Chapter 3

TECHNICAL SCIENCES

The following report should be read in conjunction with the Technical Sciences question papers of the NSC November 2019 examinations.

3.1 PERFORMANCE TRENDS (2018–2019)

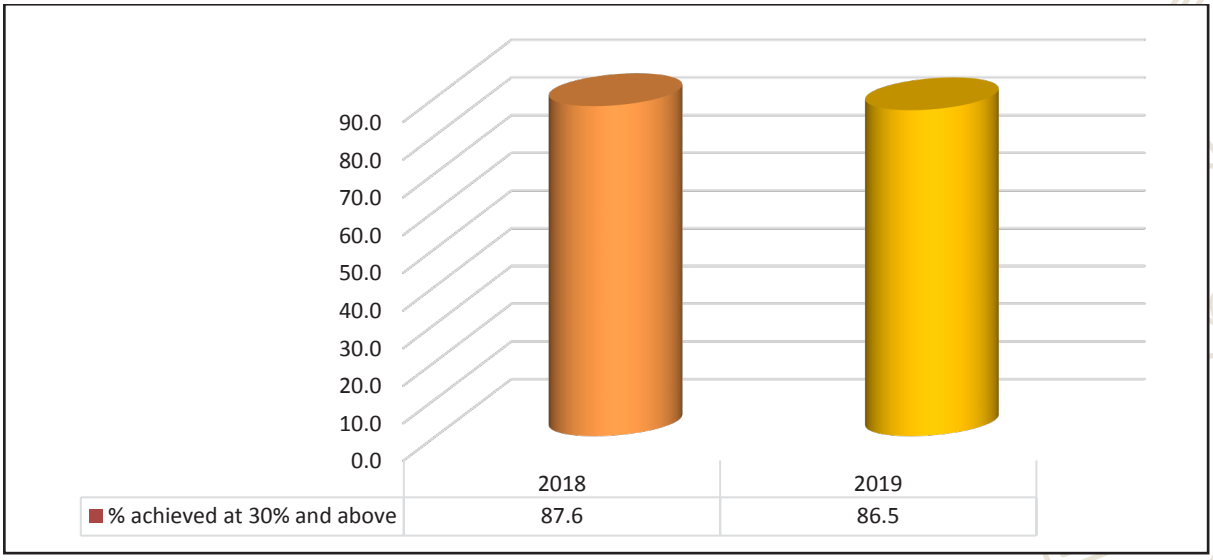
In 2019, 10 862 candidates sat for the Technical Sciences examination. The performance of the candidates in 2019 at the 30% level was 86,5% and at the 40% level it was 48,9%. This shows a slight decline when compared to the 2018 performance.

Table 3.1.1(a) Overall Achievement Rates in Technical Sciences

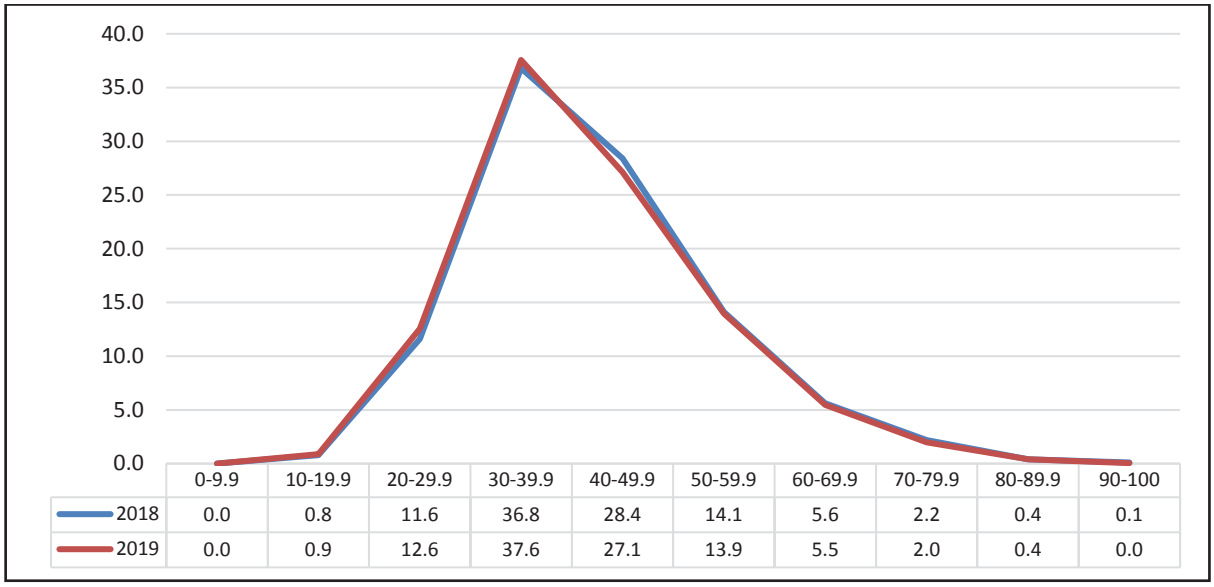
Year	No. Wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2018	10 503	9 204	87,6	5 335	50,8
2019	10 862	9 401	86,5	5 312	48,9

The performance of candidates in Technical Sciences in 2019 was good and can be attributed, in part, to the inclusion of the PAT. There is much room for improvement in the performance of the candidates as the challenges surrounding practical work, problem-solving skills, mathematical skills, conceptual understanding and integration of topics are being addressed.

Graph 3.1.1(a) Overall Achievement Rates in Technical Sciences (Percentage)



Graph 3.1.1(b) Performance Distribution Curves in Technical Sciences (Percentage)



	0-9.9	10-19.9	20-29.9	30-39.9	40-49.9	50-59.9	60-69.9	70-79.9	80-89.9	90-100
2018	0.0	0.8	11.6	36.8	28.4	14.1	5.6	2.2	0.4	0.1
2019	0.0	0.9	12.6	37.6	27.1	13.9	5.5	2.0	0.4	0.0

3.2 OVERVIEW OF LEARNER PERFORMANCE IN PAPER 1

General Comments

(a) The multiple-choice items in Q1 and the questions on Newton's First Law of Motion (Q2), Momentum (Q4), Elasticity, Hydraulics and Viscosity (Q7) as well Transformers and Generators (Q10) were generally well answered.

(b) In general Q3, Q5, Q8 and Q9 were poorly answered. Q3 examined Newton's Second and Third Laws; Q5 focused on Momentum and Impulse; Q6 dealt with Work, Energy and Power; Q8 examined Electronics and Electric Circuits and Q9 was on Electromagnetic Induction.

(c) In Q7 which covered Elasticity, Hydraulics and Viscosity, was fairly answered.

(d) Candidates performed poorly on questions pertaining to pure recall of content. Teachers are advised to use informal assessment tasks to reinforce basic concepts and principles by using, for example, short speed tests (±10 minutes). This can be used for content relating to definitions and laws listed in the *CAPS* and the examination guidelines.

(e) Compared to 2018 candidates have generally improved in drawing and labelling free-body diagrams. However, some candidates are still struggling in this regard. The drawing of free-body diagrams is central to solving problems involving forces acting on objects and teachers should therefore ensure that learners are able to draw force- and free-body diagrams and assess them in formal and informal activities. Emphasis must be placed on magnitude, direction and the labelling of forces.

(f) The application of mathematical principles is a challenge for many learners, such as understanding and using formulae and scientific notation as well as interpreting and representing direction in terms of a positive and negative sign. Learners should be given a variety of problem-solving activities that involve mathematical skills pertaining to fractions, manipulating the subject of the formula and graphs in formal and informal activities. The correct calculator skills and writing down the answer with the correct units and direction, where applicable, must also be emphasised.

(g) Learners must be able to interpret and answer questions based on a variety of action verbs. Refer to the *Examination Guidelines* (Blooms' taxonomy).

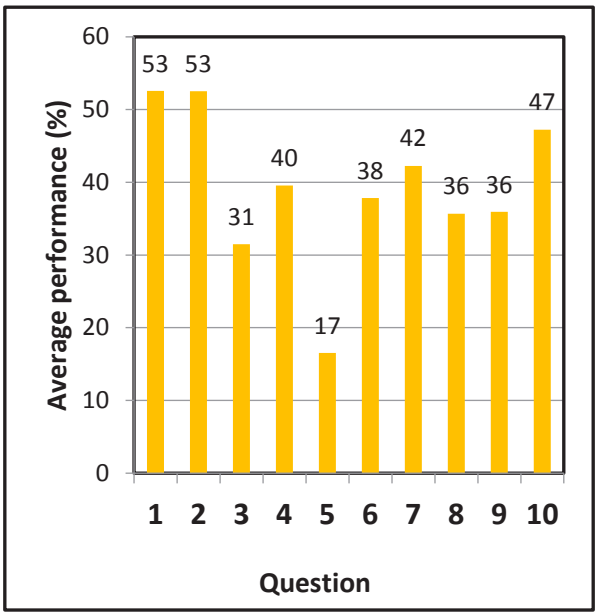
(h) Correct definitions and laws should be enforced during daily teaching and learning. Teachers should include at least multiple-choice items, definitions and laws as well as structured questions on the various topics in formal and informal activities on a regular basis. This is to enhance a deeper understanding of science concepts and content knowledge as well as to take remedial action.

(i) Enhance teaching and learning by means of teaching aids, such as models, pictures, drawings, diagrams, videos, simulations as well as experiments and demonstrations. Learners must also be able to analyse information and answer questions based on diagrams and graphs.

(j) Learners must be given enough activities to practise correct conversion of units. Rounding off must be done as instructed.

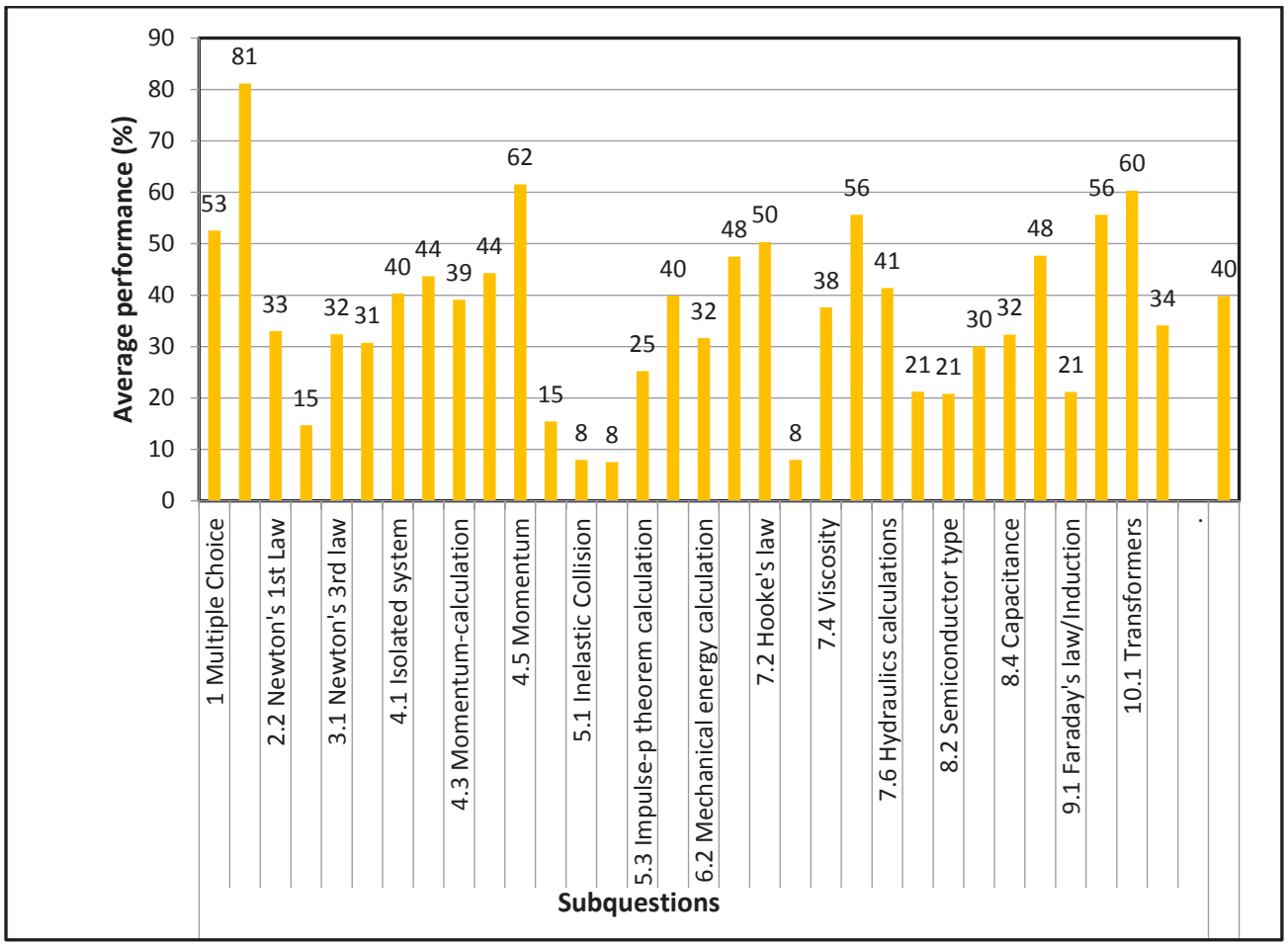
(k) Learners must be exposed to the correct use and understanding of subscripts, e.g. F_{net}, W_{net}, f_k.

Graph 3.2.1 Average Marks per Question Expressed as a Percentage for Paper 1



Q. No	Topics/Aspects
1	Multiple Choice
2	Newton's First Law
3	Newton's 2nd & 3rd Law
4	Conservation of Momentum
5	Momentum and Impulse
6	Work, Power and Energy
7	Elasticity, Hydraulics & Viscosity
8	Electronics & Electric Circuits
9	Electromagnetic Induction
10	Generators & Transformers

Graph 3.2.2 Average Marks per Subquestion Expressed as a Percentage for Paper 1



3.3 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 1

QUESTION 1: MULTIPLE CHOICE

Common Errors and Misconceptions

(a) In Q1.2 most candidates could not analyse and derive an equation that best represents the forces that are acting on the object. Application of Newton's Second Law when the force is exerted at an angle, was not well understood.

(b) In Q1.3 most candidates did not recognise the fact that the net force is equal to the rate of change in momentum.

(c) In Q1.4 candidates failed to apply the sign conversion in terms of the direction in an equation **Δp** = $mv_f - mv_i$.

(d) In Q1.8 the candidates who struggled with superscripts and understanding the notation normally used for symbols such as $C \cdot V^{-1}$ (instead of $\frac{C}{V}$ or C/V), did not perform well in this question. Many candidates chose option A or B. They did not realise that they could use the data sheet to answer this type of question.

Suggestions for Improvement

(a) Teachers must train learners to work out answers in multiple-choice questions rather than relying on guess work.

(b) Learners must be exposed to higher-order questions where they analyse complex problems and create solutions.

(c) Teachers must use various formulae to teach the relationship between different variables. Learners must be trained on how to interpret various equations and explain the relationship between variables.

(d) Sign conversions in terms of the direction when substituting in a formula and writing the final answer must be fully explained to learners.

(e) Learners must be taught to use formulae to determine equivalence units of various quantities. They should also be encouraged to refer to the formula sheet for summaries of laws and basic principles.

QUESTION 2: NEWTON'S LAWS OF MOTION (First Law)

Common Errors and Misconceptions

(a) In Q2.1.1 some candidates labelled f_s as f_k, despite the fact that the toolbox was not moving. Others drew more than four forces (the mark allocation required only 4). A few candidates drew unlabelled diagrams, lines without arrows or dotted lines. Incorrect labels like w instead of W or g instead of F_g were used.

(b) In Q2.1.2 candidates did not state Newton's First Law of Motion as they could not relate the given situation to the law. Those who could identify that Newton's First Law was involved, gave the name of the law instead of stating it. Some of those who stated the law omitted keywords like uniform velocity and resultant force.

(c) Most candidates could not use the law to explain a situation as required by the question; instead they simply stated the law.

Suggestions for Improvement

(a) Teachers must explain and emphasise the difference between f_k and f_s. They must insist that learners use labelled arrows, not just lines or broken lines and the number of forces must correlate with the mark allocation.

(b) Train learners to state the laws without omitting keywords.

(c) Learners should be exposed to the application of principles of physics by providing an explanation using daily real-life situations.

QUESTION 3: NEWTON'S LAWS (Second and Third laws)

Common Errors and Misconceptions

(a) In Q3.1.1 most candidates wrote *force* ***A*** instead of *object* **A** and some omitted keywords like *equal magnitude* and *opposite direction*.

(b) In Q3.1.2 candidates committed the following errors:

- Writing F = mg instead of F = ma or omitting the subscript *net*.
- Substituting a as 9.8 $m.s^{-2}$.
- Failing to choose direction.
- Calculating $F_{B\ ON\ A}$ only.
- Failing to realise that $F_{B\ ON\ A} = F_{B\ ON\ A}$ but in an opposite direction.
- Assuming that the two crates had the same μ_k while it was not stated. They also failed to recognise that F of object **A** on object **B** would be equal but in opposite direction to force of object **B** on **A**.

(c) In Q3.2.1 most candidates omitted the phrase *net force*.

(d) In Q3.2.2 the majority of candidates wrote the formula as F = mg and F = ma omitting the subscript *net*. Some candidates could not correctly identify all forces acting in each of the trolleys.

(e) In Q3.2.3 and Q3.2.4 candidates struggled to explain why the frictional force would decrease when the force that was acting horizontally was changed to act at an angle. They failed to reason out the relationship between the normal force and the frictional force when there is the introduction of a vertical force.

Suggestions for Improvement

(a) Teachers must teach learners to state the laws without omitting keywords. Laws and principles should be thoroughly drilled.

(b) Learners must be exposed to various questions that require calculation and application of the laws. It must be explained that action-reaction pairs work simultaneously in two objects and that they have equal magnitudes but act in opposite directions.

(c) Teachers must use the formula of $f_k = \mu_k N$ to explain the relationship between normal force and frictional force. Learners must be taught to explain their answers to questions as this will augment scientific reasoning.

QUESTION 4: CONSERVATION OF MOMENTUM

Common Errors and Misconceptions

(a) In Q4.1 most of the candidates omitted the words, *net* or *external* when defining an isolated system.

(b) In Q4.2 the majority of candidates calculated change in momentum instead of momentum. Some lost 1 mark as they omitted the direction in the final answer.

(c) In Q4.3 some candidates incorrectly used formula $\Delta p = mv_f - mvi$ or $F_{net} . \Delta t = \Delta p$ instead of $\sum p_i = \sum p_f$

(d) In Q4.4 keywords like *conservation*, *linear*, *isolated system* and *total* were omitted from the law by many candidates. Others just stated the law without naming it.

(e) In Q4.5 and Q4.6 candidates failed to apply the relationship between *momentum* and *speed* to answer these questions. Others provided options that were not in the question paper.

Suggestions for Improvement

(a) Teachers must train learners on how to state the law in full without omitting keywords. Learners must also be taught to distinguish between *naming* and *stating*.

(b) Learners must be trained on calculations; emphasis should be placed on choosing the correct formula, substitution, correct answers with correct units and direction in case of vectors.

(c) Teachers should ensure that learners are fully familiar with the data sheet and how to identify the relevant equation applicable to a specific calculation. They should make use of the data sheet during daily homework exercises.

(d) The relationship between the *momentum* and the *speed* of an object must be explained fully.

QUESTION 5: MOMENTUM AND IMPULSE

Common Errors and Misconceptions

(a) In Q5.1 most candidates could not define the term *inelastic collision*. Some omitted the keywords like *total* or just explained the concept in terms of conservation of total linear momentum or conservation of total kinetic energy only.

(b) In Q5.2 the majority of candidates omitted the word *rate.* Some defined *net force* in terms of momentum as the product of mass and acceleration instead of defining it as the rate of change in momentum.

(c) In Q5.3 many candidates failed to choose the correct formula from the data sheet; others did not write the direction in the final answer thus losing 1 mark.

Suggestions for Improvement

(a) Teachers must train learners on how to state laws, principles and definitions without omitting keywords.

(b) They should give learners many practice exercises on calculations involving momentum and impulse.

QUESTION 6: WORK, ENERGY AND POWER

Common Errors and Misconceptions

(a) In Q6.1 several candidates struggled to define *mechanical energy*. Some omitted keywords like *sum* and *gravitation*.

(b) In Q6.1.2 some candidates missed the fact that the velocity at 17 m above the ground was 3 $m.s^{-1}$.

(c) In Q6.1.3 most candidates had difficulty in establishing that after falling for 11 m, the height of an object was 6 m, i.e. 17 – 11 = 6 m.

(d) In Q6.1.4 the majority of candidates used the symbol Σ in front of E_M or M_E and forfeited all marks even though substitutions and answers were correct.

(e) In Q6.2.1 a large number of candidates did not use the formula $P_{ave} = Fv_{ave}$, despite the fact that the formula was on the formula sheet.

(f) Most candidates could not calculate the power from the given information; it might be that they have not been exposed to these kinds of problems. They also failed to convert watt to horsepower. Some of them omitted the units from their answers.

Suggestions for Improvement

(a) Teachers must ensure that learners do not omit keywords in definitions as prescribed in the *CAPS* and *Examination Guidelines*.

(b) Learners must be taught to analyse the given information carefully and extract the required information. They must also be taught the skills required to answer a variety of questions.

(c) Conversions of units to and from SI units must be revised and the writing of units in the final answer must be emphasised.

QUESTION 7: ELASTICITY, HYDRAULICS AND VISCOSITY

Common Errors and Misconceptions

(a) When defining *elasticity* (Q7.1.1) most candidates omitted keywords like *ability, property*, *original* and *deforming force is removed*.

(b) In Q7.1.2 and Q7.1.3 most candidates failed to convert the given prefixes of units into numerical values.

(c) In Q7.1.3 some candidates wrote the units in the final answer, which was not required.

(d) In Q7.3 candidates failed to list the *perfectly elastic bodies*. They only wrote the *elastic* bodies.

(e) In Q7.6.1 and Q7.6.2 some candidates failed to convert the given information into values corresponding with the correct SI units. Some failed to calculate the area while others omitted the units in the final answer.

Suggestions for Improvement

(a) Teachers must insist that learners write the definitions and state the laws as they are given in the *CAPS*.

(b) Learners must be exposed to a wide range of examples of perfectly elastic bodies. A clear distinction must be drawn between *elastic*, *perfectly elastic*, *plastic* and *perfectly plastic bodies*.

(c) Conversions of units must be revised rigorously. Teachers must also emphasise the numerical values of the prefixes of units like *kilo-*, *milli-* and *mega-*.

(d) Learners must also be exposed to multi-step calculations.

QUESTION 8: ELECTRONIC PROPERTIES OF MATTER AND ELECTRIC CIRCUITS

Common Errors and Misconceptions

(a) In Q8.1 some candidates omitted the word *material* or *conductivity* in the definition of semiconductor.

(b) When answering Q8.2 many responses included p-type, n-type, p-n semiconductors, isolator and impurities instead of intrinsic semiconductor.

(c) The candidates' responses showed that they do not understand the difference between a *p-type* and an *n-type semiconductor* in Q8.3.2.

(d) Candidates were unable to convert cm^2 to m^2 and mm to m. Hence, incorrect answers were written in Q8.4.1. Most candidates used the formula C = Q/V to calculate capacitance. Incorrect units and unconventional abbreviations like amp/Amps were used.

(e) In Q8.4.2 and Q8.4.3 candidates could not explain the relationship between *capacitance* and *distance*.

(f) Candidates incorrectly manipulated Ohm's law when calculating current. They wrote an incorrect SI unit for current and incorrect units.

(g) In Q8.5.2 candidates could not explain the relationship between *current* and *heat*.

(h) Most candidates were unable to give examples in which the heating effect of current is used. Their responses included ammeter, voltmeter, current, light bulbs, alarm systems and microwave, alarm systems, etc.

Suggestions for Improvement

(a) All concepts, definitions, terminology, laws and principles should be correctly stated as specified in the *CAPS* and *Examination Guidelines*.

(b) The difference between *intrinsic* and *extrinsic semiconductors*, as well as the difference between a *p-type* and an *n-type semiconductor* must be emphasised.

(c) Teachers should ensure that learners are fully familiar with the data sheet and are able to identify the relevant equation applicable to a specific calculation. Conversions of units and correct SI units must form an integral part of teaching and learning.

(d) The relationship between variables should be explained.

(e) Practical applications of the heating effect should be taught and assessed in informal and formal activities.

QUESTION 9: ELECTROMAGNETIC INDUCTION

Common Errors and Misconceptions

(a) In Q9.1.1 some candidates omitted to state Faraday's Law.

(b) In Q9.1.2 most candidates phrased their answers incorrectly while others omitted keywords.

(c) In Q9.2 the majority of candidates were able to calculate the magnetic flux linkage even though they did not get the SI unit.

Suggestions for Improvement

(a) Teachers must teach learners to state the laws as stated in the *CAPS* and *Examination Guidelines*.

(b) Learners must be taught to state the relationship between the magnetic strength, number of turns, speed at which the magnet is moving in and out of the coil or increase number of turns/windings and the magnitude induced emf.

(c) Emphasise the writing of units in the final answer.

QUESTION 10: GENERATORS AND TRANSFORMERS

Common Errors and Misconceptions

(a) Candidates were unable to differentiate between *step-down transformer* and *step-up transformer* in Q10.1.

(b) Candidates omitted subscripts when writing the formula $\frac{V_S}{V_p} = \frac{N_S}{N_p}$

(c) In Q10.1.2 candidates struggled with mathematical manipulation to get the correct answer.

(d) Candidates could not differentiate between *AC* and *DC generators*.

(e) Most candidates could not identify a component that enables the generator to produce DC voltage in Q10.2.2.

Suggestions for Improvement

(a) Teachers should tabulate the difference between a *step-up* and a *step-down transformer*, by making use of pictures, models and videos to help learners gain a better understanding. Teach learners that the input voltage is the primary voltage and the output voltage is the secondary voltage.

(b) The importance of subscripts in the equations should be emphasised.

(c) Compare motors and generators in a table when teaching the topic as well as AC and DC generators.

(e) Teach learners the components of generators and motors as well as the function of each component. The terminology associated with motors and generators, e.g. slip-rings, commutator and brushes should be emphasised. Use examples of actual motors and generators, models, drawings, pictures and simulations.

3.4 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 2

General Comments

(a) Questions on definitions were poorly answered. Teachers are advised to teach and assess definitions as stated in the *CAPS* and *Examination Guidelines*.

(b) Candidates could not apply scientific reasoning to explain certain phenomena.

(c) Physical properties of organic compounds in Q3, organic reactions in Q4, electrolytic cell in Q5 and light in Q7 and Q8 were poorly answered.

(d) Most candidates struggled with the interpretation and understanding of the flow diagram in Q4.

(e) Questions on drawing light ray diagrams and lenses were poorly answered.

(f) Candidates struggled with the conversion of units in Q9.

(g) The interpretation and the use of the table of standard reduction potentials posed a challenge to candidates.

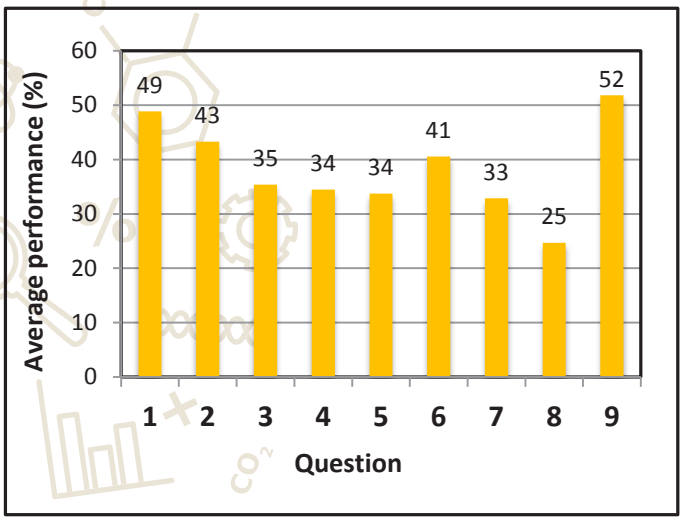
(h) Candidates struggled with the rules of assigning oxidation numbers, as taught in Grade 11.

(i) Teachers must encourage learners to read the questions and follow instructions.

3.5 DIAGNOSTIC QUESTION ANALYSIS OF PAPER 2

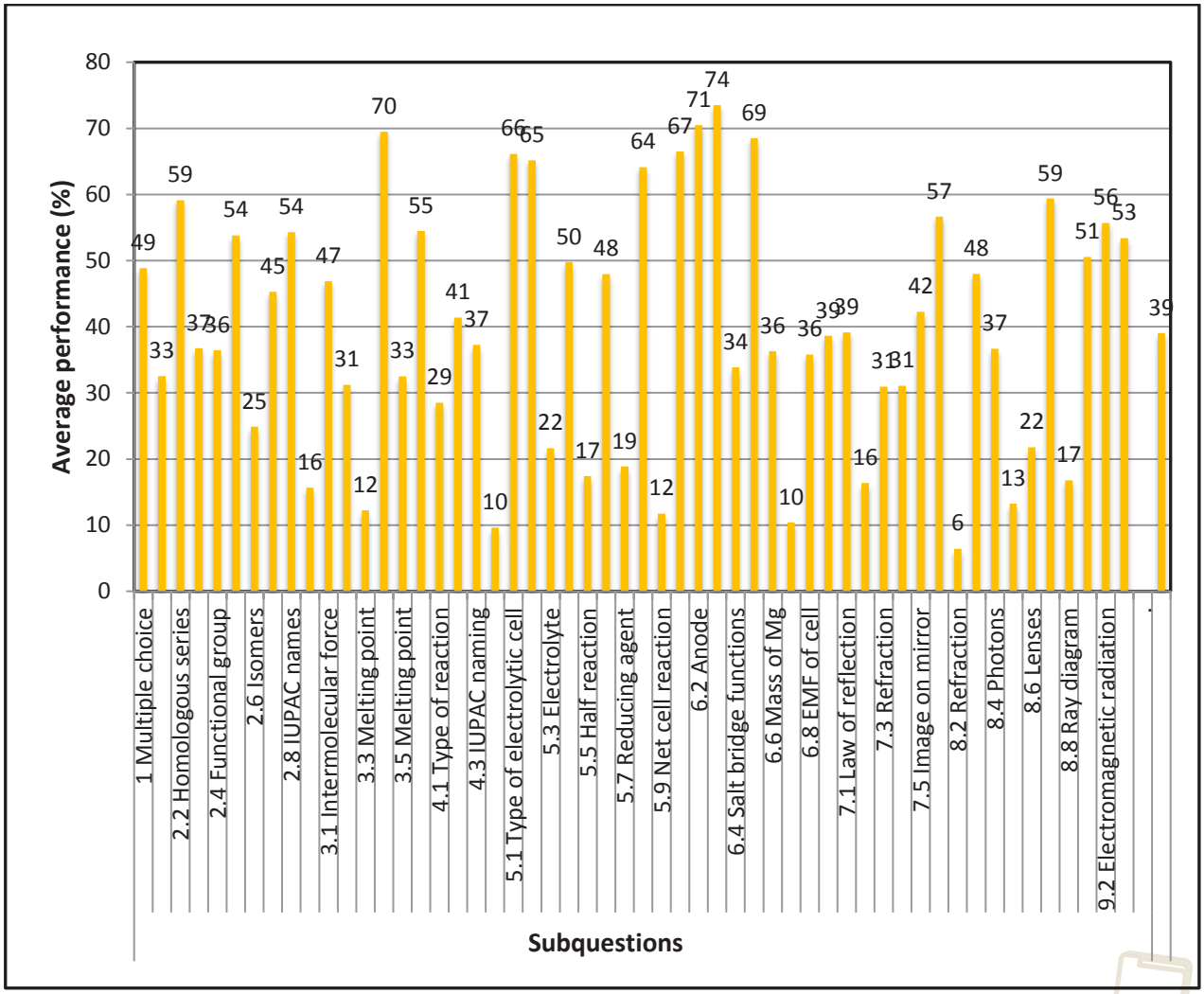
The following graph is based on data from a random sample of candidates. While this graph might not accurately reflect national averages, it is useful in assessing the relative degrees of challenge of each question as experienced by candidates.

Graph 2.5.1 Average Marks per Question Expressed as a Percentage for Paper 2



Q1	Multiple Choice
Q2	Organic Molecules: Nomenclature
Q3	Organic Molecules: Physical Properties
Q4	Organic molecules: Reactions
Q5	Electrolytic cell
Q6	Galvanic cell
Q7	Light: Reflection and refraction
Q8	Light: Reflection and refraction
Q9	Electromagnetic radiation

Graph 2.5.2 Average Marks per Subquestion Expressed as a Percentage for Paper 2



3.6 ANALYSIS OF LEARNER PERFORMANCE IN EACH QUESTION IN PAPER 2

QUESTION 1: MULTIPLE CHOICE

Common Errors and Misconceptions

(a) In Q1.2 candidates could not recall that alkanes have weaker intermolecular forces and as such are used as fuel.

(b) Some candidates did not recognise that hydrogen was added to form the product in Q1.4. They could not identify the product formed during the addition of but-2-ene.

(c) Many candidates failed to identify the oxidation number of chlorines in $CuCl_2$ in Q1.6.

(d) In Q1.8 candidates struggled to relate the properties of image and the position of the object when using a convex lens.

(e) Most candidates could not relate the degree of refraction with the frequency or wavelength of light in Q1.9.

Suggestions for Improvement

(a) The different types of reactions should be thoroughly taught and reference should be made to the *CAPS* and the *Examination Guidelines* to determine which reactions to teach.

(b) Revise the Grade 11 work, which is examinable in Grade 12, on rules for assigning oxidation numbers. The periodic table must be attached to the question paper.

(c) The drawing of ray diagrams and identification of properties of images should be emphasised.

(d) Emphasis must be placed on the fact that the extent to which light refracts is related to the wavelength of light. Learners also need to be able to arrange spectrum in order of increasing or decreasing wavelength or frequency. Experiments on the refraction of light should be conducted to emphasise the content taught. Daily activities, informal and formal assessment should include multiple-choice questions. Educators are encouraged to compile a test bank of MCQs for learners.

QUESTION 2: NAMING OF ORGANIC MOLECULES AND STRUCTURAL FORMULAE

Common Errors and Misconceptions

(a) In Q2.1 candidates left out the word *organic* in the definition for homologous series.

(b) When explaining *saturated compound* in Q2.3, candidates omitted the word 'only' to qualify that there were no other bonds except single bonds.

(c) Candidates could not define the term *functional group* in Q2.4.

(d) Candidates could not identify the correct pairs in Q2.5.4 and the type of isomers in Q2.5.5. Those who correctly identified the pairs failed to give the correct names of the types of isomers of these pairs.

(e) In Q2.7.2 many candidates could not draw the structural formula of the functional group of esters. Instead they wrote 'ester linkage', or failed to include some of the bonds around the carbon atom or the oxygen atom.

(f) In Q2.3.6 candidates struggled to draw the structural isomer of compound D.

(g) When naming compounds in Q2.8.1 and Q2.8.2, candidates either left out the hyphen or placed it in the wrong place.

(h) Most candidates struggled to define the term *polymer* in Q2.9.1.

Suggestions for Improvement

(a) Greater emphasis should be placed on the learning of definitions as stated in the *CAPS* and the examination guidelines and it should be assessed in informal and formal activities.

(b) Differentiate, using examples, the functional group, functional group name and homologous series. Learners must be taught to read the information in the question carefully and follow instructions precisely.

(c) The structural formula of the functional groups from the different homologous series should be emphasised and form part of the daily assessment activities.

(d) Teach learners the difference between homologous series and functional groups of different organic compounds.

(e) The rules of IUPAC naming of organic compounds must be emphasised, e.g. the 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 (chain, functional and position) in terms of naming, identifying and drawing.

QUESTION 3: PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

Common Errors and Misconceptions

(a) Candidates wrote *Van der Waals forces* instead of being specific about the type of intermolecular force in Q3.1.

(b) In Q3.2 candidates linked longer chain length with weaker intermolecular forces. They failed to identify which one of the two compounds is more branched and they could not relate the influence of branching to the strength of intermolecular forces. They also stated that more energy is needed to 'break' the 'bond' or 'substance' of intermolecular forces instead of saying 'overcoming' intermolecular forces. Some used the phrase 'less/lower forces' instead of 'weaker' or 'stronger intermolecular forces'.

(c) In Q3.3 candidates struggled to define the term *melting point*. They left out keywords in the definition like temperature and *equilibrium.*

(d) In their explanation in Q3.5 candidates incorrectly indicated that the 'higher the boiling point, the lower the melting point'. They did not seem to understand the relationship between boiling point, melting point and the strength of the intermolecular forces.

(e) Candidates could not identify the types of intermolecular forces and compare the strength of the forces in ethane and ethanol in Q3.4.

Suggestions for Improvement

(a) Learners should be taught definitions including all necessary keywords. Informal tests should be used to assess definitions regularly.

(b) The strength and the type of intermolecular forces acting on different organic compounds (homologous series) should be clearly explained.

(c) Candidates must be guided on how to use chain length, strength of the intermolecular forces and energy to explain trends in physical properties of organic compounds. Teachers need to use a variety of questions which require explanations in informal and formal activities.

(d) Learners must be taught which factors (chain length, branching, type of intermolecular force, homologous series) from the given structures influence the strength of intermolecular force. In addition, they must also be taught to be specific when making comparisons.

(e) Teachers must emphasise the fact that the stronger the intermolecular force, the more energy will be needed to overcome the intermolecular force instead of breaking the bond or substance.

(f) When comparing two compounds, learners should be taught to be specific and to mention both compounds rather than being too general.

(g) The relationship between *boiling point* and *melting point* should be explained; substances with high boiling points have high melting points and vice versa.

(h) The types of intermolecular forces, strength of the intermolecular forces and the energy involved must be used to explain the trends of physical properties of organic compounds.

QUESTION 4: REACTIONS OF ORGANIC COMPOUNDS

Common Errors and Misconceptions

(a) In Q4.1, Q4.2.1, Q4.2.2 candidates could not name and differentiate between the different types of reactions.

(b) In Q4.3.2 candidates struggled to name compound **B** which was Butan-2-ol. They wrote But-2-ol or But-2-anol and even omitting the hyphen or '2' which is the position of the functional group.

(c) In Q4.3.3 candidates omitted the hyphen or placed it in the wrong position, e.g. 2 bromobutane or 2-bromo-butane, 2 bromo-butane. The position of Br was also omitted or incorrectly written as bromo-2-butane.

(d) In Q4.4 candidates were unable to state the reaction conditions for the substitution reaction of the haloalkanes. Some wrote 'heat' without indicating that it is *mild* heat.

Suggestions for Improvement

(a) During teaching, emphasise differentiating between the different types of reactions (combustion/ oxidation, substitution reactions and the different types of addition reactions) as well as their reaction conditions.

(b) Use a variety of flow diagrams and teach IUPAC naming of organic compounds and interpretation of the flow diagram. This knowledge should be assessed in all assessment tasks, both formal and informal.

(c) Although the rules, viz. Zaitsev's Rule and Markovnikov's Rule, are not examinable, their applications should be stressed to learners to help them identify minor and major products in organic reactions.

QUESTION 5: ELECTROLYTIC CELL

Common Errors and Misconceptions

(a) Many candidates could not identify the type of cell in Q5.1. Those who did, used the word *electrolysis* instead of *electrolytic cell*.

(b) Candidates could not define the term *electrolyte* in Q5.3; they confused *electrolyte* and *electrolysis*.

(c) Candidates could not define *oxidizing agent* in Q5.6.

(d) In Q5.4 candidates could not tell whether the Cu^{2+} is the anion or the cation.

(e) In Q5.5.1 and Q5.5.2 candidates were unable to write the half-reactions of reactions occurring at the anode and cathode. They used double arrows for half-reactions and omitted the charges in the ions. They swapped the half-reaction at the anode with that of the cathode.

(f) In Q5.7 candidates were unable to identify the reducing agent; those who managed to identify it omitted the ions (-) in C*l*.

(g) Candidates were unable to write down the overall cell reaction in Q5.9; they omitted ions. Some left out charges on ions, e.g. Cu instead of Cu^{2+} and Cℓ instead of Cℓ^{-}.

Suggestions for Improvement

(a) The difference between *electrolytic* and *galvanic cell* must be emphasised.

(b) Definition of the concepts should be explained and assessed regularly.

(c) 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.

(d) Perform experiments of a variety of electrolytic reactions and teach learners how to make observations.

QUESTION 6: GALVANIC CELL

Common Errors and Misconceptions

(a) In Q6.1 candidates confused the definition of a galvanic cell with that of an electrolytic cell.

(b) When asked for functions of the salt bridge in Q6.4, candidates just wrote 'maintains neutrality' or 'allows the movement of ions' which was not enough to allocate marks. When writing down functions of the salt bridge, they used words incorrectly, e.g. 'It completes the cells' instead of 'It completes the circuit'.

(c) It was evident in Q6.6 that candidates could not explain why the mass of the magnesium decreased.

(d) In Q6.7 candidates struggled to write the net reaction of the cell even though the half-reactions were given in the question paper. Those who managed to write the correct net reaction of the cell were unable to balance the equation. They also left out the ions. Some thought that the reaction was between magnesium and iron.

(e) Most candidates swopped the anode and the cathode when substituting in the formula during calculation of the emf of the cell in Q6.8. In some cases the incorrect electrode potential was used. They also used unconventional abbreviations in the formula, e.g. $E_{cell} = E_{cat} - E_{an}$ and the incorrect formula, e.g. E_{cell} = Anode – Cathode even though it was given in the formula sheet.

(f) In Q6.9.1 candidates struggled to give alternative sources of energy. They were also unable to provide the advantages of using biodiesel in Q6.9.2.

Suggestions for Improvement

(a) Teachers should differentiate between the definitions of galvanic and electrolytic cells.

(b) Learners must be taught that the main functions of the salt bridge are to maintain electrical neutrality of the electrolyte through the movement of ions and to complete the circuit.

(c) It should be emphasised that the electrode which undergoes oxidation is the one that experiences loss of mass (anode).

(d) Emphasis should be on the different types of alternative sources of energy, and the advantages and disadvantages of using the different alternative energies.

(e) Teachers should ensure that learners understand how to use the table of standard reduction potentials to write half-reactions, net cell reaction and they should be able to identify and compare the strength of the reducing and the oxidizing agents. Learners must use formulae as they appear on the data sheet.

(f) The environmental advantages and disadvantages of using alternative energies should be taught and assessed.

QUESTION 7: REFLECTION OF LIGHT

Common Errors and Misconceptions

(a) In Q7.1 candidates could not state the law of reflection or they stated only one part of the law. Some confused the concepts of *reflection* and *refraction*.

(b) Candidates could not tell how the angle of the light ray should be incident on the rectangular glass block for it to emerge from the opposite side of the block without being refracted in Q7.2. Some wrote 90° without an explanation.

(c) Candidates did not know that during refraction the angle of incidence is equal to the angle of emergence and the incidence ray must be parallel to the emergent ray. They did not label the light rays but labelled only the magnitudes of the angles. Rays were drawn without arrows to indicate the direction, and they were not labelled.

(d) In Q7.4.1 candidates struggled to define *critical angle*.

(e) Candidates identified the phenomenon in Q7.4.4 as 'internal reflection' or 'reflection or refraction' instead of 'total internal reflection' and they were unable to define it in Q7.4.5. They confused the definition of *total internal reflection* with its conditions.

(f) Candidates struggled to identify the type of image formed in a flat mirror in Q7.5.1.

Suggestions for Improvement

(a) The definition of the concepts *reflection* and *refraction* and laws should be emphasised using the *Examination Guidelines* and the *CAPS*. The difference between the concepts *reflection* and *refraction* should be clarified.

(b) Teach and use practical activities to demonstrate what happens when light moves through different media or is reflected in mirrors and prisms. Scientific reasoning should be emphasised when answering questions such as differentiating between *reflection* and *refraction*.

(c) Formal and informal assessment activities should include drawing and labelling of ray diagrams.

(d) Learners should differentiate between the definitions and conditions of total internal reflection.

(e) Ensure that learners know the properties of real and virtual images.

QUESTION 8: REFRACTION OF LIGHT

Common Errors and Misconceptions

(a) Candidates could not relate wavelength/frequency to the dispersion of white light in Q8.2. Some wrote *wavelength* and *frequency* without any justification.

(b) In Q8.3 most candidates wrote 'ROYGBIV' instead of 'spectrum'.

(c) In Q8.5 candidates could not explain why green light had a higher energy than yellow light using frequency and wavelength.

(d) Candidates struggled to give the correct answer to the observation in Q8.6.

(e) In Q8.8 candidates could not draw the ray diagram through a convex lens. The extrapolation was not done until at F. The image and object did not have arrows; the position of the image was on the other side of the concave lens.

(f) Some candidates used a convex lens instead of a concave lens in Q8.8.

Suggestions for Improvement

(a) Refraction, including dispersion, spectrum and the relationship between frequency and wavelength to the degree of refraction, needs to be emphasised. Use various teaching aids such as videos, models and demonstrations during experiments using an optical kit. Teach learners to observe and explain observations scientifically.

(b) Teachers must ensure that they thoroughly teach and assess the drawing of ray diagrams for convex and concave lenses. Teach the applicable terminology such as *focal point*, *focal length* and *principal axis* as well as the list of properties of images formed by these lenses at various positions from the optical centre of the lenses.

(c) Teach learners the difference between a *virtual* and a *real image*.

(d) Applications of lenses should be taught.

QUESTION 9: ELECTROMAGNETIC WAVES

Common Errors and Misconceptions

(a) Candidates struggled with the definition of a photon in Q9.1. Most of candidates omitted the word *packet/quanta* of energy in the definition of a photon.

(b) In Q9.3 candidates could not correctly convert the wavelength from nanometres to metres. Some did not even convert the wavelength to metres and substituted the wavelength in nanometres.

(c) Wrong rounding off and the omission of SI units in the final answer were evident in Q9.3.

Suggestions for Improvement

(a) The definitions of concepts should be emphasised using the *Examination Guidelines* and the *CAPS*. Teachers should highlight keywords in definitions while teaching.

(b) Teachers must expose learners to a variety of calculations involving energy of a photon and ensure that conversion of units is done correctly. Teachers must emphasise that the final answer should have the correct units.