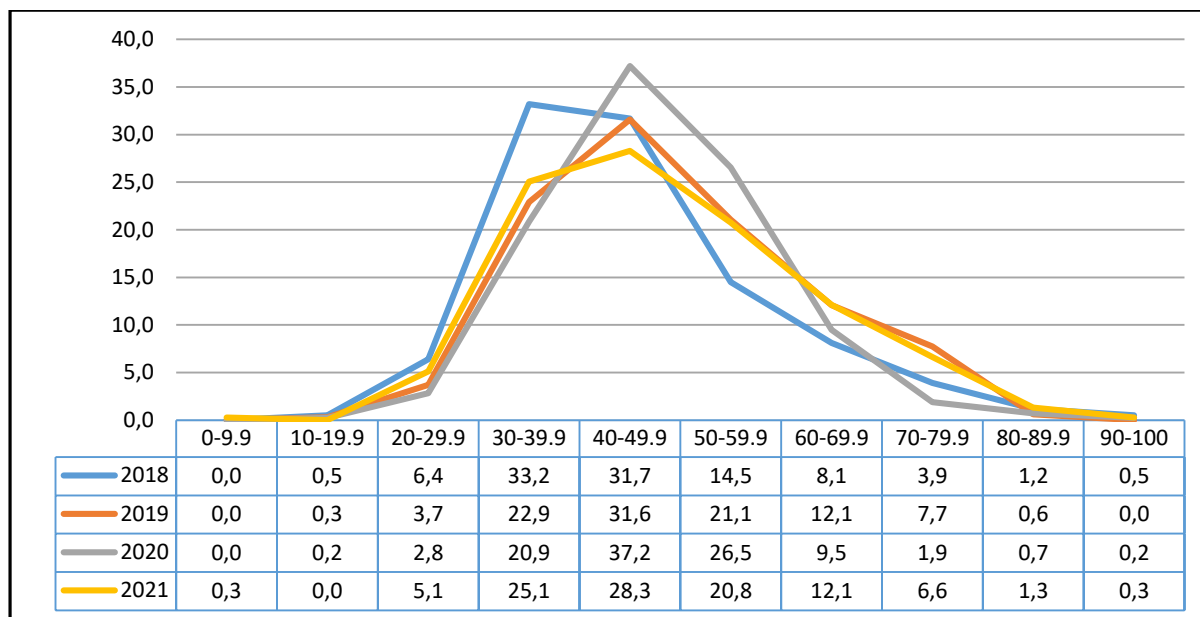
The percentage of distinctions (80%; Level 7) increased from 0,9% in 2020 to 1,6% in 2021. This translates to an increase in distinctions from 4 to 6.

Table 5.1.1 Overall achievement rates in Digital Electronics

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	407	379	93,1
2019	323	310	96,0
2020	422	409	96,9
2021	371	351	94,6

Graph 5.1.1(a) Overall achievement rates in Digital Electronics (percentage)



Graph 5.1.1(b) Performance distribution curves in Digital Electronics (percentage)

General comments

Further improved performance can be achieved if there is a strengthening of content knowledge and skills in respect of the following areas: switching circuits, digital and sequential devices and microcontrollers.

In addition, learners should have practical exposure to these areas. They also need to be exposed to complex questions that use verbs, such as explain, describe, discuss, state, determine and motivate answers.

From earlier grades, learners should be exposed to problem-solving activities in all topics in the curriculum.

5.1.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE DIGITAL ELECTRONICS PAPER

General comments

- An overall poor performance was recorded, even in questions that were set at the lower cognitive levels.
- Most candidates could not interpret the requirements of the questions due to their poor language and comprehension skills.
- It was evident that many candidates lacked relevant content knowledge and the necessary skills to answer the questions.
- Many candidates experienced difficulty with answering questions of a narrative nature.
- The question that required learners to explain basic operations of circuits is still a challenge because of a lack of knowledge and insight on the relevant concepts.
- The application of mathematics, particularly manipulation and the formulation of responses after analysing circuits, requires serious attention.

- (g) Questions on the application of theory and the analysis of circuits were poorly answered. The output waveforms were not well presented and there was a decline in the correlation between the input and output waveforms.

General suggestions for improvement

- (a) Use of past NSC Papers: It must be noted that past question papers may serve as one of many teaching and learning resources if used properly. These papers may be used for learner assessment, revision purposes and, to a certain extent, teachers may use these papers for self-diagnostic assessment. Every learner must have access to past examination papers from November 2018 to November 2021 as these are based on the current CAPS content.
- (b) Revision of relevant Grade 10 and 11 Content: Although the NSC examinations only assess Grade 12 content, prior knowledge from the Grade 10 and 11 syllabi, serves as a foundation to equip and prepare learners to respond to Grade 12 content. It is therefore significant that this prior knowledge be incorporated in their lesson preparations/plan.
- (c) Time management: Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation is a good indicator of the amount of information needed.
- (d) Practical experiments and past papers: At the end of each topic in the CAPS document, there are practical experiments which should be performed to enhance the understanding of the subject content. Teachers are encouraged to perform these practical tasks, which will in turn prepare learners for practical assessment tasks (PATs).
- (e) For the narrative nature of questions, the responses in the marking guidelines are broken down into key areas of specific content and marks are then awarded accordingly. A general response will only be awarded one mark. Learners must learn how to respond in the required fashion which will hone their comprehension skills and eliminate vague one-word responses. Refer to Q3.2.4, Q5.9 and Q6.5.2 where the responses are broken down in bullet form and ticks/marks are placed at key areas of specific content.
- (f) For graphical or diagrammatical nature of questions, the responses in the marking guidelines are broken down as in Q3.1.6, Q3.5.2, Q3.6.2, Q4.1.2, Q5.4, Q5.10 and Q6.8.

5.1.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN THE DIGITAL ELECTRONICS PAPER

QUESTION 1: MULTIPLE-CHOICE QUESTION

Common errors and misconceptions

- (a) This type of question is new. Candidates may not have had enough practice in answering them.
- (b) In Q1.1, candidates confused unsafe condition and unsafe act.

Suggestions for improvement

- (a) Learners should:
 - read carefully when answering this question;
 - not rush through the different possible answers;
 - keep in mind that only one answer is the most correct;
 - improve their content knowledge in the subject as a whole to perform well in this question;
 - be encouraged to read the textbook to gain insight; and
 - be encouraged to answer all questions because they just choose the correct answer.
- (b) Teachers are advised to include this type of question in the formal and even informal assessment tasks.

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

Common errors and misconceptions

- (a) In Q2.1 candidates confused the function of a health and safety representative with that of the safety officer. Most candidates wrote the function of a safety officer instead of a safety representative.
- (b) In Q2.2 most of the candidates answered this question by listing general human rights, but did not relate it to the workplace, hence they did not answer the question correctly.
- (c) In Q2.3 candidates could not differentiate between *unsafe acts* and *unsafe conditions*, as many wrote the definition of both.
- (d) In Q2.4 candidates confused the types of risk analysis with those of categories of risk analysis.
- (e) In Q2.5 many candidates explained *danger* in the same way as an *unsafe action or condition*.

Suggestions for improvement

- (a) It is clear that poor comprehension of the questions was a challenge. Teachers are advised and encouraged to develop activities that require definitions according to the OHS ACT and explanations of concepts and terminologies.
- (a) Teachers require content and didactic training on OHS act.
- (b) Teachers should plan, teach, and assess this topic taking CAPS into account at all times. This focuses learner responses on the proper direction and eliminates vague one-word responses.
- (c) The understanding of concepts and terminologies and how to describe and express them is a huge challenge to the majority of learners. The language barrier seems to be getting worse instead of improving. Learners must be encouraged to read technical literature (journals, technical books and other relevant guides) to familiarise themselves with the language and the syntax (the order or arrangement of words and phrases to form proper sentences) associated with it.

- (d) OHS needs emphasis from Grades 10 and 11, and should be incorporated in practical tasks and infused in teaching rather than being taught in isolation.
- (e) Teachers should identify their shortcomings by answering previous question papers. Their performance will inform them on the questions/sections they have challenges with and those that they are good at. Based on their performance, they could seek assistance to develop themselves.

QUESTION 3: SWITCHING CIRCUITS

Common errors and misconceptions

- (a) In Q3.1.1 most candidates did not know the function of the pull-up resistor R_1 as used in the circuit. They wrote that the function of a resistor is to limit the current instead of 'to pull up and keep pin 2 high'.
- (b) In Q3.1.2 most candidates did not know the operation of this circuit, so they could not determine the voltage across pin 2 when switch S was pressed. It had to be learnt or understood so that they could explain it in a logical fashion. Responses were vague and many did not attempt this question. Most candidates wrote 9 V instead of 0 V.
- (c) In Q3.1.3 candidates seemed to guess the states of the LED when Switch S is pressed.
- (d) In Q3.1.4 the majority of candidates did not know the correct threshold voltage in this circuit. They wrote 9 V instead of 6 V or $2/3 V_{cc}$.
- (e) In Q3.1.5 the concept of *switch bounce* and how the circuit responds to it were not known.
- (f) In Q3.1.6 most of candidates drew the wrong output waveform. They did not know how to draw on an answer sheet provided. Other candidates did not draw at all.
- (g) In Q3.2.1 many candidates identified the multivibrator circuit incorrectly.
- (h) In Q3.2.2 the function of the resistor R_2 used in the circuit was not known by many candidates.
- (i) In Q3.2.4 the operation of this circuit was not known. Many wrote vague responses. Very few candidates answered this question
- (j) In Q3.3.1 the trigger values could not be identified by many candidates. The majority wrote +1 V/-1 V instead of +1 V to -1 V.
- (k) In Q3.3.4 the two functions of the circuit were not known by many candidates.
- (l) In Q3.4.1 candidates lost marks due to the fact that they did not label the circuit correctly and they left out the ground connector in the circuit.
- (m) In Q3.5.1 the operation of this circuit was not mastered therefore the learner responses were poor. The majority of candidates wrote resistors instead of R_1 , or R_2 as labelled on the circuit diagram.
- (n) In Q3.5.2 most candidates did not draw the circuit diagram.
- (o) Where an answer sheet was provided for a question, candidates did not know how to draw on it.

Suggestions for improvement

- (a) It is important for teachers to understand that components in a circuit may perform different functions.
- (b) In Q3.1 teachers must:
 - Study and understand the:
 - Internal construction of the 555 IC timer, particularly in Q3.1.4, where the concept of the three resistors is used as a voltage divider.
 - Voltage across Pin 2 when:
 - Switch S is closed
 - Switch S is open
 - Understand why R_1 is used as a pull-up resistor, and furthermore, the purpose of R_2 and R_3 in the same circuit.
 - Understand how a capacitor charges and discharges, and how these capacitors are used in this circuit, particularly C_1 and C_2 . (This suggestion can also be used in Q3.2) This can also assist learners to draw-up the output waveform when Switch S is pressed.
 - Study the effect that switch bouncing has on the charging and discharging of the capacitor.
- (c) In Q3.2 the concepts of input voltage (V_{in}) and reference voltage (V_{ref}) for the operation of inverting op-amp (and furthermore for non-inverting) should be explored when the trigger pulse is applied, particularly in Q3.2.4.
Understand what will happen during the following conditions:
 - If $V_{in} < V_{ref}$, what will be the polarity of the output voltage
 - If $V_{in} > V_{ref}$, what will be the polarity of the output voltage
- (d) In Q3.3 learners should understand the following concepts:
 - Closed-loop and open-loop gain
 - Identify an op-amp circuit with feedback and the purpose of such feedback
- (e) In Q3.6 learners should understand the difference between *RC integrated circuit* and *op-amp integrated circuit*.
- (f) The functions of each component in the above circuits should be studied, e.g. a capacitor and three resistors.
- (g) Electrical Technology is an applied subject, therefore the explanation of a circuit must be coupled with calculations and input and the correlating output waveforms, e.g. in Q3.4.
- (h) The changing of components affects the characteristics and the operation of the circuit. Learners should be taught these concepts and how to apply their knowledge in a dynamic circuit and to predict the output waveforms. This should direct the teacher's approach and style when teaching this subject.
- (i) Teachers must ensure that calculations include the correct steps according to the marking guidelines so that learners do not lose marks unnecessarily.
- (j) Teachers must make sure that when drawing circuits, they draw a fully labelled circuit diagram. Remember that learners use the teacher's work as a model and copy it.

- (k) The use of ICT should be integrated to enhance teaching and learning for simulations of circuits. This will strengthen their theoretical knowledge in the process.
- (l) Teachers should assist learners to analyse and interpret multivibrator circuits and answer the question related to the circuit diagram given on the question paper.

QUESTION 4: SEMICONDUCTOR DEVICES

Common errors and misconceptions

- (a) In Q4.1.1 most candidates wrote *741 op amp* instead of *non-inverting amplifier*.
- (b) In Q4.1.3 most candidates could not explain why operational amplifiers are known as differential amplifiers.
- (c) Candidates struggled with the internal function of the components of the 555 IC. Q4.2.1 and 4.2.3 asked for the function of the components in the 555 IC. Candidates answered by giving the general use of the components as a circuit standing on its own.
- (d) In Q4.2.5 candidates did not understand the function of the threshold pin 6 of the 555 IC. They all explain how the capacitor would charge and discharge but not one candidate explained the actual function of the threshold pin in relationship to the 555 IC.
- (e) In Q4.3 candidates struggled to answer the question. They did not understand the operating principle of differential amplifier and how the amplifier will react when the same signal is applied to the two inputs of the 741 operational amplifier. From the answers that the candidates supplied it was also evident that the candidates did not know the difference between the +Vcc and –Vcc and the + and – symbols in the IEC symbol of the 741 operational amplifier. They would make reference to the positive input voltage and negative input voltage while it should be inverting and non-inverting inputs.

Suggestions for improvement

- (a) In Q4.2 a chart with pin description of the 555 IC including pin number, pin name and function of each pin should be designed and pasted on the classroom wall for learners to familiarise themselves with this IC.
- (b) The functions of the following components should be explained to learners:
 - The three series resistance used as voltage divider and how to arrive at 1/3 and 2/3 of the supply voltage
 - Two comparators
 - Transistor
 - RS flip-flop
- (c) In Q4.3 the four basic operations of the op-amp should be studied with reference to input waveform and output waveform voltages.
- (d) Learners should study the circuits and be able to distinguish between the different circuits, e.g. the difference between an *inverting operational amplifier* and a *non-inverting operation amplifier*.
- (e) Teachers must clearly explain the difference between the +Vcc and –Vcc inputs and the – and + symbols in the triangle of the IEC symbol.

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES**Common errors and misconceptions**

- (a) In Q5.1 most candidates could not explain the term *common cathode* with reference to seven-segment LED display in words. Some even drew diagrams.
- (b) In Q5.2 a few candidates lost marks by drawing the circuit diagram without labelling it.
- (c) In Q5.3.1 most candidates were unable to determine the inputs and output of the logic gates circuit. Again, it is evident that the candidates do not understand the functions of a pull-up resistor.
- (d) In Q5.4 candidates could not draw the JK latch using the given answer sheet. It is evident that they did not study how to draw the circuit diagram. Although many attempted it, they lost vital marks by not labelling their diagrams correctly. A correct circuit with no labels was awarded zero marks.
- (e) The answers provided in Q5.7 were vague. Most candidates got 1 out of 2 marks because they were not specific in their responses. For example, they would answer *A full-sequence counter counts fully to 10 and a truncated counter counts to 7*. This answer does not clearly distinguish between the two types of counters.
- (f) The circuit in Q5.9 was answered well by the high-achieving candidates.
- (g) In Q5.10 the majority of candidates could not draw a labelled diagram of a four-bit serial in parallel-out shift register using D-type flip-flops.

Suggestions for improvement

- (a) Classrooms or workshops should display charts showing drawings of the following:
 - 7-segment LED display for common anode and cathode
 - 2-to-4 binary decoders with its truth table and symbol
 - Encoders as in FIGURE 4.3, with their truth tables, and these charts should also be used as a teaching aid to accommodate all learners because they are unique and they learn differently
 - Different types of counters and registers, their operations, truth tables and the symbols. Teachers should incorporate logic gates (e.g. AND, NAND, OR or NOR gates) as prior knowledge in their lesson plans/preparations. This will assist with the understanding of the operations, drawing of circuit diagrams, truth tables, timing diagrams and symbols of the:
 - Adders (half and full adders including binary parallel adder)
 - Flip-flop (SR, JK, and D flip-flop)
- (b) Teachers must apply instruction number 5 from the examination paper when marking learners' work, which states, *Sketches and diagrams must be large, neat and fully labelled for learners to earn full marks*.
- (c) Teachers must take time to ensure that the learners understand counters and are able to explain the function of counters, step by step.
- (d) Drawings should be of the same proportion as those the diagram sheets and must always be labelled. All inputs must correlate to the outputs with all information inserted.
- (e) Note that IEC symbols and American symbols cannot be used in the same diagram.

QUESTION 6: MICROCONTROLLERS

Common errors and misconceptions

- (a) In Q6.1 candidates' definitions for the microcontroller were too general and they lost marks for this.
- (b) In Q6.2 candidates described the microcontroller instead of explaining its principle of operation.
- (c) In Q6.3.2 devices that use the RS-485 were not known.
- (d) In Q6.8 many candidates left out the symbols and labels.

Suggestions for improvement

- (a) In order to enhance teaching and learning, the use of ICT should be integrated for simulations of circuits as most schools do not have microcontrollers. This will strengthen their theoretical knowledge in the process as this part of the examination requires higher-order thinking and understanding.
- (b) Teachers must use the examination guidelines and the CAPS closely when planning their teaching of this topic.
- (c) Learners must be taught to use the correct subject terminology when answering questions, avoid statements like *voltage flow* or *the current runs through the circuit* or *the output of the circuit travels from high to low*.
- (d) Learners must NOT use their own abbreviations and they must write in full sentences. Learners must refrain from using WhatsApp language when answering questions.
- (e) The general language proficiency of the learners is not at a Grade 12 level and thus learners struggle to communicate their thoughts on paper.

5.2 ELECTRONICS

The following report should be read in conjunction with the Electronics question paper of the November 2021 examinations.

5.2.1 PERFORMANCE TRENDS (2018–2021)

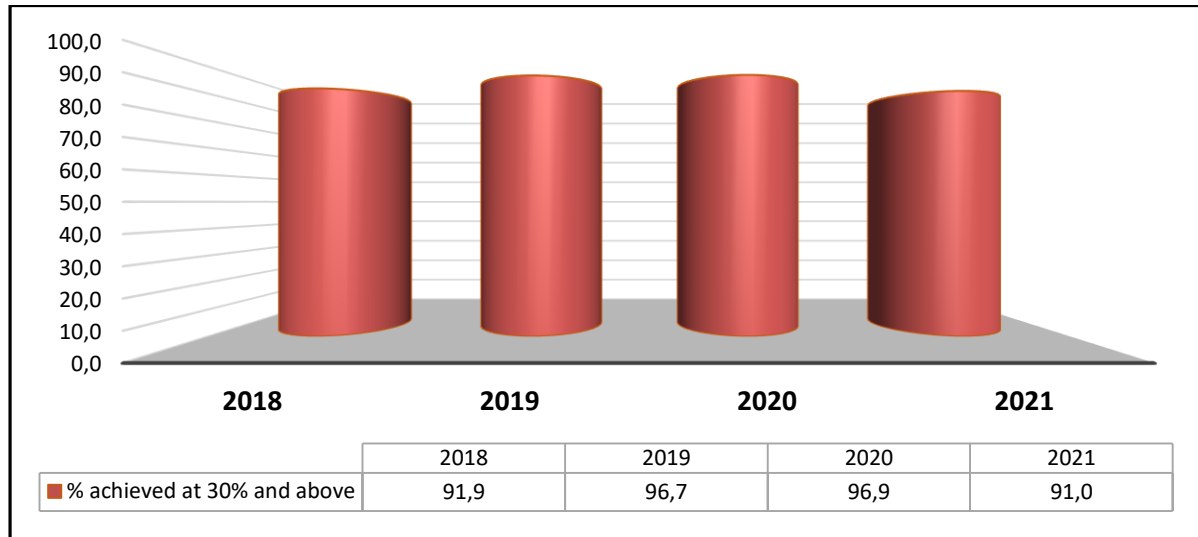
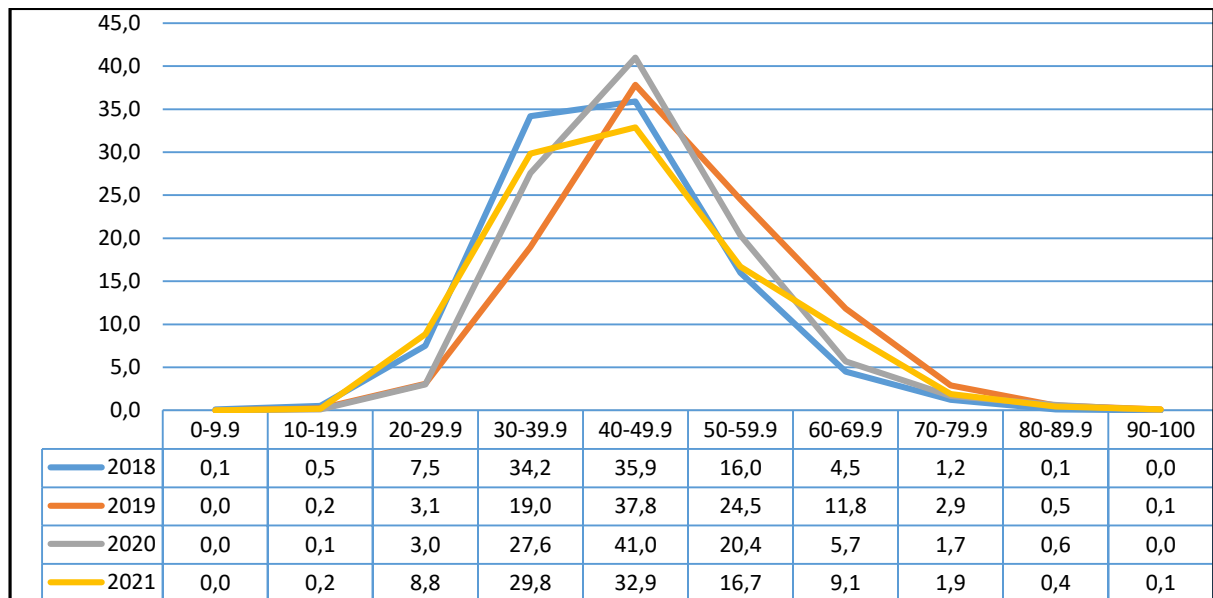
This was the fourth time that this subject was offered as an NSC examination subject. In 2021, 1 143 candidates sat for the Electronics examination, i.e. an increase of 175 in comparison to the previous year.

The results reflect that the pass rate at 30% (Level 2) declined marginally from 96,9% to 91,0%. Over the past two years approximately 28% of candidates achieved over 50%. This is a decline in comparison to 38,8% of candidates doing so in 2019.

The percentage of distinctions (80%; Level 7) remained constant at approximately 0,6% This translates to total distinctions of 6 for the past two years.

Table 5.2.1 Overall achievement rates in Electronics

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	1 077	990	91,9
2019	938	907	96,7
2020	968	938	96,9
2021	1 143	1 040	91,0

Graph 5.2.1(a) Overall achievement rate in Electronics (percentage)**Graph 5.2.1(b) Performance distribution curves in Electronics (percentage)**

5.2.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE ELECTRONICS PAPER

General comments

- (a) In general, the overall performance of candidates in the paper was very poor.
- (b) Q1 (multiple-choice questions) was well answered with an average of 40% and Q2 was also well answered with an average of 50%. However, these questions comprised only 12,5% of the entire paper. Q3 was well answered with an average of 47%. This question made up 17,5% of the question paper.
- (c) Q4, Q5 and Q6 were poorly answered. These questions comprised 70% of the total of the question paper.
- (d) In general, candidates made basic mistakes, such as not selecting correct formulae, not substituting correct values in formulae, omitting the correct units and using incorrect pre-fixes of values when doing substitutions.
- (e) Candidates had difficulty answering the narrative type questions.
- (f) Language used to answer questions was also very poor. Even though the level of language used in the question paper was simple and unambiguous, candidates' responses showed that they did not understand the requirements of questions.
- (g) It was evident that many candidates lack proper content knowledge and the necessary skills to answer the questions.
- (h) Judging from the answers presented, it was evident that candidates did not read the questions carefully and proceeded to give the wrong answers. Even the low cognitive questions were not answered as expected.
- (i) Manipulation of formulae in calculations is still a challenge for many candidates. Both the application of mathematical principles and expression of responses require further attention.
- (j) Marks were lost for the omission of units in the calculations and/or for incorrect substitutions and for the omission of labels in the drawings.
- (k) The huge volume of circuit diagrams, output waveforms and characteristic curves was a challenge for most candidates.
- (l) Substitution of accurate values into the formulae is still a challenge. This contributed to candidates not calculating answers accurately.
- (m) Candidates could not draw output waveforms of the circuits.
- (n) Candidates did not know the function of components in circuits.
- (o) Candidates could not use the answer sheets provided, correctly.
- (p) There were numerous questions in the final question paper that were similar in nature to the previous question papers. However, performance was very poor and it would seem that learners did not work through previous question papers in preparation for the final question paper.

General suggestions for improvement

- (a) Use of past NSC papers: It must be noted that past question papers may serve as one of many teaching and learning resources if used properly. These papers may be used for learner assessment, revision purposes, and to a certain extent, teachers may use these papers for self-diagnostic assessment. Every learner must have access to past examination papers from November 2018 to November 2021 as these are based on the current CAPS content.
- (b) Revision of relevant Grade 10 and 11 content: Although the NSC examinations only assess Grade 12 content, prior knowledge from the Grade 10 and 11 syllabi serve as a foundation to equip and prepare learners to respond to Grade 12 content. It is therefore significant that this prior knowledge be incorporated in their lesson preparations/plan.
- (c) Time management: Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation is a good indicator of the amount of information needed.
- (d) Practical experiments and past papers: At the end of each topic in the CAPS document, there are practical experiments to be performed to enhance the understanding of the subject content. Teachers are encouraged to perform these practical tasks, which will in turn prepare learners for practical assessment tasks (PATs).
- (e) For questions of a narrative nature, the responses in the marking guidelines are broken down into key areas of specific content and marks are then awarded to that. A general response will get only part-marks. Learners must learn how to respond in the required fashion, which will hone their comprehension skills and eliminate one-word vague responses. Refer to Q5.2.4 and Q6.4.3 where the responses are broken down in bullet form and note the ticks/marks that are placed at key areas of specific content.
- (f) For graphical or diagrammatical nature of questions, the responses in the marking guidelines are broken down as in Q4.5.2, Q5.1.6, Q5.5.2, Q5.6.2, and Q6.6 3.
- (g) A deeper understanding of presenting waveforms from circuits using an EGD (Engineering Graphics and Design) approach needs much attention. Drawing waveforms on answer sheets, taking into account the correlation between input and output waveforms, is a new concept and is a vast improvement over the past Electrical Technology approach. The EGD approach prepares candidates to think like engineers. Teachers, however, still need to apply this approach in their teaching.
- (h) It is of utmost importance for teachers to teach the function of components to learners. It forms part of circuit analysis and is crucial in understanding the operation of an electronic circuit.
- (i) It was evident that candidates did not know the effect of altered component values and input voltages on the operation and output of circuits. Teachers must demonstrate the effect of different component values and/or input voltages on the operation and output of electronic circuits. These are higher-order concepts that must be demonstrated through practical circuits and displayed on an oscilloscope.

5.2.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN THE ELECTRONICS PAPER

QUESTION 1: MULTIPLE-CHOICE QUESTION

Common errors and misconceptions

- (a) This type of question is new. Candidates may not have had enough practice in them.
- (b) In Q1.1 candidates confused *unsafe condition* and *unsafe act*.
- (c) In Q1.3 candidates did not know the difference between *leading* and *lagging* when referring to phase angle.
- (d) In Q1.4 candidates did not understand the definition of *selectivity*.

Suggestions for improvement

- (a) Learners should:
 - read carefully when answering this question;
 - not rush through the different possible answers;
 - keep in mind that only one answer is the most correct;
 - improve their content knowledge in the subject as a whole to perform well in this question;
 - be encouraged to read the textbook to gain insight; and
 - be encouraged to answer all questions because they just choose the correct answer.
- (b) Teachers are advised to include this type of question in the formal and even informal assessment tasks.
- (c) The teacher should emphasise the difference between *lagging* and *leading* terminologies, including the relationship between *current* and *voltage* in an inductive, capacitive and resistive circuit.

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

Common errors and misconceptions

- (a) In Q2.1 candidates confused the function of a health and safety representative with that of the safety officer. Most candidates wrote the function of a safety officer instead of that of a safety representative.
- (b) In Q2.2 most of the candidates answered this question by listing general human rights, but did not relate it to the workplace, hence they did not answer the question correctly.
- (c) In Q2.3 candidates could not differentiate between *unsafe acts* and *unsafe conditions*, as many wrote the definition of both.
- (d) In Q2.4 candidates confused *types of risk analysis* with *categories of risk analysis*.
- (e) In Q2.5 many candidates explained *danger* in the same way as an *unsafe action or condition*.

Suggestions for improvement

- (b) It is clear that poor comprehension of the questions was a challenge. Teachers are advised and encouraged to develop activities that require definitions according to the OHS ACT and explanations of concepts and terminologies.
- (c) Teachers require content and didactic training on the OHS Act.
- (d) Teachers should plan, teach, and assess this topic taking CAPS into account at all times. This focuses learner responses in the proper direction and eliminates one-word vague responses.
- (e) The understanding of concepts and terminologies and how to describe and express them is posing a huge challenge to the majority of learners. The language barrier seems to be getting worse instead of improving. Learners must be encouraged to read technical literature (journals, technical books and other relevant guides) to familiarise themselves with the language and the syntax (the order or arrangement of words and phrases to form proper sentences) associated with it.
- (e) OHS needs emphasis from Grades 10 and 11, and should be incorporated in practical tasks and infused in teaching rather than being taught in isolation.
- (f) Teachers should identify their shortcomings by answering previous question papers. Their performance will inform them on the questions/sections they have challenges with and those that they are good at. Based on their performance, they could seek assistance to develop themselves.

QUESTION 3: RLC CIRCUITS**Common errors and misconceptions**

- (a) In Q3.1 many candidates were unable to recall the definition of *capacitive reactance*. Many did not refer to AC in their attempt to answer the question.
- (b) In Q3.2 most candidates did not state the phase relationship between current and voltage in an inductive circuit.
- (c) In Q3.3.1 and Q3.4.4 the majority of candidates could not make L and C, respectively, the subject of the formula from the formulae taken from the formula sheet. This affected the substitution and the answer. Some candidates did not use units or they used incorrect units.
- (d) In Q3.3.2 most of candidates lost marks by omitting the units in their final answers.
- (e) In Q3.3.3 many candidates included a unit in the final answer and lost a mark because power factor has no units. Some candidates used the incorrect formula and calculated the phase angle and not the power factor.
- (f) In Q3.3.4 most candidates did not know that the unity power factor is the same as the power factor is equal to 1.
- (g) In Q3.4.1 and Q3.4.2 candidates could not identify the resonant frequency from data given to them.

- (h) Q3.4.2 most candidates could not compare the values of the inductive and capacitive reactances when the frequency increases, as given from the data in FIGURE 3.4B.
- (i) Q3.4.3 many candidates did not consider the engineering notation prefix when calculating the volt drop across the inductor resulting in the loss of 2 marks.
- (j) In Q3.5.2 candidates could not calculate the voltage drop across the inductor as many used the incorrect formula.

Suggestions for improvement

- (a) Teachers should illustrate the phase relationship between I and V in a/an:
 - Resistive circuit
 - Inductive circuit
 - Capacitive circuit
 and explain why a circuit is inductive or capacitive.
- (b) Teachers should explain the effect of varying the frequency of the supply in an RLC circuit, the characteristics curve and phasor diagrams of resonance circuits and the conditions of series/parallel resonant circuits.
- (c) The following should be considered:
 - Lesson plans developed by teachers and not by subject advisors is key to these challenges, for example:
 - To reflect on what worked well during the presentation, and what could have been done differently for further improvement of the next lesson plan
 - To reflect on prior learning to introduce the content to be learned. (i.e. prior learning might be from either the previous grades or previous topics learned from the same grade)
 - Integrate relevant mathematical concepts, e.g. manipulation of formulae, as they teach calculations
 - Teach how to identify the correct formula from the formula sheet and application thereof
 - Develop an assessment task based on the following:
 - Identification of the formula for specific calculations
 - Manipulation of formulae
 - Units for specific quantities, e.g. voltage, current, resistance, impedance, frequency, phase angle, bandwidth, etc.
 - Prefixes, e.g. nano-, micro-, milli-, kilo- and the conversion thereof
 - Use of the calculator
 - These assessment tasks should also be implemented in section with calculations, e.g. in semiconductors and switching circuits
- (d) The definitions of the terms, explanations and descriptions of concepts that are likely to be asked in the examination should be summarised in a booklet and handed to learners at the beginning of the year.
- (e) Learners must be trained to read the question carefully and to look at the mark allocation. The number of facts provided must correlate with the number of marks.
- (f) Learners need to read questions with understanding so that they answer appropriately. Similar questions should be given during the year in preparation for the final examination.

- (g) The application and understanding of data taken from these circuits to answer theoretical style questions is a major problem currently. The practical building of RLC circuits and the checking of the waveforms on the oscilloscope is a good way of reinforcing the theory.

QUESTION 4: SEMICONDUCTOR DEVICES

Common errors and misconceptions

- (a) In Q4.2.1 candidates could not identify the symbol of the P-channel enhancement-mode metal oxide silicon field effect transistor (MOSFET).
- (b) In Q4.3.1 candidates could not identify the pulse.
- (c) In Q4.3.2 most candidates did not know the meaning of *saturation region* with reference to the operation of the UJT.
- (d) In Q4.3.3 many candidates could not describe how the UJT is driven into saturation.
- (e) In Q4.3.4 candidates could not draw the output waveform on the provided answer sheet.
- (f) In Q4.4.1 many candidates identified the circuit correctly but responses were not complete. One-word answers like *transistor* or *Darlington* were given.
- (g) In Q4.5.1 most candidates confused this circuit with the inverting amplifiers. They wrote *741 op amp* instead of *non-inverting amplifier*. They could not draw the output waveforms correctly in Q4.5.2.
- (h) In Q4.5.3 the majority of candidates did not know the concept of differential voltage amplifiers and could not explain why operational amplifiers are known as differential amplifiers.
- (i) Candidates struggled with the internal function of the components of the 555 IC. Q4.6.1 and 4.6.3 asked for the function of the components in the 555 IC and the candidates answered by giving the general use of the components as a circuit standing on its own.
- (j) In Q4.6.5 candidates did not understand the function of the threshold pin 6 of the 555 IC. They all explained how the capacitor would charge and discharge but not one candidate explained the actual function of the threshold pin in relationship to the 555 IC.
- (k) In Q4.7 candidates struggled to answer the question. They did not understand the operating principle of the differential amplifier, and how the amplifier will react when the same signal is applied to the two inputs of the 741 operational amplifier. From the answers that the candidates supplied it was also evident that the candidates did not know the difference between the $+V_{cc}$ and $-V_{cc}$ and the $+$ and $-$ symbols in the IEC symbol of the 741 operational amplifier. They would make reference to the positive input voltage and negative input voltage while it should be inverting and non-inverting inputs.

Suggestions for improvement

- (a) Teachers must spend more time teaching the construction, operation and symbols of the different MOSFETs.
- (b) When teaching the operation of components, reference must be made to the characteristic curve and the construction of the components.
- (c) The operation of the Darlington pair must be carefully explained, as well as the advantages of this combination.
- (d) Teachers must provide a detailed explanation of the operation of op-amp circuits and demonstrate it with practical circuits.
- (e) It is important to use practically built circuits with voltage measurements in conjunction with the theoretical concepts being addressed.
- (f) Teachers must emphasise the identification of formulae and link it with the correct circuits during class lessons. Teachers must also emphasise the importance of using the correct prefixes in all calculations and showing them in the substitutions. This must be applied strictly during the year in informal tasks and during the marking of all assessment tasks. Candidates lose marks if these are not in place, even if all the steps are correct.
- (g) The internal operation of the 555 IC is of utmost importance, not only in this section, but also for switching circuits. Teachers can show educational videos on the operation of the 555 IC to learners. Learners must be motivated to build practical circuits to embed theoretical knowledge. Teachers can also use educational software to enhance the learning experience of difficult abstract circuits and concepts.

QUESTION 5: SWITCHING CIRCUITS**Common errors and misconceptions**

- (a) In Q5.1.1 most candidates did not know the function of the pull-up resistor R_1 as used in the circuit. They wrote that the function of a resistor is to limit the current instead of *to pull up and keep pin 2 high*.
- (b) In Q5.1.2 the majority of candidates did not know the operation of this circuit, so they could not determine the voltage across pin 2 when switch S was pressed. It had to be learnt or understood so that they could explain it in a logical fashion. Responses were vague and many did not attempt this question. The majority of the candidates wrote 9 V instead of 0 V.
- (c) In Q5.1.3 candidates seemed to guess the states of the LED when Switch S is pressed.
- (d) In Q5.1.4 the majority of candidates did not know the correct threshold voltage in this circuit. They wrote 9 V instead of 6 V or $\frac{2}{3} V_{cc}$.
- (e) In Q5.1.5 the concept of switch bounce and how the circuit responds to it were not known.
- (f) In Q5.1.6 most of candidates drew the wrong output waveform. They did not know how to draw on an answer sheet provided. Other candidates did not draw at all.

- (g) In Q5.2.1 many candidates identified the multivibrator circuit incorrectly.
- (h) In Q5.2.2 the function of the resistor R_2 as used in the circuit, was not known by many candidates.
- (i) In Q5.2.4 the operation of this circuit was not known. Many wrote vague responses. Very few candidates answered this question.
- (j) In Q5.3.1 the trigger values could not be identified by many candidates. The majority wrote +1 V/-1 V instead of +1 V to -1 V.
- (k) In Q5.3.4 the two functions of the circuit were not known by many candidates.
- (l) In Q5.4.1 candidates lost marks due to the fact that they did not label the circuit correctly and they left out the ground connector in the circuit.
- (m) In Q5.5.1 the operation of this circuit was not mastered therefore the learner responses were poor. The majority of candidates wrote resistors instead of R_1 , or R_2 as labelled on the circuit diagram.
- (n) In Q5.5.2 most candidates did not draw the circuit diagram.
- (o) Where an answer sheet was provided for a question, candidates did not know how to draw on it.

Suggestions for improvement

- (a) It is important for teachers to understand that components in a circuit may perform different functions.
- (b) In respect of Q5.1 teachers must:
 - Study and understand the:
 - Internal construction of the 555 IC timer, particularly in Q5.1.4, where the concept of the three resistors is used as a voltage divider
 - Voltage across Pin 2 when switch S is:
 - Closed
 - Open
 - Understand why R_1 is used as a pull-up resistor, and furthermore, the purpose of R_2 and R_3 in the same circuit.
 - Understand how a capacitor charges and discharges, and how these capacitors are used in this circuit, particularly C_1 and C_2 . (This suggestion can also be used in Q5.2) This can also assist learners to draw-up the output waveform when Switch S is pressed.
 - Study the effect that switch bouncing has on the charging and discharging of the capacitor.
- (c) In Q5.2 the concepts of input voltage (V_{in}) and reference voltage (V_{ref}) for the operation of inverting op-amp (and furthermore for non-inverting) should be explored when the trigger pulse is applied, particularly in Q5.2.4.
Understand what will happen during the following conditions:
 - If $V_{in} < V_{ref}$, what will be the polarity of the output voltage
 - If $V_{in} > V_{ref}$, what will be the polarity of the output voltage

- (d) In Q5.3 learners should understand the following concepts:
 - Closed-loop and open-loop gain
 - An op-amp circuit with feedback and the purpose of such feedback
- (e) In Q5.6 learners should understand the difference between *RC integrated circuit* and *op-amp integrated circuit*.
- (f) The functions of each component in the above circuits should be studied, e.g. a capacitor and three resistors.
- (g) Electrical Technology is an applied subject therefore the explanation of a circuit must be coupled with calculations and input and the correlating output waveforms, e.g. in Q5.4.
- (h) The changing of components affects the characteristics and the operation of the circuit. Learners should be taught these concepts and how to apply their knowledge in a dynamic circuit and to predict the output waveforms. This should direct the teacher's approach and style when teaching this subject.
- (i) Teachers must ensure that calculations include the correct steps according to the marking guidelines so that learners do not lose marks unnecessarily.
- (j) Teachers must make sure that when drawing circuits, they draw a fully labelled circuit diagram. Remember that learners use the teacher's work as the model and copy it.
- (k) The use of ICT should be integrated to enhance teaching and learning for simulations of circuits. This will strengthen their theoretical knowledge in the process.
- (l) Teachers should assist learners to analyse and interpret multivibrator circuits and answer the question related to the circuit diagram given on the question paper.

QUESTION 6: AMPLIFIERS

Common errors and misconceptions

- (a) In Q6.1.1 and Q6.1.2 candidates could not explain class AB and class C amplifiers. Candidates confused the biasing point or Q-point.
- (b) In Q6.2 most candidates were unable to define *negative feedback*.
- (c) In Q6.3.1 and Q6.3.2 most candidates could not provide the correct answer.
- (d) In Q6.3.3 most candidates were unable to draw the correct output waveform due to a lack of practical and theoretical knowledge of transistor operation. Most candidates did not show the DC offset at point B and C and did not show amplification and inversion.
- (e) In Q6.3.4 most candidates could not describe the relationship between the *collector current* and the *collector-emitter voltage* when the input signal is applied due to a lack of practical knowledge. The inverse relationship of the collector current and voltage was not known by many learners. They described it as a *linear relationship*.
- (f) In Q6.3.5 the majority of candidates could not select the correct formula.
- (g) In Q6.4.1 most candidates could not identify the components that determine oscillation frequency.

- (h) In Q6.4.2 candidates gave one-word answers like *capacitor* or *choke*.
- (i) In Q6.4.3 most candidates were unable to explain the operation of the circuit.
- (j) In Q6.4.4 most candidates selected the wrong formula which led to incorrect calculation of the oscillation frequency.
- (k) In Q6.5.2 candidates could not state the function of transformer T_1 . They confused this circuit with a radio amplifier. Some called it a *transformer coupled RC amplifier*.
- (l) In Q6.5.3 most candidates could not describe why the transformer T_1 is more efficient than RC stage.
- (m) In Q6.5.4, Q6.6.3, Q6.6.4 and Q6.6.5 most of the candidates did not provide the correct answer.
- (n) In Q6.6 candidates could not:
 - Identify the type of oscillator
 - State the requirement for positive feedback
 - State the function of the RC network
 - Define the term *attenuation*.

Suggestions for improvement

- (a) All classes of amplifiers, as prescribed in the CAPS document, must be explained and be graphically drawn showing input and output signals through their characteristics.
- (b) The definitions and basic concepts of amplifiers must be emphasised.
- (c) Teachers must:
 - Emphasise the skill of circuit analysis and interpretation in order for learners to correctly identify circuits and the function of each component
 - Build amplifier circuits during practical lessons and display the input and output signals on an oscilloscope. They must also change the value of the input signal and value of components to show their effect on the output of the circuit.
 - Teach characteristic curves of amplifiers with the circuit analysis and function of different components as a whole and not separately
 - Make use of educational software to demonstrate abstract concepts, especially in amplifier circuits. Display the voltages across components on an oscilloscope to make this abstract concept visual.
 - Build oscillator circuits during practical lessons to demonstrate and explain the operation of these types of circuits. Teachers can also use educational software to build these circuits to explain and demonstrate its operation.
 - Demonstrate the function of the components by either disconnecting them or replacing them with other components to show the importance of such specific components
 - Explain the use of FET and BJT transistors in oscillator circuits as well as their advantages
 - Emphasise the calculation and demonstration of oscillation frequency using different component values
 - Focus on this concept by using calculations, simulations and transistor characteristics (including drawing of the load line on the graph) in order for learners to develop visual understanding of this abstract concept

- Explain to learners how the biasing of a transistor and the different values of RB will determine the Q-point of the transistor on the load line
 - Explain the purpose of the feedback circuit and the amplifier circuit in an oscillator, e.g. LC oscillator and RC-oscillator circuits.
- (d) Content coverage and mastery with regular informal assessment activities on theory and drawing of circuits using an Engineering Graphics and Design (EGD) approach will benefit learners' understanding.

5.3 POWER SYSTEMS

This report should be read in conjunction with the Power Systems question paper and marking guidelines of the November 2021 examinations.

5.3.1 PERFORMANCE TRENDS (2018–2021)

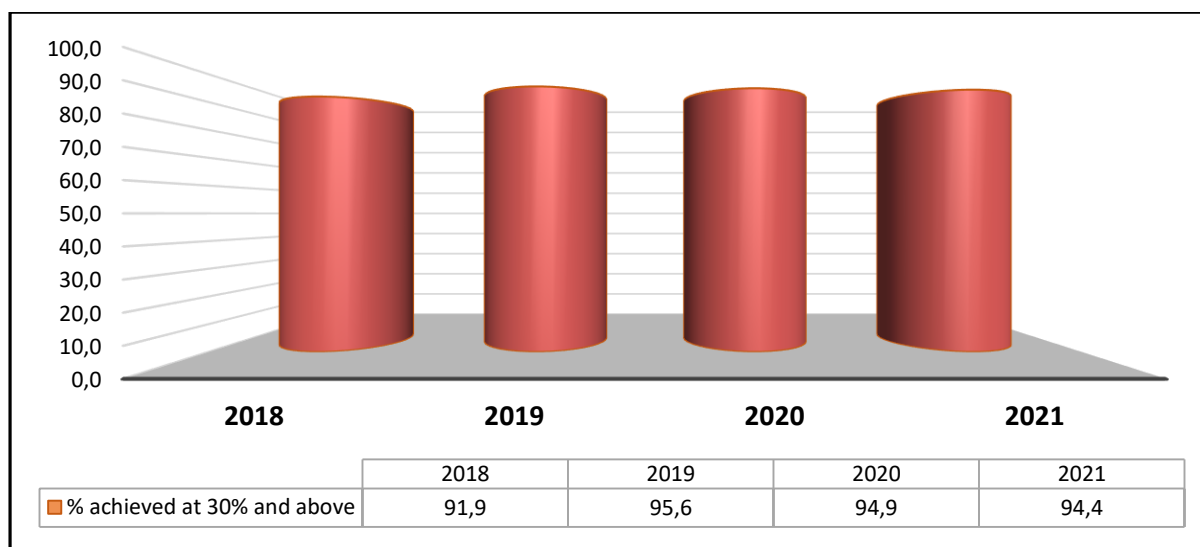
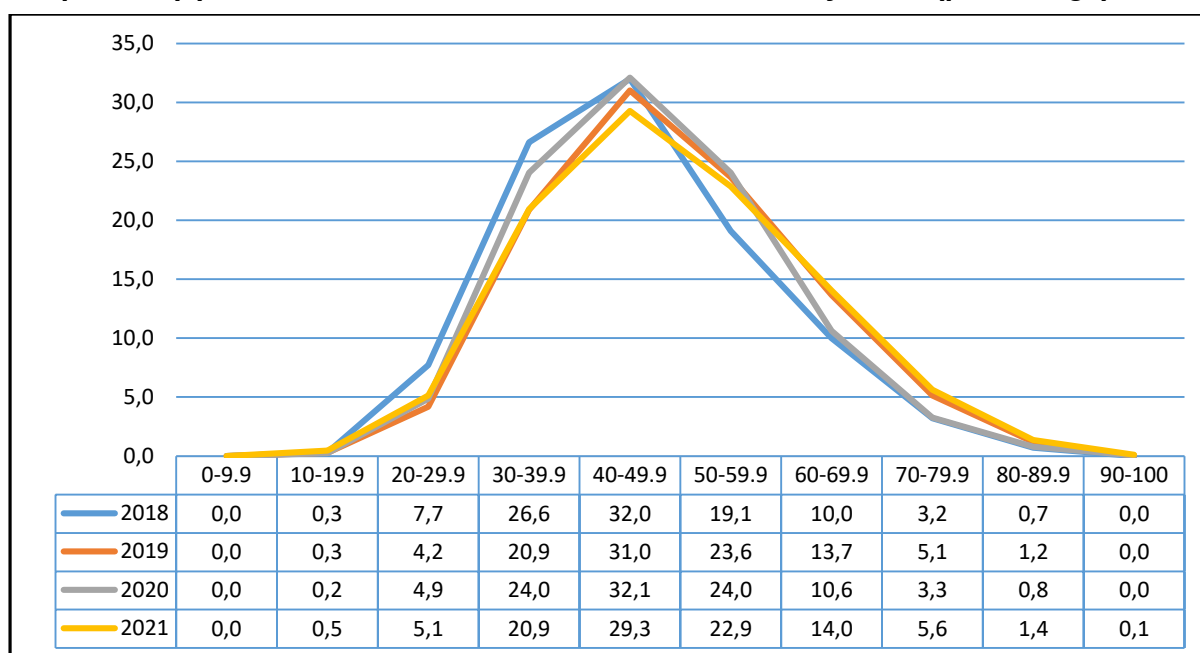
This was the fourth time that this subject was offered as an NSC examination subject. In 2021, 5 675 candidates sat for the Power Systems examination, i.e. an increase of 1 052 in comparison to the previous year. The results reflect that the pass rate in 2021 at 30% (Level 2) was 94,4%, which is consistent with that of 2020.

However, it was encouraging that 44,0% of candidates achieved over 50% this year in comparison to 38,7% of candidates doing so in 2020.

The percentage of distinctions (80%; Level 7) increased from 0,8% in 2020 to 1,5% in 2021. This translates to a significant increase in the number of distinctions from 37 to 85.

Table 5.3.1 Overall achievement rates in Power Systems

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	5 228	4 806	91,9
2019	4 796	4 583	95,6
2020	4 623	4 387	94,9
2021	5 675	5 357	94,4

Graph 5.3.1(a) Overall achievement rates in Power Systems (percentage)**Graph 5.3.1(b) Performance distribution curves in Power Systems (percentage)**

5.3.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE POWER SYSTEMS PAPER

General comments

- Based on a sample of the candidates' responses, it is evident that most candidates were still experiencing challenges with interpreting the requirements of the question and were having difficulty with answering questions of a narrative nature.
- Questions that required learners to explain basic operations of circuits were still a challenge because of a lack of content knowledge and insight of the concepts.
- The application of mathematical principles and the expression of responses after analysing circuits, require further attention.

- (d) Selection of the relevant formula/formulae from the formula sheet, manipulation of the formula, correct substitution, calculation and the writing of the correct unit were still a challenge.
- (e) Omission of labels in drawings has resulted in a loss of marks.

General suggestions for improvement

- (a) Use of past NSC papers: It must be noted that past question papers may serve as one of many teaching and learning resources if used properly. These papers may be used for learner assessment, revision purposes and, to a certain extent, teachers may use these papers for self-diagnostic assessment. Every learner must have access to past examination papers from November 2018 to November 2021 as these are based on the current CAPS content.
- (b) Revision of relevant Grade 10 and 11 content: Although the NSC examinations only assess Grade 12 content, prior knowledge from Grade 10 and 11 syllabi serve as a foundation to equip and prepare learners to respond to Grade 12 content. It is therefore significant that this prior knowledge be incorporated in their lesson preparations/plan.
- (c) Time management: Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation is a good indicator of the amount of information needed.
- (d) Practical experiments and past papers: At the end of each topic in the CAPS document, there are practical experiments to be performed to enhance the understanding of the subject content. Teachers are encouraged to perform these practical tasks, which will in turn prepare learners for the practical assessment tasks (PATs).
- (e) For the narrative nature of questions, the responses in the marking guidelines are broken down into key areas of specific content and marks are then awarded to that. A general response will only be awarded one mark. Learners must learn how to respond in the required fashion, which will hone their comprehension skills and eliminate one-word vague responses. Refer to Q5.1.4, Q6.1.1, and Q6.4.4 where the responses are broken down in bullet form and ticks/marks are placed at key areas of specific content.
- (f) For graphical or diagrammatical nature of questions, the responses in the marking guideline are broken down as in Q7.5.

5.3.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN THE POWER SYSTEMS PAPER

QUESTION 1: MULTIPLE-CHOICE QUESTION

Common errors and misconceptions

- (a) This type of question is new. Candidates may not have had enough practice in them.
- (b) In Q1.1, candidates confused *unsafe condition* and *unsafe act*.
- (c) In Q1.3, candidates did not know the difference between *leading* and *lagging* when referring to phase angle.

- (d) In Q1.4, candidates did not understand the definition of *selectivity*.
- (e) In Q1.7, many candidates did not know the difference between a *wattmeter* and a *kilowatt-hour meter*.
- (f) In Q1.8 a large number of candidates confused the function of a *step-up transformer* with that of a *stepping up of power*.
- (g) In Q1.11, many candidates did not understand the function of the overload relay in a motor starter.

Suggestions for improvement

- (a) Learners should:
 - read carefully when answering these questions;
 - not rush through the different possible answers;
 - keep in mind that only one answer is the most correct;
 - improve their content knowledge in the subject as a whole to perform well in this question;
 - be encouraged to read the textbook to gain insight; and
 - be encouraged to answer all questions because they just choose the correct answer.
- (b) Teachers are advised to include this type of question in formal and even informal assessment tasks.
- (c) In Q1.1.3, teachers must emphasise the difference between *lagging* and *leading* terminology, including the relationship between current and voltage in an inductive, capacitive and resistive circuit.

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

Common errors and misconceptions

- (a) In Q2.1 candidates confused the function of a *health and safety representative* with that of the *safety officer*. Most candidates wrote the function of a safety officer instead of a safety representative.
- (b) In Q2.2 most of the candidates answered this question by listing general human rights, but they did not relate it to the workplace, hence they did not answer the question correctly.
- (c) In Q2.3 candidates could not differentiate between *unsafe acts* and *unsafe conditions*, as many wrote the definition of both. Many candidates did not know the difference between the two.
- (d) In Q2.4 candidates confused the *types of risk analysis* with those of *categories of risk analysis*.
- (e) In Q2.5 many candidates explained *danger* in the same way as an *unsafe action* or *condition*.

Suggestions for improvement

- (a) It is clear that poor comprehension of the questions was a challenge. Teachers are advised and encouraged to develop activities that require definitions according to the OHS Act and explanations of concepts and terminologies.
- (b) Teachers require content and didactic training on OHS Act.
- (c) Teachers should plan, teach, and assess this topic taking CAPS into account at all times. This focuses learner responses in the proper direction and eliminates one-word vague responses.
- (d) The understanding of concepts and terminology and how to describe and express them is posing a huge challenge to the majority of learners. The language barrier seems to be getting worse instead of improving. Learners must be encouraged to read technical literature (journals, technical books and other relevant guides) to familiarise themselves with the language and the syntax (the order or arrangement of words and phrases to form proper sentences) associated with it.
- (e) OHS needs emphasis from Grades 10 and 11, and should be incorporated in practical tasks and infused in teaching rather than being taught in isolation.
- (f) Teachers should identify their shortcomings by answering previous question papers. Their performance will inform them on the questions/sections they have challenges with and those that they are good at. Based on their performance, they could seek assistance to develop themselves.

QUESTION 3: RLC CIRCUITS**Common errors and misconceptions**

- (a) In Q3.1 many candidates were unable to recall the definition of *capacitive reactance*. Many did not refer to AC in their attempt to answer the question.
- (b) In Q3.2 most candidates did not state the phase relationship between current and voltage in an inductive circuit.
- (c) In Q3.3.1 and Q.3.4.4 the majority of the candidates could not make L and C, respectively, the subject of the formula from the formulae taken from the formula sheet. This affected the substitution and the answer. Some candidates did not use units or they used incorrect units.
- (d) In Q3.3.2 most of candidates lost marks by omitting the units in the final answer.
- (e) In Q3.3.3 many candidates included a unit in the final answer and lost a mark because power factor has no units. Some candidates used the incorrect formula and calculated the phase angle and not the power factor.
- (f) In Q3.3.4 most candidates did not know that the unity power factor is the same as the power factor is equal to 1
- (g) In Q3.4.1 and Q3.4.2 candidates could not identify the resonant frequency from data given to them.

- (h) Q3.4.2 most candidates could not compare the values of the inductive and capacitive reactances when the frequency increases, as given in the data in FIGURE 3.4B.
- (i) Q3.4.3 many candidates did not consider the engineering notation prefix when calculating the volt drop across the inductor resulting in the loss of 2 marks.
- (j) In Q3.5.2 candidates could not calculate the voltage drop across the inductor as many used the incorrect formula.

Suggestions for improvement

- (a) Teachers should illustrate the phase relationship between I and V in a/an:
 - Resistive circuit
 - Inductive circuit
 - Capacitive circuit
 and explain why a circuit is inductive or capacitive.
- (b) Teachers should explain the effect of varying the frequency of the supply in an RLC circuit, the characteristics curve and phasor diagrams of resonance circuits and the conditions of series/parallel resonant circuits.
- (c) The following should be considered:
 - Lesson plans developed by teachers and not by subject advisors are key to these challenges, for example:
 - To reflect on what worked well during the presentation, and what could have been done differently for further improvement of the next lesson plan
 - To reflect on prior learning to introduce the content to be learned
 - When covering calculations, integrate relevant mathematical concepts e.g. manipulation of formulae.
 - Focus on identification of appropriate formulae from the formula sheet and application thereof.
 - Develop an assessment task based on the following:
 - Identification of the formula for specific calculations
 - Manipulation of formulae
 - Units for specific quantities, e.g. voltage, current, resistance, impedance, frequency, phase angle, bandwidth, etc.
 - Prefixes, e.g. nano, micro, milli, kilo and the conversion thereof
 - Use of the calculator
 - These assessment task should also be implemented in section with calculations, e.g. in semiconductors and switching circuits
- (d) The definitions of the terms, explanations and descriptions of concepts that are likely to be asked in the examination should be summarised in a booklet and handed to learners at the beginning of the year.
- (e) Learners must be trained to read the question carefully and to look at the mark allocation. The number of facts provided must correlate with the number of marks.
- (f) Learners need to read questions with understanding to answer appropriately. Similar questions should be given during the year in preparation for the final examination.
- (g) The application and understanding of data taken from these circuits to answer theoretical style questions is a major problem currently. The practical building of RLC circuits and the checking of the waveforms on the oscilloscope is a good way of reinforcing the theory.

QUESTION 4: THREE-PHASE AC GENERATION (SPECIFIC)**Common errors and misconceptions**

- (a) In Q4.1.1 most candidates did not name the processes but merely described the diagram.
- (b) In Q4.1.2 candidates were unable to draw the generated waveforms correctly at point A. Of those who attempted to draw it, many did not include the correct phase and sequence.
- (c) In Q4.1.3 many candidates focused on a step-up transformer increasing the voltage but they did not mention how this affects the current in the transmission lines which reduces the copper losses.
- (d) In Q4.1.4 candidates did not know why a *star connection* would be used at transformer 3 to supply both three-phase users and single-phase users.
- (e) In Q4.2 candidates used incorrect units, incorrect formulae and incorrect numbering of questions. This resulted in the loss of many marks.
- (f) In Q4.4 the concept of leading and lagging power factor was a challenge, as most candidates were unable to analyse/read/interpret the reading on an analogue power factor meter.

Suggestions for improvement

- (a) It is advisable to develop a chart as part of teaching aids, where the three powers, namely: *active power*, *reactive power*, *apparent power* and the *power factor* will be explained or defined. These terms should be put on the wall so that learners become familiar with them. This technique can also be used for other sections where similar misconceptions exist.
- (b) Reading the question with understanding is crucial in questions of this nature. Candidates tend to provide inappropriate answers to questions only if they did not read the questions carefully. The skill of reading the questions with understanding can be honed through constant practice throughout the year. Learners should be taught to analyse the question before they attempt to answer it. In interpreting and understanding of questions, focus should be placed on the following verbs: explain, define, describe and explain.
- (c) Teachers should spend time in explaining the following concepts:
 - True power
 - Apparent power
 - Reactive power and efficiency
 - Power factor.
- (d) Calculations count for approximately 50% of the marks in the question paper. Learners should be trained on how to select the correct formula, manipulate this where necessary, and to substitute correctly, e.g. 2 kW should be written as 2 kW or 2 000 and not as 2).

$$\begin{aligned}
 P_T &= P_1 + P_2 \\
 &= 1,2\text{k} + 2,3\text{k} \\
 &= 3,5 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 P_T &= P_1 + P_2 \\
 &= 1200 + 2300 \\
 &= 3,5 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 P_T &= P_1 + P_2 \\
 &= 1,2 \times 10^3 + 2,3 \times 10^3 \\
 &= 3,5 \text{ kW}
 \end{aligned}$$

The units must also be included at the end of the final answer. Learners should be exposed to more calculations and in the process, identify and address omissions (formulae, units, prefixes, etc.), knowledge gaps and misconceptions. Learners must also be encouraged to refer to the formula sheet because it gives the summaries of laws and principles.

- (e) Learners made careless mistakes that lost them many marks unnecessarily. The mechanics and procedures used when presenting calculations was lacking this year. Learners require more practice in this approach and constant checking and feedback from teachers.
- (f) Teacher must ensure that candidates understand the three main stages of the National Grid in a block diagram. A video can also be used for demonstrations
- (g) Teachers should ensure that their learners understand the following:
 - How to draw and interpret a waveform diagram of three-phase AC generation including their phase angles
 - Why the AC voltage has to be stepped up after generation before transmission and step-down before distribution to household and industries
 - The purpose of each transformer in each stage of the network distribution and simulate the distribution network using software.

QUESTION 5: THREE-PHASE TRANSFORMER (SPECIFIC)

Common errors and misconceptions

- (a) In Q5.1.1 candidates could not identify the parts of a three-phase transformer.
- (b) In Q5.1.2 the cooling methods for three-phase transformers were not given in full. Instead of *oil natural air forced* candidates just answered as *oil cooled* and marks were lost here. Candidates should be encouraged to write out the full name of cooling methods and not use abbreviations.
- (c) In Q5.1.3 candidates did not list the specific protection devices. They incorrectly listed the causes and symptoms of overloading a transformer.
- (d) In Q5.1.4 many candidates confused the operation and purpose of a solid-state transformer with a rotating motor. Most candidates explained the construction of transformers and their application instead of a step-down transformer's operation.
- (e) In Q5.2 candidates were not familiar with the core types of three-phase transformer.
- (f) In Q5.3.3 candidates wrote the ratio of the transformer in fractional form, e.g. $\frac{5}{1}$ and others in decimal form, e.g. 4.95: 1, instead of 5:1.
- (g) In Q5.3.5 an incorrect formula used in the calculation resulted in a loss of marks.

Suggestions for improvement

- (a) Teachers must show learners practical identification of a part and how the part contributes to the functioning of the transformer.

- (b) Teach learners the difference between:
 - Coolant and the method of cooling in transformers;
 - Step-up transformer (transformer that increases the voltage on its secondary winding with respect to the primary) and a step-down transformer (transformer that decreases the voltage on the secondary winding with respect to the primary) and how each operates.
- (c) Teach learners the ratio between the numbers of turns of the primary windings to that of the secondary windings and that it has no units. This ratio is written with a colon, e.g. 6:1.
- (d) Use practical examples when teaching.
- (e) Familiarise learners with protective devices.
- (f) Teach learners to change values; manipulate formulae and use the correct units for the different power calculations. Assess them on these calculations regularly to encourage learners to pay attention to these aspects.

QUESTION 6: THREE-PHASE MOTORS AND STARTERS (SPECIFIC)

Common errors and misconceptions

- (a) In Q6.1.2 candidates could not explain how a rotating magnetic field was created in the stator windings. Many of them described the assembly, construction or connection of the stator windings.
- (b) In Q6.1.4 candidates could not state the factors that determined the speed of rotation in a three-phase induction motor.
- (c) In Q6.2.2 candidates' responses were vague and they just said 'swap lines'. The specific and concise nature of the subject was lost.
- (d) In Q6.2.3 candidates confused motor testing with mechanical inspection. Candidates did not realise that the insulation resistance test is an electrical test and that before testing the motor the power lines must be disconnected and the connecting plates must be removed.
- (e) In Q6.3.1 candidates used incorrect pole pairs resulting in an incorrect answer.
- (f) In Q6.3.3 candidates used an incorrect formula and many did not write the unit. They lost marks for this.
- (g) In Q6.4 most candidates did not know the application of components used in the manual sequence starter.

Suggestions for improvement

- (a) Teachers need to encourage learners to understand the formula in relation to theory.
- (b) This challenge in Q6.4 might be attributed to lack of practical work at school. Teachers must use digital media, e.g. the internet or videos.
- (c) The control circuits, as stipulated in the CAPS, must be drawn on the chart with components, function and the operation in sequential form.

- (d) Teach learners the difference between *motors* and *motor starters*. More focus should be given to the sequence starter and star-delta starters that learners are not as familiar with as with the normal direct-on-line starter and forward-reverse starters. Teach them that each starter has its own name and function.
- (e) Latching is a very important concept as it is used in starters as well. Teachers should focus on insight information as the questions are not posed in a straight-forward way. Use keywords, such as *why*, *how*, *describe* and *explain*, when teaching the theory part of the subject. Teach candidates to explain and not simply answers.
- (f) More calculations on speed formulae need to be practised.
- (g) Teachers should explain to learners that phase values will never be greater than line values; they can, however, be equal.
- (h) Explain/describe:
 - How the control circuit is operated
 - Function of each component in the circuit
 - Analysis of the control circuit
 - The effect that an inserted fault will have on the operation of the circuit. This is usually a 3-mark question.
- (i) It is important that learners are taught the theory behind the starters. If learners know the operation of each starter and the function of each component in the starters, they should be able to answer all the questions in Q6.

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS (PLCs) (SPECIFIC)

Common errors and misconceptions

- (a) In Q7.1.1 candidates confused *types of hardware modules* with *discrete components and software*.
- (b) In Q7.1.2 candidates wrote vague, generalised or incorrect answers. The marking guidelines focused on specific concise responses.
- (c) In Q7.1.3 candidates did not realise that the word *component* referred to a hardware device.
- (d) In Q7.2 candidates did not make reference to the time taken to complete one scan cycle. Their response referred to it as a period of time of operation.
- (e) In Q7.3 candidates wrote vague, generalised responses that did not focus on what software is in reference to PLCs, where it is installed and what it instructs.
- (f) In Q7.5 candidates are still confused about whether the switches should be open or closed but the marking guidelines catered for that. A pattern that is emerging often is that learners are drawing a mirror image of the programme and this poses a problem because the program only works in a left to right sequence. A correct mirror image is incorrect resulting in a loss of many marks. This programme will not operate the programming software for PLCs. Note that interlocking contacts MC2 NC and MC1 NC must be closed to indicate interlocking contacts.

- (g) In Q7.6.1 candidates could not identify the DC to AC inverter in the circuit.
- (h) In Q7.6.4 most candidates did not know the vector drives.
- (i) In Q7.6.3 candidates did not know the advantages of variable speed drives.
- (j) In Q7.8 most candidates could not explain regenerative braking energy when the momentum drives the motor.

Suggestions for improvement

- (a) The specific and concise nature of the subject must be stressed by teachers when delivering the content.
- (b) Variable speed drives and regenerative braking need a lot more attention in terms of block diagrams, basic purpose of blocks, applications and advantages.
- (c) Explain what sensors are. The definitions and uses of sensors should be given in full.
- (d) Teachers should show the hardware components of the PLC practically to learners. Teach them all the hardware components and not only the CPU.
- (e) Teach learners what applications are. Teach them to look for the specific words; in this case it is the overload sensor.
- (f) Extra time should be given to teaching the *latching concept* to learners. Teachers can show this practically as well.
- (g) Teach learners the function of the different components.
- (h) Teachers should allocate more time to teaching VSDs. Focus should be on what is happening at each stage and how it is achieved.
- (i) With regard to Q.7.7, teachers must teach the purpose or function of regenerative braking and the energies involved in this process. Note that learners learn differently and at different paces, therefore teachers must consider all learners when preparing lessons. Some learners learn more effectively when they see and touch, while others learn more effectively through verbal or visual ways.
- (j) Teachers need to explain and demonstrate to learners how the conversion of hard wiring to ladder logic diagram is done, and show correct labelling of inputs and outputs. Note that ladder logic diagrams are drawn from:
 - Left power rails with input instruction to right power rails with output instruction
 - Top to bottom with rungs connected between two power rails
 - The ladder logic diagram drawn should use the Engineering Graphics and Design (EGD) approach and not crude freehand drawings.
- (k) Teachers should assist learners to:
 - Identify the latching circuit, which is the start button connected in parallel with the normally open contact (N/O) of the coil
 - Understand the purpose of latching
 - Explain the different types of contact used for latching, which is normally open contact (N/O)

- (l) Teachers should assist learners to:
- Understand the purpose of interlocking
 - Use the correct symbols for interlocking
 - Explain the concept of series connection as used in interlocking circuit
 - Perform the practical experiment.

CHAPTER 6

MECHANICAL TECHNOLOGY

6.1 AUTOMOTIVE

The following report should be read in conjunction with the Automotive question paper of the December 2021 examinations.

6.1.1 PERFORMANCE TRENDS (2018–2021)

This was the fourth examination in which the specialisation subjects were examined. In 2021, 3 330 candidates sat for the Automotive examination, which was an increase of 491 candidates in comparison to the previous year.

The candidates performed well, with 95,2% of the cohort passing at 30% (Level 2). This reflects an improvement on the 2020 pass rate of 94,1%.

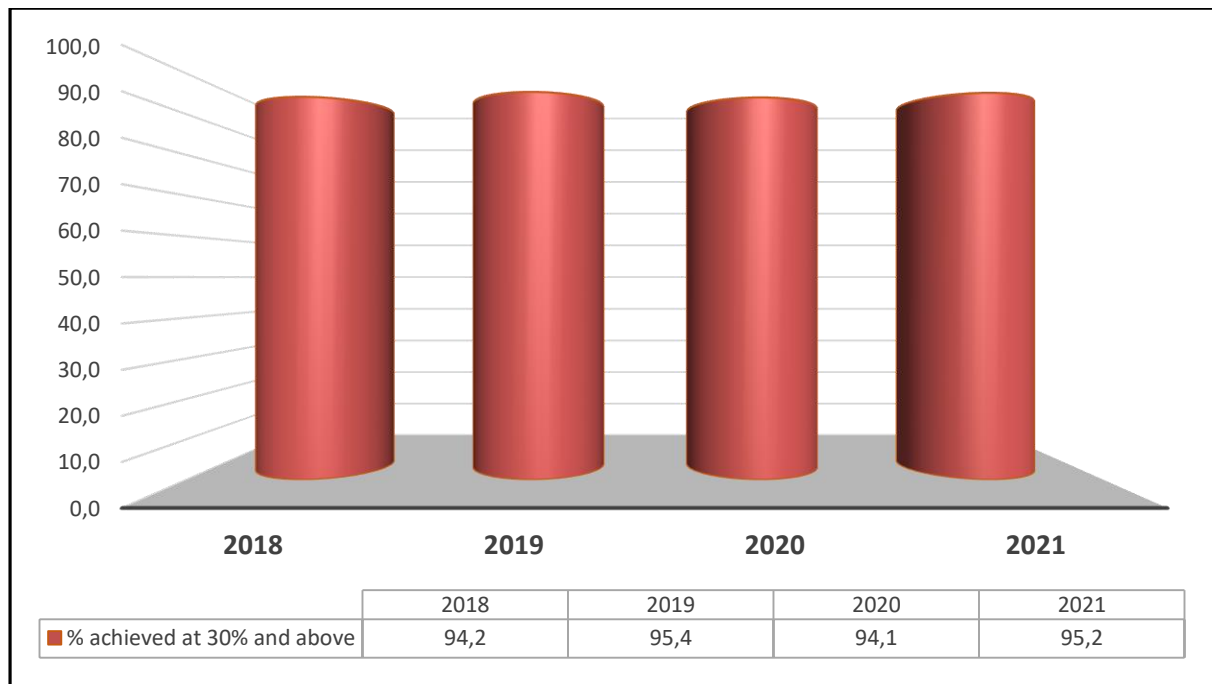
The percentage of distinctions (80%; Level 7) increased marginally to 0,9% in 2021. This converts to an increase in the number of distinctions from 21 to 30. Candidates who achieved over 50% comprised 35,5% of the cohort which was in line with that of previous years.

The results may improve in future, with stability in the curriculum and with teachers and learners becoming familiar with the assessment style of the subject. Candidates' performance in the 2021 examination was marginally better when compared to 2020. Their problem-solving skills, mathematical skills and conceptual understanding still remain a challenge. In this regard, integrated problem-solving must become an integral part of teaching and learning.

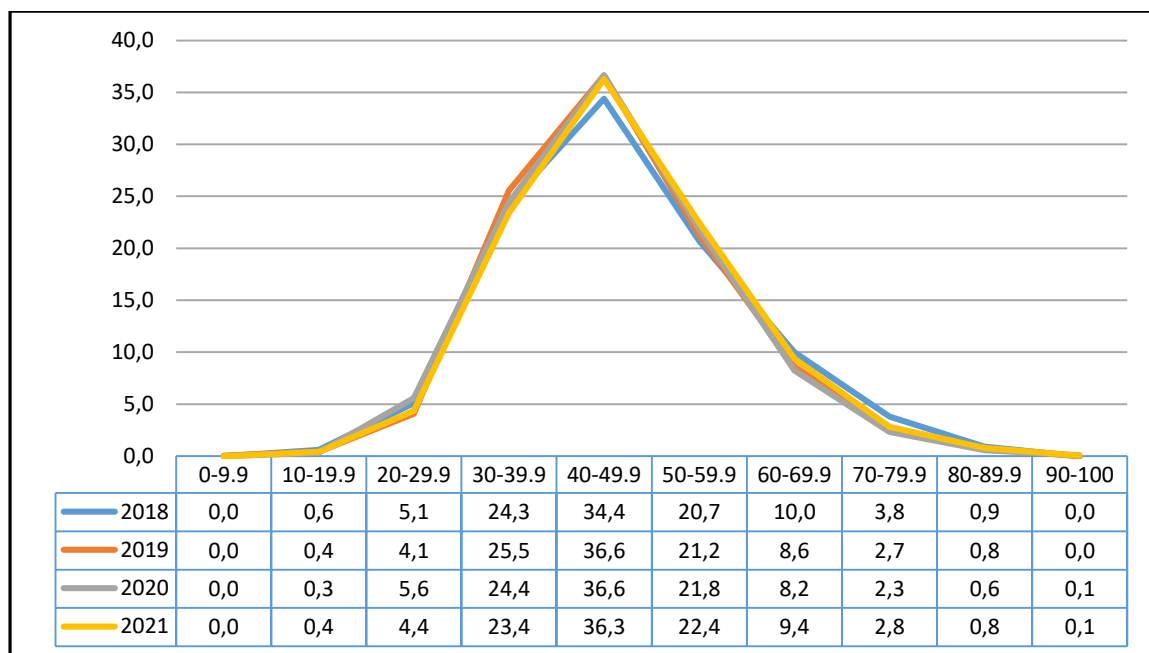
Table 6.1.1 Overall achievement rates in Automotive

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	2 986	2 814	94,2
2019	2 784	2 657	95,4
2020	2 839	2 671	94,1
2021	3 330	3 171	95,2

Graph 6.1.1(a) Overall achievement rates in Automotive (percentage)



Graph 6.1.1(b) Performance distribution curves in Automotive (percentage)



6.1.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE AUTOMOTIVE PAPER

General comments

- (a) The majority of the questions pertaining to pure recall of content were very poorly answered. Short informal assessment tasks should be used to reinforce basic concepts and principles. This can be used effectively for content relating to definitions, functions, labelling and operations as listed in the CAPS and the *Examination Guidelines*.
- (b) Candidates did not manipulate formulae correctly. Teachers must emphasise the following: use of the relevant formulae provided on the formula sheet, correct substitution thereof and providing the answer with the correct unit and direction in terms of what is required by the question.
- (c) The application of mathematical principles is still a challenge for candidates
- (d) Candidates' handwriting should not be too small and calculations should not be cramped onto one section of the page. Candidates should ensure that their work is legible and neatly presented and they should also be able to follow the instructions on the cover.
- (e) It appears that candidates do not read questions carefully and consequently do not answer certain subquestions appropriately.
- (f) Candidates lacked knowledge of, or exposure to, the use of various tools and equipment.
- (g) Many candidates and teachers were frequently absent from school due to quarantines or isolation in respect of Covid-19. Non-attendance of school means both candidates and teachers had missed important contact time. Candidates were further impacted by the lack of contact time in Grade 11 due to shortened school weeks the previous year. The knowledge and understanding gained in Grade 11 were fundamental to their proper preparation. Contact time was also negatively impacted due to time-tabling models and limited class sizes.

6.1.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN AUTOMOTIVE

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) The majority of candidates did not know the purpose of the *hardening of steel* in Q1.5.
- (b) In Q1.6, most of the candidates could not identify the correct process that follows hardening.

Suggestions for improvement

- (a) Teachers should provide worksheets to identify the different properties of materials and then practically demonstrate these properties and processes in the workshop.

- (b) Teachers should make use of practical demonstrations to explain the definitions of the properties of steel.
- (c) Ensure in-depth revision and remediation measures are in place on the topics of safety and materials. In order to prepare learners to respond with reasons to multiple-choice questions, the use of past question papers is encouraged. They must apply their practical knowledge in theory questions. Learners should be taught the technique of arriving at the correct answer by the process of elimination in instances where they are unable to identify the correct alternative immediately.

QUESTION 2: SAFETY

Common errors and misconceptions

- (a) In Q2.1 some candidates were unable to provide the specific measures to be taken when treating an open wound. They stated prevention and contamination of the open wound.
- (b) Q2.2 specifically asked for safety precautions that must be observed *after* the surface grinder has been switched on, instead candidates provided general safety precautions that included precautions that must be observed before and during the operation of a machine.
- (c) In Q2.6 majority of the candidates could not identify the type of workshop showed in the figure.

Suggestions for improvement

- (a) When using tools and equipment, demonstrate the importance of using surgical gloves when someone cuts himself or herself. Video presentations and demonstrations would give learners an advantage when answering these types of questions on first aid. Also state who is responsible for the administering of first aid.
- (b) Learners need to read the question with understanding, as some learners tend to write down what comes to mind regarding the topic but not specifically what is required by the question.
- (c) Learners should be exposed to workshop practice relating to the safety of tools, the equipment in the workshop and the workshop environment.
- (d) Teachers should provide worksheets to differentiate between the responsibilities of the employer and the employee with regard to safety in the workshop.

QUESTION 3: MATERIALS

Common errors and misconceptions

- (a) In Q3.2 the candidates' responses indicated a lack of theoretical knowledge, as well as practical application when labelling the drawing about the annealing process.
- (b) In Q3.5 the majority of the candidates did not know which quenching media had to be used to harden steel.

Suggestions for improvement

- (a) Learners should be exposed to the different processes to enhance the properties of metal.
- (b) The revision programme must include exercises requiring explanation, definition and application of heat-treatment processes. Schools need to organise educational excursions to foundries or other places where materials are processed in order to acquaint learners with metallurgy and to further improve their understanding of the processes involved.

QUESTION 4: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) Most of the multiple-choice questions were incorrectly answered due to a lack of content knowledge by candidates.
- (b) Q4.7 was poorly answered, as most candidates were unable to state the use of dynamometer.
- (c) Q4.10 and Q4.11 were incorrectly answered due to a lack of practical knowledge about automatic transmission system.

Suggestions for improvement

- (a) Learners should be able to distinguish between the different components of an automatic transmission and to provide the function of each component. This could be enhanced by providing learners with a diagram of an automatic gearbox.
- (b) Learners are required to label the different components on the diagram and provide a short description of the functions of each component.

QUESTION 5: TOOLS AND EQUIPMENT

Common errors and misconceptions

- (a) In Q5.1.1 to Q5.1.4 the majority of the candidates could not state the correct sequence of events when conducting a compression test.
- (b) In Q5.5 most of the candidates could not identify the missing safety component of the equipment shown in the diagram.

Suggestions for improvement

- (a) Learners should be exposed to all tools as prescribed in the *CAPS* for Automotive. They should be taught the purpose of each tool and be trained to use them correctly. This should enable learners to identify the different tools.
- (b) Practical skills in performing dynamic wheel balance must be incorporated into the teaching of this content. Teachers need training in the use of specialised tools and equipment before imparting this knowledge to learners.

QUESTION 6: ENGINES

Common errors and misconceptions

- (a) In Q6.1 some candidates could not state how the firing order assisted the functioning of the crankshaft.
- (b) In Q6.7.1 to Q 6.7.4 most candidates could not give the degrees of crankshaft rotation for power impulses of the different four stroke engines.

Suggestions for improvement

- (a) Teachers must emphasise how the firing order assists the functioning of the crankshaft.
- (b) Teachers should cover the theory and demonstrate crankshaft rotation practically so that learners will be able to give the degrees of crankshaft rotation for power impulses of the different four stroke engines.

QUESTION 7: FORCES

Common errors and misconceptions

- (a) Most candidates could not state the definition of brake power in Q7.1.1.
- (b) In Q7.3.1 most candidates could not identify what V_1 and V_2 represented in the diagram showing volumes in the cylinder.
- (c) In Q7.3.3 the majority of the candidates could not calculate the total cylinder volume because they did not know that 1 ml is equal to 1 cm³.
- (d) In Q7.3.4 the majority of the candidates could not manipulate the formula to calculate the new bore diameter using the swept volume in Q7.3.
- (e) In Q7.5.1 some candidates could not calculate indicated power using the information given in the instructions. Candidates could not convert standard units to the required units. Many candidates were challenged by the mathematical concepts which are essential for such calculations.

Suggestions for improvement

- (a) Teachers are advised to design a worksheet to cater for definitions in respect of terminology involving forces, such as *compression ratio*, *brake power* and *mechanical efficiency*.
- (b) Making use of a line sketch to define *swept* and *clearance volume* is useful to enhance understanding of these concepts.
- (c) The manipulation of formulae forms the basis of calculations in the subject. Learners must be assisted to acquire this skill. Teachers should provide more calculation activities using examples from previous question papers and various textbooks.
- (d) Discuss each step in the calculation using the Indicated Power and Cylinder Volume formulae. Teachers should illustrate how to do each subcalculation indicating the conversion of the unit separately and then applying these results in the main formula.

QUESTION 8: MAINTENANCE

Common errors and misconceptions

- (a) In Q.8.1.1 and Q8.1.2 most candidates were not able to state the causes and corresponding corrective measures for low CO₂ exhaust reading.
- (b) Many candidates were challenged by Q8.7. They were asked to explain in point form how to conduct a radiator cap test but instead they explained how to do a radiator test.

Suggestions for improvement

- (a) When conducting an exhaust gas analysing test, the teacher must draw up a worksheet where learners can indicate causes and corrective measures.
- (b) A practical demonstration of how to do a radiator cap test and a radiator test by the teacher is essential to identify the differences in testing.
- (c) Teachers should also use video clips related to safety measures when conducting all types of test.

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX)

Common errors and misconceptions

- (a) In Q9.1.2, the majority of the candidates could not explain the functions of a torque convertor.
- (b) Many candidates were unable to explain how overdrive is obtained in the epicyclic gear train in Q9.2.

Suggestions for improvement

- (a) Teachers should use charts to show the labels of the torque converter, its advantages, functions and its operation. If possible, use a sectioned automatic gearbox or an actual vehicle and videos to show learners the differences in the operation of the power transmission between automatic and manual vehicles.
- (b) Teachers are advised to design a worksheet that will assist learners with identifying various parts and understanding their functions, purposes and advantages and disadvantages of the automatic transmission including the epicyclic gear train.

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONICS)

Common errors and misconceptions

- (a) In Q10.1 many candidates were unable to state the reasons for wheel alignment.
- (b) The majority of the candidates were unable to identify causes of camber wear in Q10.2.1.
- (c) In Q10.2.3 the majority of the candidates could not state how camber can be adjusted.
- (d) Most candidates did not read Q10.3 carefully. This question required them to draw and fully label the drawing. Many candidates failed to do this.

- (e) In Q10.5 most candidates did not know the different types of injectors.
- (f) In Q10.8.3 the majority of the candidates could not draw the two types of stator windings used in an alternator.
- (g) Some candidates were unable to state the advantages of electrical fuel pump in Q10.9.

Suggestions for improvement

- (a) Teachers must do the practical application of a steering mechanism so that learners can have a better understanding of the topic.
- (b) Teachers should assign more drawing exercises to allow learners to master all wheel alignment angles, definitions and labels. Take learners to a wheel alignment workshop for learners to understand the alignment and setting of wheel alignment angles. Alternatively, videos can be used to achieve this.
- (c) Use an actual alternator to show the components and explain their stator wiring, functions, operations and methods to increase their frequency as well as safety measures.
- (d) Design a worksheet for learners to complete regarding the difference between an *electrical* and a *mechanical* fuel pump as well as the types, advantages and disadvantages of each. Alternatively, they can use video clips to demonstrate how electrical and mechanical fuel pumps operate.
- (e) Teachers must show learners the different types of injectors. Using videos or charts will be of great assistance.
- (f) Teachers should administer frequent weekly short informal assessment tasks to enhance candidates' knowledge and drill revision work.

6.2 FITTING AND MACHINING

The following report should be read in conjunction with the Fitting and Machining question paper of the November 2021 examinations.

6.2.1 PERFORMANCE TRENDS (2018–2021)

In 2021, 1 991 candidates sat for the Fitting and Machining examination. This was the fourth examination of the specialisation subjects. The performance of the candidates in 2021 reflects good achievement, with 97,1% of the cohort passing at 30% (Level 2). This was a marginal increase over the 2020 pass rate of 96,8%.

The percentage of distinctions (80%; Level 7) decreased from 3,8% in 2020 to 3,1% in 2021 a decrease of 0,9% in 2021. This converts to a decrease in the number of distinctions from 73 to 61. Candidates who achieved over 50% comprised 48,5% of the cohort compared to 41,4% in the previous year.

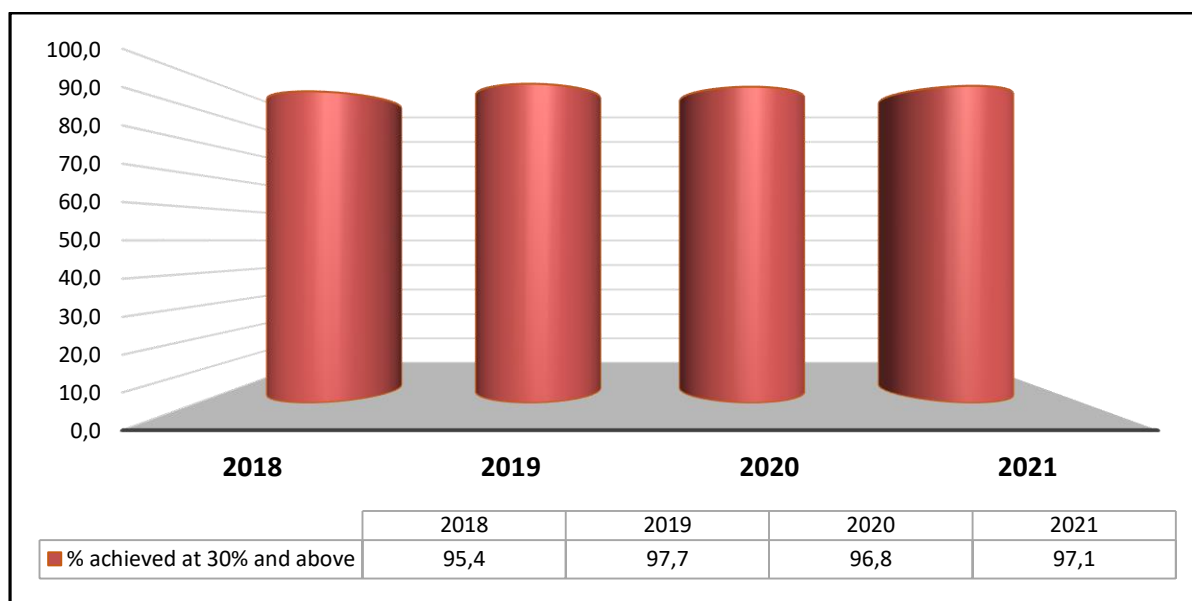
The level of the results may improve in the future with stability in the curriculum as well as with the teachers becoming familiar with the assessment style of the subject. There is still room for improvement in the performance of the learners if the challenges surrounding problem-solving

skills, mathematical skills, conceptual understanding and integration of topics are addressed. In this regard, integrated problem solving must become an integral part of teaching and learning.

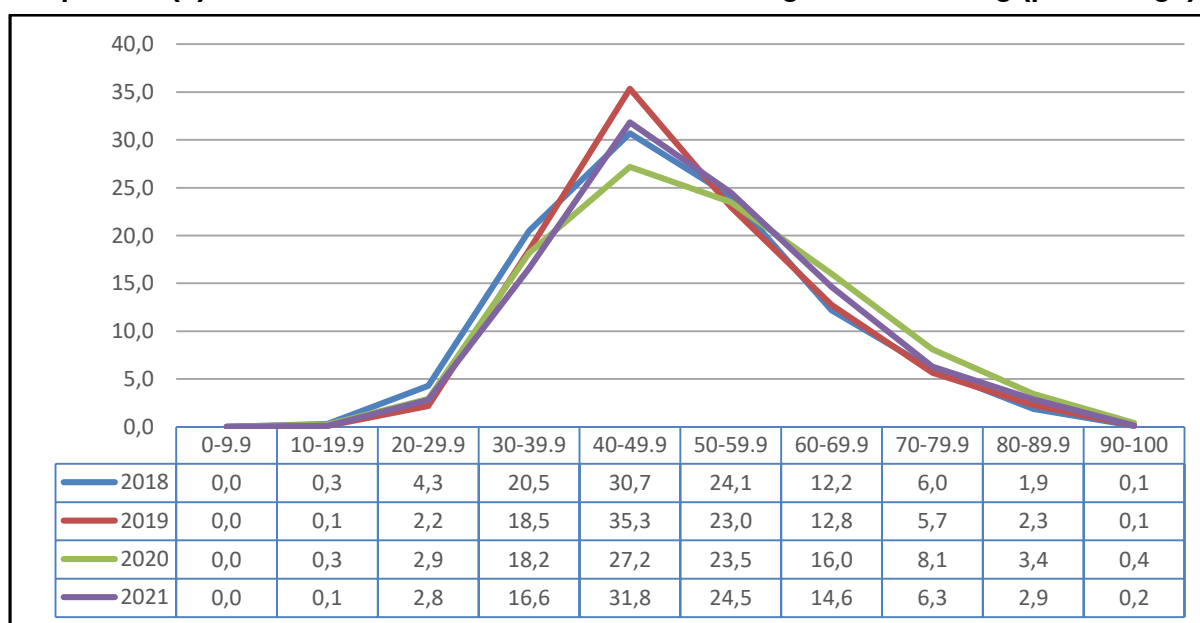
Table 6.2.1 Overall achievement rates in Fitting and Machining

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	2 088	1 992	95,4
2019	2 012	1 966	97,7
2020	1 914	1 853	96,8
2021	1 991	1 933	97,1

Graph 6.2.1(a) Overall achievement rates in Fitting and Machining (percentage)



Graph 6.2.1(b) Performance distribution curves in Fitting and Machining (percentage)



6.2.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE FITTING AND MACHINING PAPER

General comments

- (a) The majority of the questions pertaining to pure recall of content were very poorly answered. Short informal assessment tasks should be used to reinforce basic concepts and principles. This can be used effectively for content relating to definitions, functions, labelling and operations as listed in the *CAPS* and the *Examination Guidelines*.
- (b) Candidates did not manipulate formulae correctly. Teachers must emphasise the following: use of the relevant formulae provided on the formula sheet, correct substitution thereof and providing the answer with the correct unit and direction in terms of what is required by the question.
- (c) The application of mathematical principles is still a challenge for candidates.
- (d) Candidates' handwriting should not be too small and calculations should not be cramped onto one section of the page. Candidates should ensure that their work is legible and neatly presented and they should also be able to follow the instructions on the cover.
- (e) It appears that candidates do not read questions carefully and consequently do not answer certain sub questions appropriately.
- (f) A lack of knowledge of, or exposure to the use of various tools and equipment, was revealed by candidates.
- (g) Many candidates and teachers were frequently absent from school due to quarantines or isolation with regard to Covid-19. Non-attendance of school means both candidates and teachers had missed important contact time. Candidates were further impacted by a lack of contact time in Grade 11 due to shortened school weeks the previous year. The knowledge and understanding gained in Grade 11 were fundamental to their proper preparation. Contact time was also negatively impacted due to time-tabling models and limited class sizes.

6.2.3 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN FITTING AND MACHINING

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) The majority of candidates did not know the purpose of the *hardening of steel* in Q1.5.
- (b) In Q1.6 most of the candidates could not identify the correct process that follows hardening.

Suggestions for improvement

- (a) Teachers should provide worksheets to identify the different properties of materials and then practically demonstrate these properties and processes in the workshop.
- (b) Teachers must use practical demonstrations to explain the definitions for the properties of steel.
- (c) Ensure in-depth revision and remediation measures are in place on the topics of safety and materials. In order to prepare learners to respond with reasons to multiple-choice questions, the use of past question papers is encouraged. They must apply their practical knowledge in theory questions.
- (d) Learners should be taught the technique of arriving at the correct answer by the process of elimination in instances where they are unable to identify the correct alternative immediately.
- (e) In Q2.1 some candidates were unable to provide the specific measures to be taken when treating an open wound. They stated prevention and contamination of the open wound.
- (f) Q2.2 specifically asked for safety precautions that must be observed *after* the surface grinder has been switched on, instead candidates provided general safety precautions, which included precautions that must be observed before and during the operation of a machine.
- (g) In Q2.6 majority of the candidates could not identify the type of workshop showed in the figure.

Suggestions for improvement

- (a) When using tools and equipment, demonstrate the importance of using surgical gloves when someone cuts himself or herself. Video presentations and demonstrations will give learners an advantage when answering these types of questions on first aid. Also state who is responsible for the administering of first aid.
- (b) Learners need to read the question with understanding, as some learners tend to write down what comes to mind regarding the topic but not specifically what is required by the question.
- (c) Learners should be exposed to workshop practice relating to the safety of tools, the equipment in the workshop and the workshop environment.
- (d) Teachers should provide worksheets to differentiate between the responsibilities of the employer and the employee with regard to safety in the workshop.

QUESTION 3: MATERIALS

Common errors and misconceptions

- (a) In Q3.2 the candidates' responses indicated a lack of theoretical knowledge as well as practical application when labelling the drawing about the annealing process.
- (b) In Q3.5 majority of the candidates did not know which quenching media had to be used to harden steel.

Suggestions for improvement

- (a) Learners should be exposed to the different processes to enhance the properties of metal.
- (b) The revision programme must include exercises requiring explanation, definition and application of heat-treatment processes. Schools need to organise educational excursions to foundries or other places where materials are processed in order to acquaint learners with metallurgy and to further improve their understanding of the processes involved.

QUESTION 4: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) Some candidates did not read the questions carefully.
- (b) The majority of the candidates seem to lack proper skills to answer multiple-choice type questions.
- (c) Most candidates did not know the principle used on an incremental cutter in a CNC milling machine.
- (d) Many candidates seem to lack proper knowledge of the definitions of terminologies regarding *stress*, *strain* and *break stress* and *safety factor*.

Suggestions for improvement

- (a) Learners must be taught the technique of arriving at the correct answer through the process of elimination in instances where they are unable to identify the correct alternative immediately.
- (b) Teachers should explain the main difference between *absolute* and *incremental programming* on a three-axis digital read-out system. A practical demonstration will enhance learners' understanding of this term.
- (c) Teachers should focus on the definitions of all terminology in the subject during informal as well as formal assessment activities.

QUESTION 5: TERMINOLOGY – LATHE AND MILLING MACHINE

Common errors and misconceptions

- (a) Answers to Q5.1 revealed that candidates lacked the mathematical skills required to answer the question.
- (b) Q5.2.2 requested the set-over of the tailstock. Only a few candidates managed to give the correct answer because they required the length of the taper from Q5.2.1.
- (c) Q5.4 was based on the theory of the practical application of skills regarding the milling processes. Candidates who did not perform well could not relate this content to the process in practice.

Suggestions for improvement

- (a) The subject teacher needs to integrate relevant sections with Mathematics (trigonometric equations) and Technical Mathematics.
- (b) Teachers should give learners more weekly activities with different questioning techniques such as substitution, manipulation of formulae and calculations.
- (c) Learners should practise using previous question papers.
- (d) Performing practical tasks can assist learners to understand the concepts, processes and advantages and disadvantages. This should improve the quality of answers to questions.
- (e) Mathematical skills can only improve with practice. Use the steps as suggested:
 - Identify the formula
 - Formula manipulation (if necessary)
 - Substitution (correct values or units)
 - Answer with unit of measure indicated

QUESTION 6: TERMINOLOGY – INDEXING AND DOVETAILS

Common errors and misconceptions

- (a) Q6.2.1 and Q6.2.2 required the candidates to calculate dovetail dimensions and the majority of the candidates could not answer these questions correctly.
- (b) In Q6.3.1 the majority of the candidates did not give the final answers for indexing. There were no full turns and 8 holes on the 28-hole circle and no full turns and 12 holes on the 42-hole circle.
- (c) Q6.3.2 required the candidates to calculate change gears. Unfortunately, very few candidates could perform the calculation.
- (d) Candidates still struggle with basic fraction calculations.

Suggestions for improvement

- (a) The subject needs to be integrated with Mathematics and Technical Mathematics. Teachers must give learners more activities with different questioning techniques such as substitution, manipulation of formulae and calculations.
- (b) Use diagrams (separate triangles) for the dovetail calculations.
- (c) Give learners practical exposure to the machines and equipment. Explain the calculation while doing the practical tasks.
- (d) Teachers should give more weekly calculation activities to enhance learners' mathematical skills and improve formula manipulation through practice.

QUESTION 7: TOOLS AND EQUIPMENT

Common errors and misconceptions

- (a) Candidates could not identify the type of tester shown in the figure in Q7.4.
- (b) Q 7.4 was based on the theory of the practical application of skills related to testing of material and measuring skills. The candidates who did not perform well could not make reference to the content in practice.
- (c) Q7.8 required the use on interchangeable rods used in a depth micrometre. This was poorly answered.

Suggestions for improvement

- (a) Teachers should use electronic media and practical exercises to cover the content on testers used to determine specific properties of materials and the application of measuring equipment.
- (b) Learners must know the names and uses of the tools that they are using. Teachers can create practical tasks to improve measuring skills using Vernier callipers, micrometres and accessories.

QUESTION 8: FORCES

Common errors and misconceptions

- (a) In Q8.1 the majority of the candidates ignored the hint provided in the question. There was an improvement in the response to this question, although many candidates struggled with the direction needed in the final answer (north of west) and they incorrectly labelled the horizontal and vertical components.
- (b) Q8.2.2 and Q8.2.3 required reactions at support A and B. Some candidates mixed up the supports.
- (c) Many candidates did not convert to the correct units before and after completing the calculation, as required in the question, e.g. MPa and mm.
- (d) Calculations with exponents in Q8.3 were a great challenge for the candidates. They were unable to state the required units of measure. Furthermore, candidates were not able to work with formulae on stress calculations.

Suggestions for improvement

- (a) Drawing a diagram will assist candidates in determining the direction of the resultant.
- (b) Learners should be encouraged to perform calculations systematically according to the following steps:
 - Identify/Use the correct formula (this may be on the formula sheet)
 - Manipulate the formula, if necessary, depending on the information available
 - Substitution correct values or units, as per the question
 - Express the final answer with the relevant unit of measure
- (c) Learners must ensure that they use exponents and the correct unit in the answer.

- (d) Different methods of calculations should be explored and explained to the learners. Manipulation of formulae should be practised and the meaning of every entity in the formula should be explained in a broader sense.
- (e) Different areas must be practised during homework and assessments.

QUESTION 9: MAINTENANCE

Common errors and misconceptions

- (a) All questions, except Q9.4, Q9.5 and Q9.6, were poorly answered. This has resulted in the overall poor performance in this question. It was evident that this content was not adequately covered, or not at all in some cases.
- (b) This section consists mostly of factual information and most of candidates' responses showed a lack of knowledge and understanding in this topic.
- (c) The majority of the candidates' answers indicated a lack of practical experience in respect to maintenance.
- (d) Most of candidates had difficulty giving a reason or providing an explanation or stating a procedure, when required to do so.

Suggestions for improvement

- (a) Resources on this content are readily available on the internet. It is recommended that teachers make use of videos and other visual resources during the lessons.
- (b) Maintenance procedures cannot be learnt from a book or notes. It has to be observed or performed in practice. Teachers can design practical tasks that involve maintenance procedures. It is advisable that the procedures be listed in point form. It is also important that the correct terminology related to maintenance is taught.
- (c) The integration of theory and practice in the workshop is imperative.

QUESTION 10: JOINING METHODS

Common errors and misconceptions

- (a) The majority of the candidates generally lack mathematical skills that were necessary to answer the questions.
- (b) There was evidence that many candidates did not work systematically through the question. They found it difficult to complete a calculation which had to be applied in a subsequent calculation in order to determine the final answer on the specific question. For example, first calculate *pitch diameter*, then *pitch circumference* and then *helix angle*.
- (c) Candidates lost marks because when the first calculation was incorrect, subsequent calculations would also be incorrect. e.g. 10.2.1 – 10.2.4. (11 marks).

Suggestions for improvement

- (a) Teachers need to make sure that learners know and understand screw thread terminology and advantages.
- (b) Learners should practise calculations more to gain confidence to answer this type of question.
- (c) Learners should work systematically through the calculations according to the following steps:
 - Formula
 - Formula manipulation (if necessary)
 - Substitution (correct values or units)
 - Answer with unit of measure.

QUESTION 11: SYSTEMS AND CONTROL

Common errors and misconceptions

- (a) This question was answered poorly. This was possibly due to the topic being placed towards the end of the year on the ATP and teachers had to cope with the time constraints imposed by Covid-19 protocol, disruptions and load shedding.
- (b) This section was a higher-order section and most candidates struggled with systems and control calculations.
- (c) Q11.1.1 and Q11.1.2 were answered very poorly due to a lack of mathematical skills. Candidates lost marks because when the first calculation was incorrect, subsequent calculations would also be incorrect.
- (d) In Q 11.5.1 and Q11.5.2 many candidates were not able to apply the formulae correctly but also expressed the answer in the incorrect unit of measure.
- (e) In Q11.6 many candidates did not calculate the *product* of the number of gear teeth, they calculated the *sum* of the number of gear teeth, which was not a requirement of the question. This was a common mistake among many candidates.

Suggestions for improvement

- (a) Mathematical skills can only improve with practice. Teachers must create many opportunities to ensure material is always available.
- (b) Learners must work systematically through the calculations according to the following steps:
 - Formula
 - Formula manipulation (if necessary)
 - Substitution (correct values or units)
 - Answer with unit (Pay attention to requirements in the question)
- (c) Practical application of this content will assist the learner in understanding the content. The subject needs to be integrated with Mathematics, Technical Sciences and Technical Mathematics.

6.3 WELDING AND METALWORK

The following report should be read in conjunction with the Welding and Metalwork question paper of the November 2021 examinations.

6.3.1 PERFORMANCE TRENDS (2018–2021)

In 2021, 2 308 candidates sat for the Welding and Metalwork examination. This was the fourth examination of the specialisation subjects. The performance of the candidates in 2021 reflects good achievement, with 90,6% of the cohort passing at 30% (Level 2). This was a marginal increase over the 2020 pass rate of 88,8%.

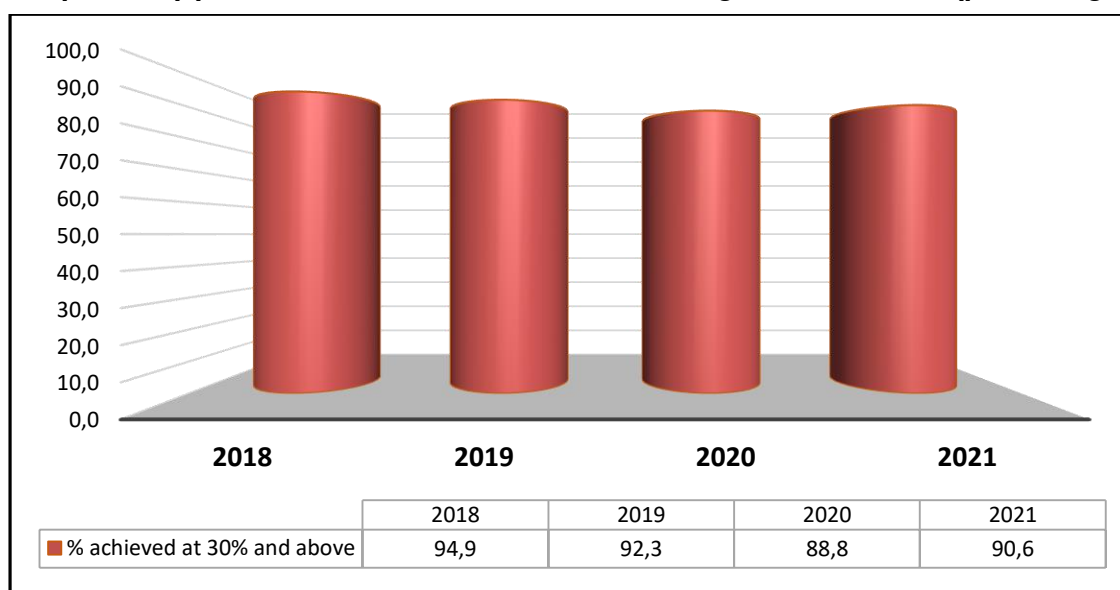
The percentage of distinctions (80%; Level 7) increased marginally to 0,8%. Given the increase in the number of candidates, this converts to an increase in the number of distinctions from 8 to 18. Candidates who achieved over 50% comprised 31,0% of the cohort compared to 25,9% in the previous year.

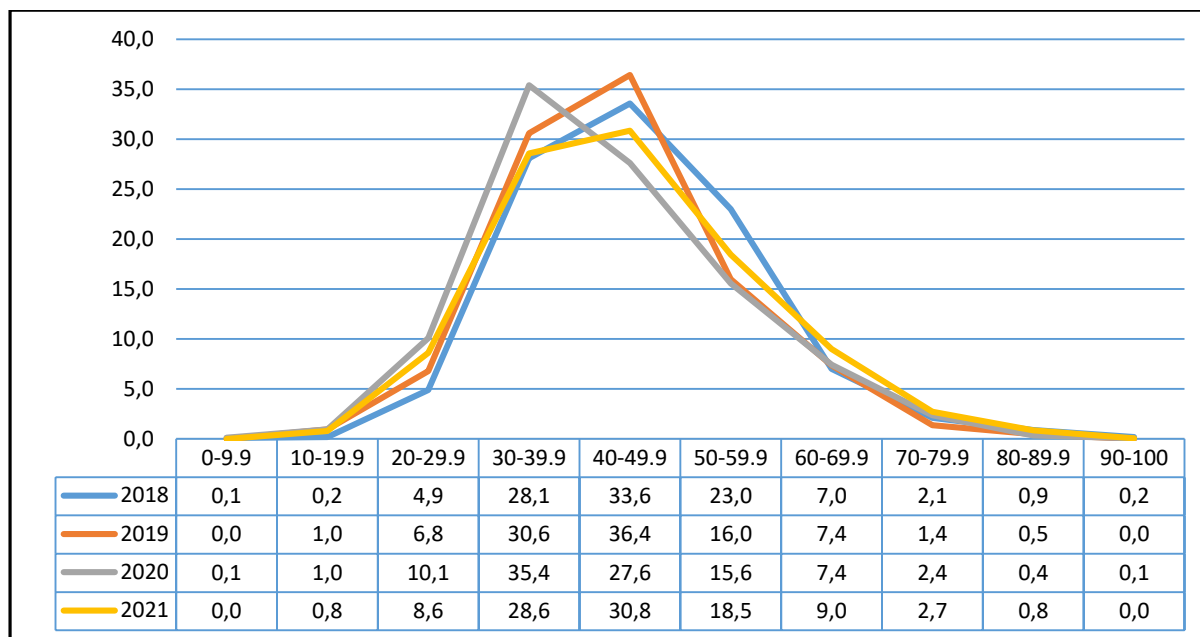
Results may improve in future with stability in the curriculum and with teachers and learners becoming familiar with the assessment style of the subject. There is still room for improvement in the performance of the learners if challenges surrounding problem-solving skills, mathematical skills, conceptual understanding and integration of topics are addressed. In this regard, integrated problem solving must become an integral part of teaching and learning.

Table 6.3.1 Overall achievement rates in Welding and Metalwork

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	1 934	1 835	94,9
2019	1 682	1 552	92,3
2020	1 683	1 495	88,8
2021	2 308	2 091	90,6

Graph 6.3.1(a) Overall achievement rates in Welding and Metalwork (percentage)



Graph 6.3.1(b) Performance distribution curves in Welding and Metalwork (percentage)

6.3.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN THE WELDING AND METALWORK PAPER

General comments

- The majority of the questions pertaining to pure recall of content were very poorly answered. Short informal assessment tasks should be used to reinforce basic concepts and principles. This can be used effectively for content relating to definitions, functions, labelling and operations as listed in the *CAPS* and *Examination Guidelines*.
- Candidates did not manipulate formulae correctly. Teachers must emphasise the following: use of the relevant formulae provided on the formula sheet, correct substitution therein and providing the answer with the correct unit and direction, in terms of what is required by the question.
- The application of mathematical principles is still a challenge for candidates.
- Candidates' handwriting should not be too small and calculations should not be cramped onto one section of a page. Candidates should ensure that their work is legible and neatly presented and they must be able to follow instructions on the cover.
- It appears that candidates do not read questions carefully and consequently do not answer certain sub questions appropriately.
- A lack of knowledge of, or exposure to, the use of various tools and equipment, was revealed by candidates.
- Many candidates and teachers were frequently absent from school due to quarantines or isolation with regard to Covid-19. Non-attendance of school means both candidates and teachers had missed important contact time. Candidates were further impacted by a lack of contact time in Grade 11 due to shortened school weeks the previous year. The knowledge and understanding gained in Grade 11 were fundamental to their proper preparation. Contact time was also negatively impacted due to time-tabling models and limited class sizes.

6.3.3 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN WELDING AND METALWORK

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) The majority of candidates did not know the purpose of the *hardening of steel* in Q1.5.
- (b) In Q1.6, most of the candidates could not identify the correct process that follows hardening.

Suggestions for improvement

- (a) Teachers should provide worksheets to identify the different properties of materials and then practically demonstrate these properties and processes in the workshop.
- (b) Teachers must use practical demonstrations to explain the definitions for the properties of steel.
- (c) Ensure in-depth revision and remediation measures are in place on the topics of safety and materials. In order to prepare learners to respond with reasons to multiple-choice questions, the use of past question papers is encouraged. They must apply their practical knowledge in theory questions.
- (d) Learners should be taught the technique of arriving at the correct answer by the process of elimination in instances where they are unable to identify the correct alternative immediately.
- (e) In Q2.1 some candidates were unable to provide the specific measures to be taken when treating an open wound. They stated prevention and contamination of the open wound.
- (f) Q2.2 specifically asked for safety precautions that must be observed *after* the surface grinder has been switched on, instead candidates provided general safety precautions, which included precautions that must be observed before and during the operation of a machine.
- (g) In Q2.6 majority of the candidates could not identify the type of workshop showed in the figure.

Suggestions for improvement

- (a) When using tools and equipment, demonstrate the importance of using surgical gloves when someone cuts himself or herself. Video presentations and demonstrations would give learners an advantage when answering these types of questions on first aid. Also state who is responsible for the administering of first aid.
- (b) Learners need to read the question with understanding, as some learners tend to write down what comes to mind regarding the topic but not specifically what is required by the question.
- (c) Learners should be exposed to workshop practice relating to the safety of tools, the equipment in the workshop and the workshop environment.
- (d) Teachers should provide worksheets to differentiate between the responsibilities of the employer and the employee with regard to safety in the workshop.

QUESTION 3: MATERIALS

Common errors and misconceptions

- (a) In Q3.2 the candidates' responses indicated a lack of theoretical knowledge, as well as practical application when labelling the drawing about the annealing process.
- (b) In Q3.5 majority of the candidates did not know which quenching media had to be used to harden steel.

Suggestions for improvement

- (a) Learners should be exposed to the different processes to enhance properties of metal.
- (b) The revision programme must include exercises requiring explanation, definition and application of heat-treatment processes. Schools need to organise educational excursions to foundries or other places where materials are processed in order to acquaint learners with metallurgy and to further improve their understanding of the processes involved.

QUESTION 4: MULTIPLE-CHOICE QUESTIONS

Common errors and misconceptions

- (a) In Q4.2 some candidates were not familiar with different types of taps to cut a full thread in a blind hole.
- (b) In Q4.4 some candidates were not familiar with the calculation of angles in a right angle triangle.
- (c) Most candidates did not know the use of the web template in Q4.7.

Suggestions for improvement

- (a) Teachers should show the learners the different types of taps and how to use them.
- (b) Teachers should give learners more practice with applying Pythagoras' theorem and calculating trigonometric ratios.
- (c) Teachers should show learners the different parts of the roof truss and how the different templates are used.

QUESTION 5: TERMINOLOGY

Common errors and misconceptions

- (a) Q5.2.1 to Q5.2.5 required candidates to draw the weld symbols for resistance welds. This was not answered satisfactorily.
- (b) In Q5.3.1 to Q5.3.3 candidates could not identify templates shown in the figures.
- (c) In Q5.5 candidates were unable to name the hand tools used for template making.
- (d) In Q5.6 candidates were unable to name machines used for template making.

Suggestions for improvement

- (a) Learners should be trained to read and interpret questions carefully to ensure that they respond appropriately to the requirements of the question at hand.
- (b) Teachers should familiarise learners with the Codes of Practice for welding which are stated in the South African National Standards.
- (c) More practical exposure will improve the performance in written assessments. Use welding symbols in the PAT drawings. Practical application of theory will help understanding and remembering of the content.
- (d) Learners must be exposed to the different hand tools and machines used in template making.

QUESTION 6: TOOLS AND EQUIPMENT

Common errors and misconceptions

- (a) In Q6.1 many candidates were not able to describe the working principles of resistance welding machines.
- (b) Q6.3 required candidates to describe the process of cutting an external thread on a round shaft using a circular split dies. This was answered poorly.
- (c) In Q6.4 candidates could not state the advantage of using a punch machine over a pedestal drill.

Suggestions for improvement

- (a) Teachers should emphasise the difference between the *working principles* and the *function* and *safety* of machines. Learners should work on the machines to gain a practical experience on they function.
- (b) Teachers should show learners the practical operation of the tools and equipment.
- (c) Teachers should draw up worksheets of advantages and disadvantages of various tools and equipment.

QUESTION 7: FORCES

Common errors and misconceptions

- (a) Most of the candidates were unable to label reactions correctly but provided correct answers in Q7.1.1.
- (b) Most candidates could not manipulate the given formulae to calculate the diameter of the bar, strain and change in length using the load and stress in Q7.2.1 to Q7.2.3.

Suggestions for improvement

- (a) Learners must perform many examples and continuously practise their drawing skills.
- (b) Learners should be exposed to more exercises related to the bending moments and shear force diagrams.

- (c) Learners should practise their mathematical skills. Supporting subjects like Mathematics, Technical Mathematics and Technical Sciences should emphasise relevant sections related to forces.

QUESTION 8: JOINING METHODS – WELD INSPECTION

Common errors and misconceptions

- (a) In Q8.3 the majority of candidates had difficulty to differentiate between the causes of welding defects such as lack of fusion, porosity and incomplete penetration.
- (b) In Q8.4 some candidates had difficulty in describing procedures to set an oxy-acetylene torch flame to a neutral flame.
- (c) Candidates could not state the different types of dye used to conduct a dye penetration test in Q8.7

Suggestions for improvement

- (a) Teachers should expose learners to practical work in order to bring the subject matter closer to the learner.
- (b) Teachers should use previous papers for revision and preparation for examinations.
- (c) Teachers should use videos and other electronic media during the lessons. Field trips should be arranged where welding inspections are conducted.

QUESTION 9: JOINING METHODS – STRESSES AND DISTORTION

Common errors and misconceptions

- (a) In Q9.2 most candidates were unable to state the factors that affect the cooling rate in a welded joint. Instead they stated the methods of cooling.
- (b) Many candidates had difficulty in stating the methods used to reduce distortion in Q9.6.

Suggestions for improvement

- (a) Learners should be exposed to videos during lessons as well as simulations on the factors of cooling rate compared to methods of cooling.
- (b) This section consists of facts and teachers should conduct thorough revision to ensure that learners have become familiar with the content.

QUESTION 10: MAINTENANCE

Common errors and misconceptions

- (a) In Q10.1 the majority of the candidates had difficulty to explain why lock-out is applied to machines during maintenance.
- (b) Candidates were unable to state the effects of overloading on a rolling machine in Q10.5.

Suggestions for improvement

- (a) Learners should be given more informal assessment tasks and they should be exposed to industrial site visits where they could observe maintenance being done on machines.
- (b) At these visits learners will gain first-hand information on why machines are not overloaded.

QUESTION 11: DEVELOPMENT BY CALCULATIONS

Common errors and misconceptions

In Q11.3.1 and Q11.3.2 the majority of the candidates were not familiar with calculating true lengths of a square-to-rectangle on-centre hopper.

Suggestions for improvement

- (a) Subject advisors should provide training workshops to teachers on this topic so that teachers can deliver more effective lessons.
- (b) Different methods to derive an answer should be explored as learners might not understand one method but could understand an alternative method.
- (c) The subject needs to be integrated with Mathematics (trigonometric equations), Technical Sciences and Technical Mathematics as serving subjects

CHAPTER 7

ENGINEERING GRAPHICS AND DESIGN

The following report should be read in conjunction with the Engineering Graphics and Design question papers of the NSC November 2021 examination.

7.1 PERFORMANCE TRENDS

This is the second year that Engineering Graphics and Design has been included in the Diagnostic Report. Statistical information about candidates' performance in questions and subquestions have not been collected. Consequently, no tables or graphs are available to highlight performance in the subject. Therefore, no comment is made about the performance trends.

7.2 OVERVIEW OF CANDIDATES' PERFORMANCE IN PAPER 1 AND PAPER 2

(a) Quality of candidates' performance

It is no surprise that the performance of the candidates in both Paper 1 and Paper 2 of the 2021 NSC examination was lower than in 2020. Consensus among the provinces was that both papers were of a good standard and that the decline in candidate performance can be attributed in a large part to the educational environment that has persisted since 2020.

It must be noted that all questions in both the Engineering Graphics and Design papers are designed to be accessible to every candidate. The good quality of responses from a number of candidates in many centres across all the provinces is evidence that, despite the systemic challenges, teachers at these centres have planned well and prepared their learners adequately to cope with the complexities and the content of the examination. These candidates have illustrated an ability to address the requirements of the questions, to extract and use information appropriately and to manage their time effectively. The inability of the weaker candidates to effectively deal with even the less challenging parts of questions is a clear indication of the deficiencies in the teaching and learning processes. If the lack of understanding of basic concepts and procedures is not properly addressed at an early stage, it will impact negatively on examination performance.

(b) Pertinent factors that cause poor results:

Poor results in many centres have highlighted the fact that challenges in teaching and learning are still prevalent. The following factors continue to be identified as reasons for poor performance:

- **Language barriers linked with poor comprehension skills:** Many candidates find it difficult to understand the requirements of questions adequately. Consequently, they provide incomplete responses or responses that do not address the requirements of the question at all. The format of many questions in both papers have remained the same from year to year with only the requirements or specifications being altered. Learners need to be taught to *read with meaning*.

- **Laziness in reading the questions to identify relevant information:** The standard structure of an Engineering Graphics and Design question remains relatively constant. Candidates are expected to sift through and extract relevant information as and when required. Many weaker candidates find this very challenging. It appears that they simply look at the graphics and then make an assumption on what the expected response to the question should be.
- **Planning an answer:** This goes hand-in-hand with *read with meaning*. When a candidate does not read and understand what is required of a question, they cannot plan the answer. Often candidates rush into answering a question and only later discover that they have not left sufficient space on the drawing sheet to place the required views.
- **The continued use of prepared drawing sheets:** It appears that many teachers are still making use of prepared drawing sheets in school-based tasks. As convenient as it may be for the teacher, the use of prepared drawing sheets removes the necessary practice in the fundamental aspects of the curriculum from the learner and often restricts access to answering a question in an examination. The prepared drawing sheets disadvantages particularly the weaker learner and this is made very clear when a learner cannot, for example, construct a simple polygon.
- **Lack of meaningful revision of relevant Grade 10 and 11 content:** Every examination question is based on content that is derived from concepts covered in previous years. It is therefore essential that the fundamental concepts of every topic are being reinforced continually. Teachers must factor these aspects into their teaching, assessment and intervention programmes by making the learner practise even the most fundamental aspects of the drawing.
- **Lack of formative testing:** Teachers are expected to plan and implement an informal assessment programme to support formal assessment tasks. Short, formative tests must be used to build confidence in all topics. Self-marking or peer marking is an effective tool in providing immediate feedback. Learners will also gain an understanding of the mark allocation and will be able to promptly identify errors or valid alternative responses.
- **Drawing fitness:** Engineering Graphics and Design is essentially a knowledge-based subject. However, an essential and unique requirement of the subject is a high level of skill and practice needed to draw quickly and accurately so that learners are able to complete a paper in the time allocated. This concept is referred to as *drawing fitness*. Drawing fitness is achieved through regular practice at preparing drawings under examination conditions.

General suggestions for improvement

Limited instruction time in each term necessitates that teachers build the following practices into their annual teaching plan (ATP):

- (a) **Essential prior knowledge:** The teaching of every topic should commence by revising the basic concepts and terminology pertaining to it. This should ensure that learners are able to make connections between old and new knowledge.
- (b) **Understanding and planning:** In order for learners to plan the layout of a drawing, they must first read and understand the requirements of the question, in other words, *read with meaning*. Teachers also need to mediate the language barriers as part of the English across the curriculum (EAC) initiative.
 - Due to the specific nature of the subject, learners must be informed of the necessity of reading the instructions carefully and in so doing, understanding what needs to be drawn. Learners should be encouraged to:

- Read each word of the instruction
 - Underline or highlight key words in the instructions
 - Identify where the relevant source information can be found
 - Plan the layout of the requirements of a drawing
 - Identify where it would be most appropriate to start an answer
 - Often poor or incorrect answers result from learners not taking note of the specific requirements and instructions of questions. This is a common problem because skim-reading is a widespread habit currently.
 - Teachers are advised to, at appropriate times during the Grade 10–12 years, demonstrate the skill of interpreting and analysing past examination questions to their classes. This should assist learners in developing these skills.
- (c) **Time management:** Training in time management must be an on-going process. This must be applied even when preparing course drawings, or when sitting for controlled tests and examinations. The mark allocation on examination questions provides a time guide, and learners must practise the skill of adhering to the suggested time allocations.
- (d) **Use of past NSC examination papers:** Past question papers serve as one of many teaching and learning resources and must be incorporated into the planning and teaching process. Recent past examination papers provide a reliable trend on questioning patterns and style. Past examination papers, with their marking guidelines, are easily accessible on the Department of Basic Education (DBE) website. Every learner should have this resource readily available to them.
- (e) **Use of textbooks:** A mandatory requirement for all Engineering Graphics and Design learners is a CAPS compliant textbook. Teachers can select from a number of DBE-approved textbooks.
- (f) **Practice and drawing fitness:** Ongoing and regular practice is essential in developing and maintaining a high level of skill and the ability to draw quickly, accurately and neatly. Preparing a drawing requires the constant manipulation of drawing instruments, which is both tiring and time-consuming. In order to be able to complete an examination paper in the allocated time, learners must be *drawing fit* and this is only achieved through physically drawing and more specifically, drawing to time limits.

7.3 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: CIVIL ANALYTICAL

Candidates generally performed very well when answering the first few questions. These questions were intended to be less challenging. Candidates simply had to read correctly and then find the answer on the drawing.

The middle set of subquestions were less predictable and therefore a little more challenging as these required the recall of knowledge of the *SANS 10143 code of practice for building drawing*.

The last few questions were intended to be, and regarded as the most challenging as they examined application of the *SANS 10143* content and the application of mathematical concepts in a civil context. Although these questions were reasonably predictable, the responses remained disappointing.

All the questions covered a variety of civil concepts, in particular, the site plan and title panel. Weaker candidates continued to be challenged by these topics. However, the more capable candidates were able to show insight and understanding, and they achieved good marks.

Common errors and misconceptions

- (a) The need to pay attention to detail is an important skill in Engineering Graphics and Design. This skill was needed when answering a number of the analytical subquestions. Regrettably, many candidates lacked this skill.
- (b) The high number of candidates who displayed poor reading, comprehension and problem-solving skills is a matter for concern. The answers given by some candidates in Q.1.12 to Q.1.16 had no relevance to the question being asked.
- (c) In calculating the length of the perimeter of the *stand* in Q1.18, candidates had to understand the basic mathematical concept of adding the lengths given in the table on the drawing. There was a 3,6 m driveway that then had to be included in the calculation. Many candidates could not answer this question correctly because they neglected to pay attention to the details in the question.
- (d) Determining the total area of *the proposed new house* in Q1.19 was not an unfamiliar concept. It was disappointing that many candidates still experienced difficulty in dividing the shape of a simple structure into workable portions and applying the basic mathematical formula of *area = length x breadth*.
- (e) All work in this subject must be presented neatly, including printing and freehand line work. Neatness and proportion are two fundamental requirements that candidates are expected to adhere to when they draw in *neat freehand*. Candidates often overlook these criteria when preparing freehand drawings.
- (f) The content of the *SANS 10143 Code of Practice for Building Drawings* is fundamental to the content of Paper 1. It was disappointing that many candidates were unable to recall the graphical symbol for a *bidet* when answering Q1.20.

Suggestions for improvement

- (a) To balance the predictable nature of this question, examiners will always strive to be restrictively creative when designing subquestions. Teachers can assist learners by providing them with a wide variety of questions on civil content, and in particular past NSC examination papers with marking guidelines.
- (b) If learners are taught to *read with meaning*, it will help them understand the requirements of the question. Candidates would then not provide incomplete responses or responses that were not relevant to the question.
- (c) Learners must practise applying the mathematical formulae for determining area and perimeter of shapes. Regularly including these calculations in short formative tests can serve as reinforcement and revision.

The formula for calculating the perimeter in Q1.18 is: PERIMETER = S + S + S+ ...

In this case, the information needed to calculate the perimeter was found in the survey table and on the site plan. Take note of where marks were awarded in the calculation:

ANSWER 18

APPLYING CORRECT FORMULA ✓

$$\text{Perimeter} = AB + BC + CE + EG + FG + FA$$

$$= 38,16 + 60 + 3,6 + 33,8 + 34,56 + 26,2$$

$$= 196,32 \quad \text{CONVERTED TO METRES} \quad \checkmark$$

LAND SURVEYOR'S CERTIFICATE OF THE CORNER HEIGHTS AND BOUNDARY LENGTHS OF SUB-A AND SUB-B OF STAND 32.			
CORNER HEIGHTS IN METRES		BOUNDARY LENGTHS IN METRES	
A	351,5	AB	38,16
B	349,2	BC	60
C	351,5	CD	38,16
D	352,2	DA	60
E	351,5	FD	33,8
F	351,7	EG	33,8
G	350,4	FG	34,56

- (d) The formula for calculating the area in Q1.19 is: $\text{AREA} = L \times B$.

In this case, the information needed to calculate the area was found by dividing the proposed new house into workable areas and then adding the answers to get the overall area. Take note of where marks are awarded in the calculation:

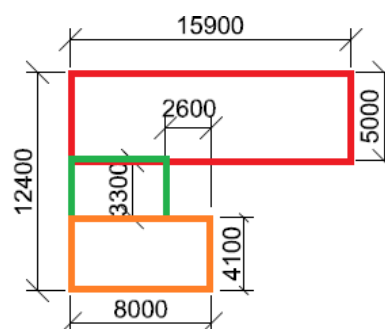
ANSWER 19

APPLYING CORRECT FORMULA ✓

$$\text{Area} = L \times B$$

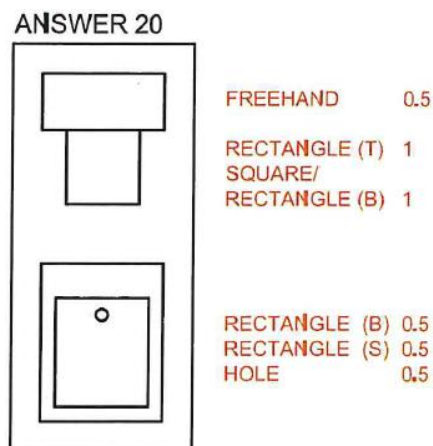
$$= (15,9 \times 5,0) + (3,3 \times 5,4) + (8 \times 4,1)$$

$$= 130,12 \text{ m}^2 \quad \checkmark \quad \checkmark$$



- (e) The quality of a learner's line work is assessed in the PAT. This does not mean that freehand work should be presented poorly in an examination. There are far too many candidates who present unacceptably untidy and meaningless freehand drawings. All work presented in freehand must be graphically and proportionally correct, meaningful and neat. Printing must also be prepared correctly and neatly.
- (f) The teacher must be in possession of the *SANS 10143 Code of Practice for Building Drawings* and regularly refer to the contents. The content can be reinforced by giving learners short formative tests which will also serve as useful revision of work.

Q1.20: Symbols from the SANS 10143 for a bidet. Take note of where marks are awarded to the symbol.



(Graphics courtesy of the Eastern Cape)

- (g) Teachers must make use of past NSC examination papers as they are a useful resource that would benefit every learner.
- (h) Subject advisors or subject coordinators should convene regular content workshops to help teachers who are experiencing challenges with content and to offer support where it is required.

QUESTION 2: INTERPENETRATION AND DEVELOPMENT

The concept of interpenetration starts with the construction of polygons in Grade 10. These are then extended to prisms and pyramids so that the knowledge, techniques, understanding and perceptual ability of the learner is developed. Interpenetration is the final phase in the progression and involves practice, understanding, perception and graphic problem-solving skills. These all take time and effort to develop.

There were centres in all the provinces where a large percentage of candidates performed well above the average. However, there were many centres in each province where the candidates experienced challenges.

It is important to note that the question was designed to allow the weaker candidates to project three views of the less complicated equilateral triangle and then to correctly place a regular hexagon in the designated position relative to the triangle. The stronger candidate should have been able to extrude the *tube*, then determine the curve of interpenetration. The top learners should have been able to draw the development of the triangular tube. It was unfortunate that most of the candidates did not even show the ability of a Grade 10 learner.

Common errors and misconceptions

- (a) Point 3 under *Instructions and Information* on the cover page of the examination paper states that *ALL drawings are in first-angle orthographic projection*.

Orthographic projection is a fundamental Grade 10 concept. Many candidates were unable to differentiate between first-angle and third-angle orthographic projection. It was unclear whether this was a reading problem, a planning problem or a lack of understanding of the concept.

- (b) Constructing polygons is also a Grade 10 topic, yet many of the weaker candidates could not start the drawing because they could not draw a simple equilateral triangle or a regular hexagon. It must be mentioned that by simply copying the drawing

correctly, a candidate could have achieved 34%. Correctly adding the side view takes the total to 43%. However, the majority of candidates could not even complete Grade 10 content.

- (c) The first bullet in the *Instructions* on the question states clearly: *Planning is essential*.

Many of those candidates who managed to construct the equilateral triangle and the regular hexagon were unable to align the axes of the hexagon in the top view with the axis of the triangle in the side view. *The axes of both tubes lie in a common vertical plane.*

- (d) The candidates who managed to copy the required views correctly then found difficulty in visualising the curve of interpenetration. Some candidates were able to complete the visible outside lines in the front view but were then unable to place the hidden detail lines correctly.
- (e) A very poor attempt was made at drawing the development. Those who managed to attempt the development showed very little knowledge as to where measurements were supposed to be taken from to complete the development.

Suggestions for improvement

- (a) It is important that the teacher regularly emphasises the difference between first-angle and third-angle orthographic projection. It is also imperative that the teacher, as early as Grade 10, stresses the importance of first reading the question, understanding what views have to be drawn and where to place them. This is one of the elements of planning.
- (b) One of the many possible reasons why many of the weaker candidates could not construct an equilateral triangle or a regular hexagon is because teachers are using prepared answer sheets. Prepared answer sheets usually have the 'easy' part of the drawing, e.g. the polygon, prepared for the candidate. The use of prepared answer sheets must be discouraged, as it diminishes the learners' ability to attempt an answer by depriving them of regular practice of drawing the basic elements.
- (c) The ability to visualise a three-dimensional object drawn on a two-dimensional surface is challenging for many learners. This skill is developed through ongoing and regular practice in preparing drawings of relevant complexity. Learners who are then still unable to visualise the drawing may use other methods of determining the curve of interpenetration, e.g. by adding numbers or letters to the edges of the tubes. It is recommended that teachers make extensive use of past NSC examination papers.
- (d) It is important that every topic should be introduced by revising previously taught concepts and terminology pertaining to that topic. This should enable learners to make connections between old and new knowledge. If learners get the basics right, the more challenging concepts will be easier to grasp.
- (e) Teachers who are *spotting* which of the topics are most likely to appear in the examination must stop this practice immediately. You may have been successful once or twice before, but more often than not you will get it wrong and this will be to the detriment of your learners.
- (f) Subject advisors must identify the underperforming schools, as informed by the analysis of results, and support teachers by providing relevant material on an on-going basis, rather than engaging in damage control prior to the examinations.

QUESTION 3: PERSPECTIVE DRAWING

Preparing a two-point perspective drawing is a challenging concept that requires candidates to convert the orthographic views of an object into a three-dimensional drawing.

Although many candidates attempted the question, the general tendency was that candidates started the drawing off well, then rapidly regressed, producing poor quality line work that was very inaccurate. The receding portion of the dressing room was poorly attempted with the table and semicircular mirror not being attempted by most of the candidates.

It was generally found that correct perspective drawings were produced by candidates from the same centres and that incorrect perspective drawings tended to be produced by candidates from the same centres.

Common errors and misconceptions

- (a) Candidates were unable to accurately determine the position of the two vanishing points with the result that whatever was drawn from that point on was incorrect.
- (b) There were candidates who moved the position of the given *Horizon Line (HL)*, *Picture Plane (PP)* and *Ground Line (GL)*. Moving these lines could possibly alter both the cognitive and difficulty levels of the question.
- (c) Many candidates were unable to correctly determine a height line and thereby unable to determine the height of the receding lines of objects.
- (d) Most candidates did not even attempt to draw the semicircle in perspective. Many of those who did used an inaccurate method to determine the perspective curve, and the quality of their perspective curves were poor. The candidates who drew the table and mirror often did not complete the lower portion of the table.

Suggestions for improvement

- (a) Vanishing points are projected off the *Station Point (SP)*, parallel to the inclined edges of the top view of the object to the *Picture Plane (PP)*. At the point of intersection, they are then projected perpendicularly downwards to meet the *Horizon Line (HL)*. They must be neatly labelled *VPL* on the left and *VLR* on the right. The teacher must ensure that all learners are able to perform these basics.
- (b) It must be made clear to the learners that the position of the given *Horizon Line (HL)*, *Picture Plane (PP)* and *Ground Line (GL)* must not be moved. Projection lines are B-type or construction lines that must be visible. Learners must be taught to erase or draw them so faintly that the method used to determine the drawing cannot be seen during marking.
- (c) The height of an object can only be determined in the picture plane. This is why it is important for the teacher to reinforce the method of first determining the height of an object in the picture plane, then applying the method of moving the object to the correct position by joining the heights to the correct vanishing point. When this is done correctly, new height lines may then be constructed.
- (d) Projecting a semicircle is a challenging process which requires in-depth knowledge and skills to project correctly and accurately. It is expected that the weaker candidates should demonstrate some basic knowledge by dividing up the views of the semicircle into 30° segments.

- (e) The complexity of a perspective drawing increases as the drawing is built up by the ever-increasing number of lines used to find the points in perspective. Learners need to work systematically through the drawing so that they do not waste time determining the same points multiple times.
- (f) The teaching of the fundamentals of perspective drawing along with methodology and terminology pertaining to that topic is essential. On-going and regular practice is necessary in developing and maintaining a high level of skill and the ability to draw accurate and neat perspective drawings.
- (g) It is imperative that teachers provide learners with a number of relevant course drawings which are at the level of complexity that is expected of the Grade 12 learner and ensures that the learner engages with these drawings meaningfully.
- (h) Teachers need to address bad drawing practices such as inaccuracy, untidy and incorrect line work, and poor printing techniques before they become issues which cannot be fixed. This should start in Grade 10 and continue through to Grade 12.

QUESTION 4: CIVIL AND ELECTRICAL ASSEMBLY

This question was attempted by the majority of candidates and in many instances, answered well.

A civil assembly question involves working with graphic, numeric and verbal information that requires understanding and the application of civil drawing practices contained in the *SANS 10143 Code of Practice for Building Drawings*.

The question is divided into three subsections, a floor plan, a north elevation and a detailed sectional view which is drawn to a larger scale than the other two views. It is designed in such a way that every candidate who applied themselves and practised by preparing previous NSC examination papers should have had access to at least part of each subsection.

Many of the weaker candidates appeared to become overwhelmed with processing the information and possibly found it challenging.

Common errors and misconceptions

(a) FLOOR PLAN

Common errors drawing windows and doors:

- Windows were not drawn using the dimensions shown in the window schedule but simply drawn to fill the gap in the wall on Answer Sheet page 6.
- There was an improvement with drawing doors. However, in some instances, they were not drawn to the correct size. The door swing is an arc scribed with a compass.
- The sliding door was poorly answered with the arrow very seldom included.

Common errors drawing electrical layout:

- When candidates added the electrical fittings to the floor plan, it was often poorly executed. This demonstrated a lack of knowledge of the correct symbols. The symbols were often haphazardly placed and drawn in freehand.

- The irregular curve connecting the light fitting to the light switch was incorrectly joined to the 'flag' and not to the circle.
- Labelling of the fluorescent light was poorly attempted.

Common errors drawing fixtures:

- Candidates still drew fixtures as shown in the fixture table rather than converting them to the required *SANS 10143* symbols. The purpose of the table of fixtures is only to inform the candidate of the measurements.
- The fixtures were not drawn accurately using drawing instruments and many candidates prepared them in freehand.

Common errors drawing the roofline:

Adding the roofline in the floor plan was a new aspect to the drawing and was relatively well executed. The roofline must be indicated by a chain line as clearly indicated on the incomplete floor plan on Answer Sheet page 6.

Common errors adding the hatching:

There was a general improvement in the quality and correct application of hatching from previous years. There were candidates who were still applying mechanical hatching to the walls or not clearly showing sets of double parallel lines at 45°.

Common errors with the labels:

Candidates generally did not label the floor finishes which can be attributed to not reading the instructions as the room designations were given. Labels must always be printed neatly to the correct size and using the correct font.

(b) NORTH ELEVATION

Common projecting errors:

The projection of the walls and the roofline off the floor plan were done well. Some candidates, however, did not project the pillar from the floor plan.

Common errors drawing the roof:

- As accuracy is a fundamental and an essential component of drawing, only a deviation of 1 mm or 1° is permissible on any measurement in the examination. There was a general problem with accuracy in determining the 20° roof angle on the north elevation. Many candidates were then unable to correctly determine the height of the small roof which should have been projected off the floor plan. The ridge cover proved to be an even greater challenge even though the measurements were given.
- Candidates drew the fascia board, gutter and the break lines as shown in the incomplete north elevation. This was not necessary. It is vital that learners have access to past NSC examination papers with the marking guidelines so that this type of elementary mistake is not repeated. The instructions in Q4.2 were also very clear.
- The rainwater down pipe (*RWDP*) was correctly and accurately projected but the candidates omitted the gulley or used incorrect measurements.

Common errors drawing the window, door and veranda:

- The window was correctly projected off the floor plan but then the incorrect measurement for the height was used. It is difficult to assess whether this was a reading, measuring, accuracy or knowledge mistake as any of these could have been the reason for the error.
- The window opening lines as well as the window sill were mostly omitted or poorly attempted.
- The height of the finished floor level (*FFL*) was not always determined correctly. The *FFL* must be indicated by a chain line as clearly shown in the incomplete north elevation.
- The weaker candidates found determining the height of the veranda and then adding the height of the door challenging.

Common errors with the labels:

Labelling of the *FFL* and *North Elevation* were done poorly.

(c) DETAILED SECTION

Fewer candidates than expected attempted the detailed sectional view prepared to scale 1 : 20 than the other two views. Many of those who attempted this drawing applied the scale correctly. Many candidates appeared not to understand the purpose of a break line and continued drawing past it. The candidates who merely copied the given foundation, external wall and veranda detail, as it was given on page 5, revealed a lack of understanding of a section plane.

Common errors with the walls:

The height of the wall, from the bottom of the foundation to the wall plate, was measured incorrectly. Candidates then made mistakes with the measurements of the height and thickness of the lintel.

Common errors with the window and basin:

- Very few candidates attempted to add the basin. Those who did made unnecessary mistakes.
- The window frame was correctly drawn. However, candidates showed little or no knowledge in drawing the window sill.

Common errors drawing the roof:

- Not many candidates completed the roof detail. Those who did presented many of the components incorrectly and inaccurately. Of those candidates who attempted to assemble the 12 elements, assessed on the detailed section, many then did not draw them correctly. The most common errors were that candidates either left off components or drew them to the incorrect scale or angle. This is an indication that they either did not know the roof structure or did not read the question correctly.
- The pitch of the roof was poorly attempted with the tie beam and rafter not drawn in the correct position through the inside corner of the wall plate and at the correct angle. The knowledge of the beam fill was poor.

- Candidates showed little knowledge of the measurements of the RWDP and gutter. The rotated shoe appeared to have confused the candidates. Many of them had no knowledge that the shoe had to be drawn facing in the opposite direction.

Common errors with hatching:

The application of the *SANS 10143* codes for hatching has shown a tremendous improvement over the years, especially the freehand substructure hatching. Having said that, there is still a way to go before hatching is applied satisfactorily across all provinces.

Suggestions for improvement

- (a) The basic format of this question has remained constant and at the same standard for many years. One of the underlying problems is that it is covered very early in the year. This can be overcome by giving learners revision drawings, preferably past examination papers, throughout the year, to prepare them for the end of the year.
- (b) FLOOR PLAN
 - Weaker candidates should be advised to start the drawing by completing the floor plan and correctly including the following: neatly printing the room designations and floor finishes; correctly drawing in the doors and windows to the correct size; adding the electrical layout and filling in the hatching detail. It must be pointed out once again that a window frame must be drawn as a set of parallel lines situated in the middle of the wall. The window sill is then a single line that protrudes outwards beyond the wall.
 - The tables on the question sheet that contain information should be used correctly. The window and door schedule give the sizes of these features. The relevant electrical symbol must be selected from the table and correctly copied across onto the drawing. The candidate must have learnt the *SANS 10143* graphical symbol for the fixtures and apply them using the dimensions given in the table. The positioning of the text on the *incomplete floor plan* indicates the orientation and placement of the fixture. Hatching must be added using drawing instruments and not in freehand.
- (c) NORTH ELEVATION
 - In order to draw an elevation, there are three general areas that the teacher needs to concentrate on. There are projection techniques, drawing the roof and accuracy. Projecting requires selecting the necessary information off the floor plan and projecting it to the elevation.
 - The construction of a roof is a Grade 12 topic and can be challenging. Once the detail and the method have been taught to the learner, the learner should practise assembling and drawing all the components of the roof.
 - As a deviation of only 1 millimetre or 1 degree is allowed in any measurement in the examination, it is imperative that accuracy be emphasised.
- (d) DETAILED SECTION
 - The detail of a roof is Grade 12 content. Learners must be taught and assessed on the order in which the components of the roof are assembled.
 - The same applies to hatching patterns used to differentiate the various elements in the sectional elevation.

- (e) Teachers should have an ample supply of resources to prepare for this topic. The minimum requirements must be a copy of the *SANS 10143 Code of Practice for Building Drawings*, DBE-approved textbooks and past NSC examination papers.
- (f) Course drawings must be set at an appropriate level so that learners can engage meaningfully with work at the required level.
- (g) All drawings must be prepared using drawing instruments and learners are expected to be skilled to use them correctly. It must be noted that any work presented in freehand, unless specified in the question, is not marked, even if correct.
- (h) Learners should not be expected to sit for an examination without being taught time management. This concept can only be realised by setting course drawings that must be completed within specified time constraints.
- (i) Subject advisors must address the issue of language across the curriculum by providing opportunities for teacher development on an on-going basis.

7.4 ANALYSIS OF CANDIDATES' PERFORMANCE IN EACH QUESTIONS IN PAPER 2

QUESTION 1: MECHANICAL ANALYTICAL

The marks obtained by candidates across the country in this question showed a decline in 2021. It is a cause for concern as candidates generally perform very well when answering the analytical question.

The first few subquestions in the analytical question are intended to be less challenging as the candidates must simply find the answer on the drawing. These were generally well answered.

The middle set of subquestions are less predictable and therefore more challenging as these required knowledge of the *SANS 10111 Code of Practice for Engineering Drawings* and the recall of knowledge.

The last few questions are intended to be, and regarded as, the most challenging, as they examine content and the application of mechanical concepts. All these questions cover a variety of mechanical concepts that include the machining symbol, determining a tolerance range and the welding symbol. Some of the questions that were attempted were well answered by the more capable candidates, but weaker candidates continued to be challenged.

Common errors and misconceptions

- (a) A matter of concern is the high number of the candidates who displayed poor reading and comprehension skills. This was evident in Q1.6 where candidates provided answers that had no relevance to the question being asked.
- (b) A thorough understanding of the third-angle orthographic projection is essential in Paper 2. Both Q1.5 (identifying the view) and Q1.14 (completing cutting plane K-K) on the given drawing were poorly answered by many candidates,
- (c) Calculating dimensions is a standard question and has been asked for many years. Candidates struggled to properly calculate or determine the *complete dimensions* in Q1.10. A complete dimension requires, when a dimension has a prefix (diameter, radius), or a suffix (degrees), that they are added to the dimension.

- (d) Q1.15 and Q1.16 required candidates to display knowledge of a machining symbol. Both these questions were poorly answered by most candidates. Q1.19 required specific knowledge of a welding symbol. It is concerning that few candidates could match a label with the given letter.
- (e) Calculating a tolerance is a basic mathematical process that has been asked before. However, in Q1.18 candidates did not read and fully understand the question before attempting to answer it.
- (f) The content of the *SANS 10111 Code of Practice for Engineering Drawings* is fundamental to the content of Paper 2. The answer to Q1.20 required candidates to recall the convention for an *interrupted section*. The few candidates who attempted this question, presented the free-hand answer incorrectly and unacceptably poorly.

Suggestions for improvement

- (a) To balance the predictable nature of this question, examiners will always strive to be restrictively creative when designing subquestions. Teachers can assist learners by providing them with a wide variety of questions on mechanical content, and in particular past NSC examination papers with marking guidelines.
- (b) Paying attention to detail is an important skill required in Engineering Graphics and Design. It is a skill that can and should be developed over time. This skill was required particularly when answering a number of the analytical subquestions.
- (c) Teachers must address the issue of language across the curriculum by teaching learners to *read with meaning* which will help them to understand and apply terminology correctly. Teachers must make use of past NSC examination papers as this is a wonderful resource that would benefit every learner by teaching them the terminology used in a drawing and the way in which questions are phrased.
- (d) Teachers must devote more attention to the content of the *SANS 10111 Code of Practice for Engineering Drawings* by setting more regular formative assessments.
- (e) Neatness and proportion are two fundamental requirements that are expected to be adhered to when learners are expected to draw in neat freehand. The graphic should also be correct in order for marks to be allocated. Teachers need to address bad drawing practices such as inaccuracy, untidy and incorrect line work and poor printing techniques in Grade 10 and continue through to Grade 12. One way to remediate this is to penalise learners for these poor practices in school-based assessment tasks.
- (f) Subject advisors or subject coordinators should convene regular content workshops to help the teachers who are experiencing challenges with content and offer support where it is required.

QUESTION 2: LOCI

The concept of a cam is introduced in Grade 11. It consists of two interrelated parts, namely the displacement graph and the cam profile. Both parts contain a number of variations that require knowledge, application and skill when combined into a meaningful answer.

Many candidates attempted this question and some achieved relatively good results. In all the provinces, candidates who performed well generally came from the same centres and many of those who experienced challenges also came from the same centres.

Common errors and misconceptions

- (a) Drawing the base line of the displacement graph equal in length to twelve 8 mm segments, in other words 96 mm long, and drawing the dwell and uniform motion sections of the graph are fundamental concepts that the weakest candidates should have been able to perform. However, many candidates were unable to complete these basics correctly.
- (b) Although capable candidates were able to score good marks in this question, many of them did not read the question with understanding. This was made obvious when they did not follow simple instructions.
- (c) The position of the follower was given at its maximum displacement which was clearly indicated as such both verbally and graphically. Many candidates drew an inverted displacement graph, again suggesting that they did not read the question correctly.
- (d) Producing the more complex simple harmonic motion and the uniform acceleration and retardation motion on the displacement graph were designed and intended to be answered by the stronger candidate. Both these motions require more advanced construction methods which many of the stronger candidates omitted to include on their answers. Many candidates got the two motions confused. They did not divide the 90° rotation of the simple harmonic motion into 15° segments on either the displacement graph or the cam profile. The majority of candidates did not end their displacement graph with uniform acceleration and retardation.
- (e) Most of the candidates who attempted to draw the cam profile did so with some success. However, the basic knowledge of inserting centre lines was either left off the drawing or poorly executed. Some candidates changed the required roller-follower to a wedge-shaped follower and showed little knowledge about anticlockwise rotation.
- (f) In many instances the line work was exceptionally poor. Candidates displayed no differentiation in the application of the different line types including poor quality curves.

Suggestions for improvement

- (a) The teaching of every topic should commence by revising previously taught concepts and terminology pertaining to that topic to ensure that learners are able to make connections between old and new knowledge. Teachers should spend time introducing new concepts. If the learner is able to get the basics right, the more challenging concepts should be easier to grasp.
- (b) Ongoing and regular practice of the basics concepts is essential in developing and maintaining a high level of skill and ability.
- (c) Construction must always be shown on the drawing when it is required to determine an answer as marks are allocated for it. Simple harmonic motion and uniform acceleration and retardation require more advanced construction methods and must therefore always be included on the drawing.
- (d) The use of prepared answer sheets must be discouraged.
- (e) Teachers who are *spotting* which of the topics are most likely to appear in the examination must stop this practice immediately. When they get it wrong, it disadvantages the candidate.

- (f) Subject advisors or subject coordinators need to investigate the cause for the differentiation in performance between the various centres. These issues need to be addressed as a matter of urgency.
- (g) Subject advisors or subject coordinators should convene regular content workshops to help the teachers who are experiencing challenges with content and offer support where it is required.

QUESTION 3: ISOMETRIC DRAWING

The ability to convert a two-dimensional orthographic drawing into a three-dimensional isometric drawing remains one of the more challenging topics in Engineering Graphics and Design because it requires visual perceptual ability.

Isometric drawing is introduced in Grade 10 and it is therefore a cause for concern that so many candidates are still not able to get the basics right. Having said that, it is important to note that there were many candidates who obtained 80% and above, with a few candidates obtaining 100% for this question.

The ability to convert a Grade 12 third-angle orthographic drawing into an isometric drawing takes a considerable amount of practice. From the number of candidates who find this question challenging, it is evident that many of the centres in all provinces are not giving learners enough practice tasks and course drawings at an appropriate level.

It must be noted here that there are different methods of preparing an isometric drawing, all of which are acceptable.

Common errors and misconceptions

(a) ORIENTATION

- Candidates were unable to place the isometric drawing in correct orientation. Some candidates were unable to place the *lowest point* of the isometric drawing on the designated point A. This suggests that these candidates failed to read the question.
- Many candidates drew an isometric box, then copied the three orthographic views onto the three surfaces of the box. These candidates showed no knowledge of depth perception and very little knowledge of isometric drawing.

(b) AUXILIARY VIEW

- Many candidates did not show the required auxiliary view for the half-regular hexagon on the drawing sheet but in many instances still ended up with a correctly drawn hexagon suggesting that it must have been drawn somewhere.
- Some candidates could not transfer the dimensions from the auxiliary view to the isometric drawing correctly.

(c) CIRCLE

- Many candidates did not show the required circle construction clearly.
- Some candidates drew the arcs of the isometric circle in freehand.
- Most candidates, even some of those who answered the question correctly, did not include the centre lines in the arc.

(d) LINE WORK

- Many candidates demonstrated poor drawing skills as they drew inaccurately. In many instances, the line work was untidy and of a poor quality.
- Some candidates completed the isometric drawing in construction lines only and not by using the mandatory A-type lines.

Suggestions for improvement

- Isometric drawings require practice. The practice is not only in preparing isometric drawings, applying the concept of the auxiliary view and constructing isometric circles but also about acquiring the skill of converting a drawing from third-angle orthographic into an isometric drawing. The latter takes many learners a long time to acquire.
- The auxiliary view, a concept introduced in Grade 10, must be used in cases where it is necessary to draw non-isometric lines where angles and not the lengths of the lines have been given. When an auxiliary view is required to answer the question, the auxiliary view must be visible on the drawing sheet.
- Constructing an isometric circle or semicircle is a Grade 11 concept. The method that must be used is the one that requires the candidate to use a compass to draw the ellipse. Freehand curves are unacceptable and are not marked. Learners must remember to draw centre lines in circular objects.
- It is imperative that the teacher provides learners with a suitable number of relevant course drawings from Grade 10 through to Grade 12 and at the expected level of complexity. It is important that Grade 12 learners engage with the work meaningfully in order to fully prepare themselves for the examination. Teachers can assist learners by providing them with a wide variety of examples to expose them to as many different isometric questioning as is possible, and in particular past NSC examination papers with marking guidelines.
- Accuracy is a fundamental and essential skill in drawing. This is especially so in isometric drawing in order to get the different features on the drawing to align. Drawing equipment, if used regularly, needs to be replaced when the numbers and divisions become faded to the extent that they can no longer be seen.

QUESTION 4: MECHANICAL ASSEMBLY

A mechanical assembly question involves working with graphic and numeric information that has to be understood, and applying drawing practices contained in the *SANS 10111 Code of Practice for Engineering Drawings*. Many of the weaker candidates become overwhelmed with processing all this information and often find it challenging. To this end an exploded isometric drawing, showing the position of each part relative to all the others, is included on the instruction sheet as an aid to help candidates visualise the shape and sequencing of the assembly.

The question was divided into two subsections, a half-sectional front view and a right view. If the candidate did not read the question or understand the concept of the placement of views in third-angle orthographic projection, they may have had a problem fitting both views onto the drawing sheet.

Most of the candidates attempted this question with a wide variety of results. Many showed a lack of time management, reading and comprehension ability and appropriate practice.

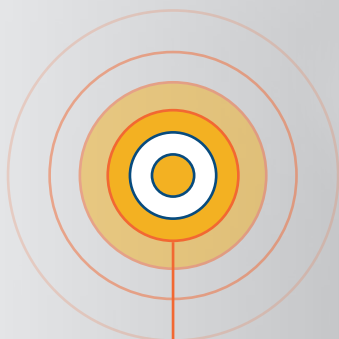
Common errors and misconceptions

- (a) Many candidates did not attempt to draw the right view; the reason for this is unclear. This could have been due to: poor time management, a lack of understanding third-angle orthographic projection, not reading the question with understanding, running out of space or lack of practice.
- (b) Poor planning was the main contributing factor when the two views were not aligned or correctly placed.
- (c) Candidates also showed little to no understanding of the half-section. This was demonstrated by the candidates hatching the entire front view.
- (d) The presentation of the candidates' line work was well below the expected standards of competency and skill. Many candidates were also inaccurate with measurements which compounded their challenges.
- (e) The information given for the construction of the M18 hexagonal nut required a candidate to understand that the *AF* (across the flats) distance which is determined by applying the formula $1,5 \times M$. Construction of the nut in the assembly was poorly executed.
- (f) There were some unnecessary but general mistakes made by many candidates. These include omitting centre lines which should have been copied across from the parts sheet.
- (g) The exploded isometric drawing, showing the position of each part of the assembly relative to all the others, should be used both as an aid to help the candidate visualise the general shape of the parts, but more so the sequencing of the parts in the assembly. The assembly was generally poorly attempted with some candidates having challenges assembling the parts of the crane hook assembly. Some candidates still drew the individual parts unassembled.

Suggestions for improvement

- (a) Teachers must have an ample supply of resources to prepare for this topic. The minimum requirements would be a copy of the *SANS 10111 Code of Practice for Engineering Drawings*, a DBE-approved textbook and past NSC examination papers.
- (b) The rules of hatching used to differentiate the various parts in a sectional elevation are contained in the *SANS 10111* and all DBE-approved textbook. The rules of hatching, along with the various types of sectioning, must be addressed.
- (c) Accuracy has to be mentioned again as it is a fundamental aspect in preparing drawings. A tolerance of only 1 mm is allowed when marking a drawing. Learners must be regularly informed of the necessity to work accurately.
- (d) Course drawings must be set at an appropriate level so that learners can engage meaningfully with work and at the required level.
- (e) One of the underlying problems with mechanical assemblies is that it is covered very early in the year. It is therefore necessary that learners be given regular revision drawings throughout the year to prepare them for the end-of-year examinations.

- (f) All drawings must be prepared using drawing instruments and learners are expected to be skilled in using them correctly. It must be noted that any work presented in freehand, unless specified in the question, is not marked, even if correct.
- (g) Learners should not be expected to sit for an examination without being taught time management. This concept can only be realised by setting course drawings that must be completed within specified time constraints.



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