CHAPTER 4

ELECTRICAL TECHNOLOGY

4.1 DIGITAL SYSTEMS

The following report should be read in conjunction with the Digital question paper of the November 2018 examinations.

4.1.1 PERFORMANCE TRENDS (2018)

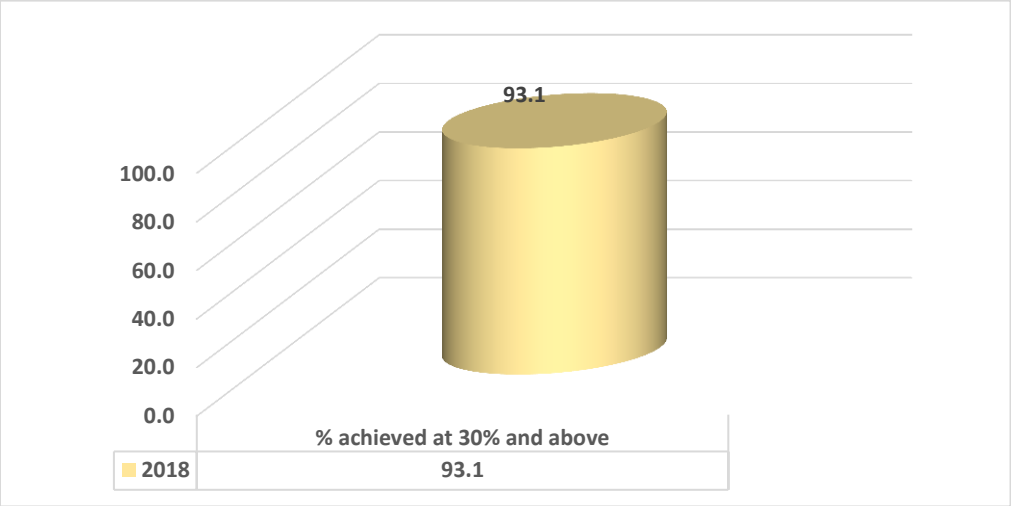
In 2018, 407 candidates sat for the Digital examination. This is the first time that this subject is being offered as an NSC examination subject. Although the pass rate of 93,1% at the 30% level is pleasing, it is disappointing that only 28,2% of the candidates were able to achieve at the 50% level and above.

Table 4.1.1 Overall Achievement Rates in Electrical Technology – Digitals

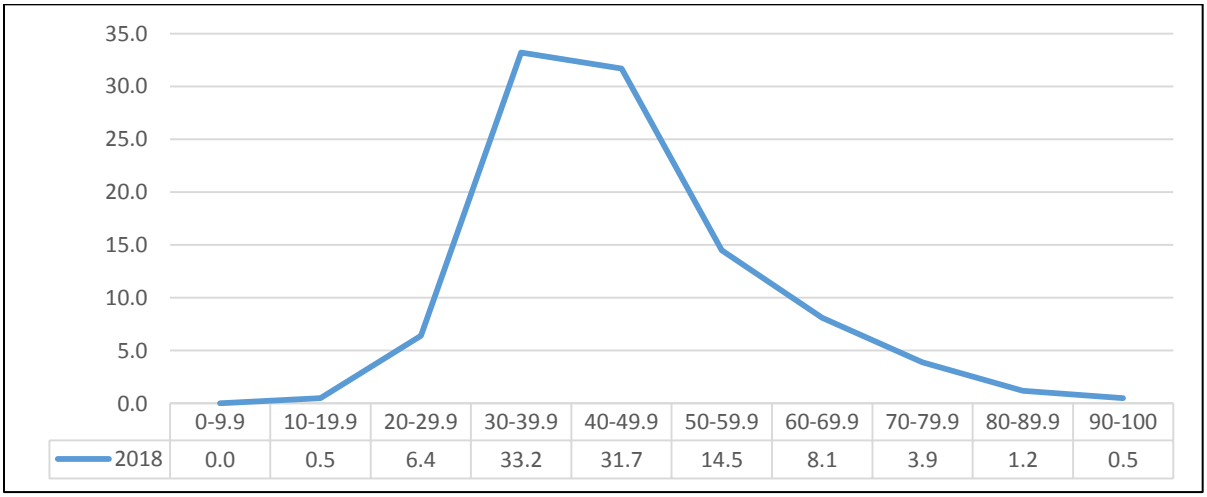
Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	407	379	93,1

Performance will be further enhanced if attention is given to the following areas: strengthening the content knowledge in switching circuits, digital and sequential devices and microcontrollers and learners' practical exposure to these areas. Learners need to be exposed to complex questions and problem solving in all topics in the curriculum. This should start in earlier grades.

Graph 4.1.1 Overall Achievement Rates in Electrical Technology – Digital (Percentage)



Graph 4.1.2 Performance Distribution Curves in Electrical Technology – Digital (Percentage)



4.1.2 OVERVIEW OF LEARNER PERFORMANCE IN DIGITAL

General Comments

(a) The overall performance of the candidates was poor, with only Q1 being fairly well answered.

(b) Q2 and Q4, which consisted of 115 marks (57,5% of the paper), were answered the worst of all the questions. The candidates seemed to have a lack of basic knowledge of the content and therefore could not answer the questions.

(c) Q3 and Q5, which consisted of 75 marks (37,5% of the paper), were poorly answered questions.

(d) Candidates' language use when answering questions was very poor. Even though the level of the language used in the question paper was simple and unambiguous, candidates' responses showed that they did not actually understand the requirements of the questions.

(e) It is evident that many candidates lacked the proper content knowledge and the necessary skill to answer the questions. It appears that candidates did not prepare themselves well for this examination.

(f) Judging from the answers presented, it was evident that candidates did not read the questions carefully before they answered, therefore giving the wrong answers. Low cognitive questions could not be answered.

(g) Many candidates seemed to struggle to answer questions of a narrative nature.

(h) Manipulation of formulae with regard to calculations is a challenge for candidates. The application of mathematics and expressing their responses requires attention.

(i) The huge volume of circuit diagrams, output waveforms and characteristic curves proved to be a challenge for most candidates.

(j) The deeper understanding of presenting waveforms in an EGD approach from circuits and drawing them on answer sheets taking the correlation between input and output waveforms is a new concept. This is also a vast improvement over the past Electrical Technology approach. This requires candidates to think as engineers would, which makes it imperative that teachers will need to apply this approach in their teaching.

(k) There were numerous questions in the final question paper that were similar in nature to the exemplar question paper. However, performance was very poor and it seems that candidates did not work through the exemplar question paper in preparation for the final question paper.

General suggestions for improvement

(a) ***CAPS* and Exemplar Paper**: Teachers should use the *CAPS* and 2018 Exemplar Guidelines when teaching and assessing formally and informally.

(b) **Use of Past NSC Papers**: Firstly, it must be noted that past question papers serve as one of many teaching and learning resources. It must be used for revision purposes only. Past papers cannot replace the *CAPS* document and Examination Guidelines. Every learner must have access to past examination papers. Papers such as the 2018 exemplar, November 2018 and the June 2019 supplementary paper would be appropriate for revision purposes as these are based on the current *CAPS* content. In addition, teachers should ensure that learners revise questions on switching circuits, digital and sequential devices and microcontrollers as this is stipulated for Grade 12 in the *CAPS*. Further consolidation of these topics is required.

(c) **Revision of Relevant Grades 10 and 11 Content**: In the Grade 12 NSC examinations only Grade 12 content will be assessed. However, prior knowledge from Grades 10-11 may be necessary to interpret and answer some of the questions.

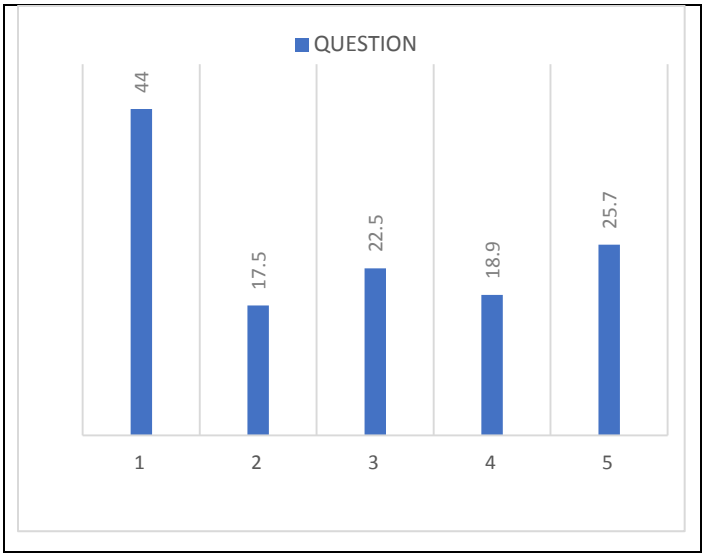
(d) **Time Management:** Learners must be trained in the art of managing their time and to adhere to the suggested time allocations provided in the paper. The mark allocation and the spaces provided in the answer book are good indicators of the amount of information needed.

(e) **Practical Experiments and Past Papers**: Teachers must do more practical experiments with learners showing them the working principles and understanding applicable to Q2 to Q5. Learners should use past Grade 12 past papers to develop skills to interpret requirements in the question paper.

4.1.3 DIAGNOSTIC QUESTION ANALYSIS OF DIGITAL

The following graph is based on data on a random sample of learners. 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 learners.

Graph 4.1.3.1 Average Marks per Question Expressed as a Percentage



Q1	Safety
Q2	Switching circuits
Q3	Semiconductor devices
Q4	Digital & Sequential devices
Q5	Microcontrollers

The average performance in Q2 to Q5 was very poor.

Q2 covered switching circuits and was the question that was answered the worst, followed by Q4 which covered digital and sequential devices. Candidates seem to have a lack of basic knowledge of the content and therefore could not answer the questions. In Q2 the total marks awarded for output wave forms were 22. Q3 contained 2 marks on this topic which brought the total marks to 24 (i.e. 12% weighting). Candidates generally could not answer these questions.

4.1.4 ANALYSIS OF LEARNER PREFORMANCE IN INDIVIDUAL QUESTIONS

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

Common Errors and Misconceptions

(a) In Q1.1 candidates did not explain the severity of the injury or damage, but merely referred to it as an injury at work.

(b) In Q1.2 candidates stated the general duties but not with regard to a product. Candidates responded generally to questions based on 'Safety' instead of being specific to the equipment or scenario depicted.

(c) In Q1.3 candidates knew the consequences of horseplay, but could not explain why it was an unsafe act.

(d) In Q1.4 candidates wrote procedures to be followed when helping a person shocked by electricity instead of procedures to protect themselves.

(e) In Q1.5 candidates defined risk analysis instead of qualitative analysis.

Suggestions for Improvement

(a) Teachers must stress the full definitions of the terms e.g. 'major incident' to learners. Teachers should focus on the definitions in the prescribed textbook. Definitions should be emphasised in both daily assessment and formal assessment.

(b) Learners must be taught to read the whole question before attempting to answer it. Learners could not express themselves when trying to answer the question.

(c) Teachers must ensure that learners know the difference between an unsafe act and an unsafe condition and the general safety regulations that applies to a workshop.

(d) Teachers should make sure that learners understand the concept of both qualitative risk analysis and quantitative risk analysis. These topics should be included in both daily and formal assessment.

(e) The chapter on occupational health and safety should be taught by teachers and should not be given to learners as self-study work. The use of educational videos on health and safety issues will go a long way to improve learner understanding on health and safety issues.

QUESTION 2: SWITCHING CIRCUITS

Common Errors and Misconceptions

(a) Questions requiring candidates to do any type of explanation were poorly answered. There was a lack of knowledge and insight into the basic operation of circuits. Candidates struggled to explain the nature of change at the output when a certain input signal is applied to the circuit. See Q2.2.3, Q2.3.3, Q2.4.3, Q2.5.3, Q2.6.2, Q2.7.2, Q2.7.3 and Q2.9.2.

(b) Candidates struggled to explain the effects of changing certain component values on the circuit in the questions mentioned above.

(c) In Q2.3.2, Q2.4.1, Q2.5.2, Q2.6.3, Q2.7.4, Q2.8.1, Q2.8.2 and Q2.9.1 candidates were required to draw the output wave for many different types of circuits, however, they were unable to do so, showing that they lacked the basic required knowledge of circuit operation in this section.

(d) Candidates lost marks by not labelling their diagrams and or labelling them incorrectly on the provided answer sheets.

(e) Some candidates were not able to use the answer sheet with the given information correctly. The specific trigger points on the input of Q2.5.2 were given to guide the candidates' responses, but they did not project construction lines down in order to draw the correct corresponding output signal.

(f) In Q2.7.1 candidates lost marks because they did not include the prefixes in their substitution of the calculation.

(g) The majority of candidates did not attempt the questions on switching circuits using operational amplifiers and timers. They could not correctly identify the different multivibrators in order to correctly interpret the question.

(h) In Q2.9.2, candidates struggled to correctly respond to the question. The textbook supplied only the response to a passive integrator and candidates had to apply that knowledge to the given circuit.

(i) Candidates were confused between the different circuits and their input and output waveforms as well as their operation.

Suggestions for Improvement

(a) Learners need more exposure to the simulations that can be used to enhance learning and conceptual understanding of the curriculum. Electrical Technology is an applied subject therefore it is good practice to consolidate the theory with practical simulations, experiments and demonstrations.

(b) The changing of component values affects the characteristics and the operating point of a circuit. This should be shown and explained by the teacher during practical sessions.

(c) When explaining the operation of the different circuits, teachers also need to build the different circuits and demonstrate these to learners by displaying the different waveforms on the oscilloscope. Thereafter the learners must build these circuits practically as prescribed by the CAPS policy document and not focus on the circuits and simulations in the prescribed PAT only.

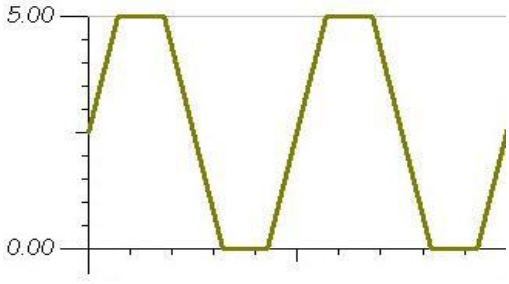
(d) Teachers must emphasise the importance of correct labelling during teaching and when discussing the marked assessment tasks with the learners.

(e) Teachers must emphasise the integration of EGD and Electronics especially when drawing the output waveforms. Similar answer sheets must be used in the assessment tasks for learners to familiarise themselves with using it.

(f) Teachers must emphasise the importance of using the correct prefixes in all calculations and showing them in the substitution. This must be strictly applied during the year in informal tasks and during the marking of all assessment tasks. Learners should know that they lose marks if these are not in place even if all the steps are correctly followed.

(g) Teachers must ensure that multivibrator circuits using both operational amplifiers and timers are covered theoretically and practically according to the *CAPS*.

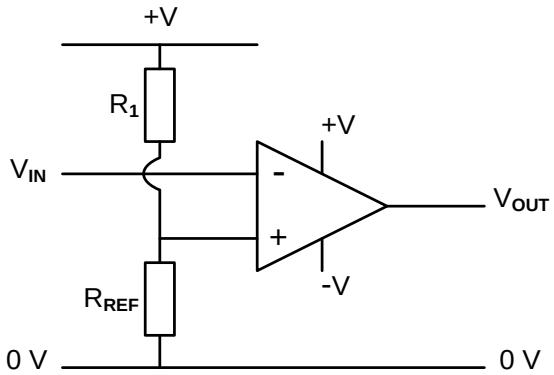
(h) The correct response to the question is as follows: If the RC time constant is short, the output will rise in a linear manner until reaching the maximum output voltage and remain there until the input falls again. This results in the output having straight sloping leading and trailing edges with flat tops and bottoms. It will resemble a triangular wave with its top and bottom peaks cut off.



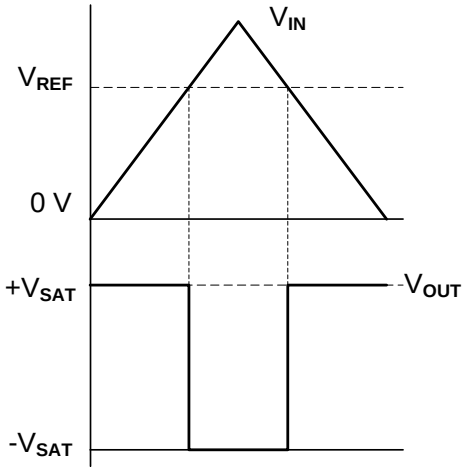
(i) Teachers can assist learners in summarising the circuits with relevant input and output waveforms and operation. An example is provided below.

INVERTING COMPARATOR

CIRCUIT DIAGRAM



INPUT AND OUTPUT WAVEFORMS



OPERATION

A comparator compares the two voltages appearing at the two input terminals (V_{IN} and V_{REF}). When one of its two input voltages is greater than the other, the output will go into one of the two saturation states ($+V_{SAT}$ or $-V_{SAT}$) e.g. shown on the waveform above, when V_{IN} is smaller than V_{REF}, the output is at $+V_{SAT}$. The moment when V_{IN} is bigger than V_{REF}, the output will immediately change to $-V_{SAT}$. The moment when V_{IN} falls below V_{REF}, the output will immediately change back to $+V_{SAT}$.

QUESTION 3: SEMICONDUCTOR DEVICES

Common Errors and Misconceptions

(a) In Q3.1.2 candidates did not know the type of 'package' for the '741 op amp'.

(b) In Q3.4 candidates could not distinguish between 'closed loop gain' and 'open loop gain'.

(c) In Q3.5 candidates were unable to identify the correct op-amp configuration to select the correct formulae for the calculation.

(d) Candidates also lost a lot of marks for using wrong units when doing the calculations.

Suggestions for Improvement

(a) More emphasis should be placed on the operation and effects or functions of components in circuits. More informal testing is also recommended. Special worksheets should be developed by teachers, with emphasis on drawing circuits, input and output waveforms, operation and the effects of the various components. Demonstrations using different values should be done.

(b) Learners must be informed of the importance of learning definitions, formulae, circuit diagrams and symbols.

(c) Learners need more exposure to the simulations and practical circuits that can be used, to enhance learning and conceptual understanding of the curriculum.

(d) During the explanation of circuits it must be emphasised that the correct formulae must be used in the calculations.

(e) Teachers must ensure learners always use units and use them correctly. An answer without a unit is not valid and a mark is lost although the calculated answer is correct.

QUESTION 4: DIGITAL AND SEQUENTIAL DEVICES

Common Errors and Misconceptions

(a) In Q4.1 candidates did not understand how LCD controls the passing of light. The concept of 'polarization' when explaining how the 'LCD' controls the passing of light was not known by many learners.

(b) In Q4.3 candidates could not complete the truth table of a decimal-to-binary encoder. The basic application of gates used in a complex circuit was not evident when candidates answered the question on the 'decimal to binary encoder'. This answer could have been attempted by using the truth table of the basic function of logic gates.

(c) In Q4.4 candidates could not identify the difference between a three-bit and a four-bit parallel adder.

(d) In Q4.5 and 4.7 candidates could not differentiate between the J-K Flip-Flop and Three-stage synchronous self-stopping up-counter diagrams.

(e) Many candidates could not differentiate between 'synchronous' and 'non-synchronous' counters.

Suggestions for Improvement

(a) Teachers should cover the operation of the two displays (LCD and LED) thoroughly in daily assessment and formal assessment.

(b) Learners should be taught the application of logic gates as used in complex circuits.

(c) The truth tables, the drawing of circuits with numbering and labelling must be taught to learners. Learners must also be taught how to analyse circuits and understand the difference between half adders and full adders.

(d) Learners should be taught how to analyse the circuit in order to explain its operation. The operation of JK Flip-Flop should be thoroughly treated through explanation and Truth Table. Learners should be given daily assessment on flip flops.

(e) The basic construction of counters should be well-explained and learners must be given daily and formal assessment on the topic.

(f) Learners need more exposure to the simulations that can be used, to enhance learning and conceptual understanding of the curriculum. This part of the exam required higher-order thinking and understanding.

(g) Learners must be informed of the importance of learning definitions, formulae, circuit diagrams and symbols. The general impression is that the learners did not know what to expect in the question paper.

QUESTION 5: MICROCONTROLLERS

Common Errors and Misconceptions

(a) In Q5.3 candidates failed to explain the basic processes of the microcontroller.

(b) In Q5.4 candidates could not label and identify 'the communication in a microcontroller' diagram.

(c) In Q5.6 candidates did not know the 'types' and 'function' of registers.

(d) In Q5.7 candidates could not differentiate between ROM and RAM. The Read Only Memory 'ROM' was not defined by many learners.

(e) In Q5.8 candidates could not differentiate between synchronous and asynchronous serial communication.

(f) Most candidates could not design the flow diagram of a home security system in Q5.12. Candidates could not identify the flow symbols for the 'microcontroller' flow chart. In the design flow chart section many learners confused the symbols and did not label them. Many drew the arrows in the wrong direction or left them out.

Suggestions for Improvement

(a) Different memory units involved in microcontroller operation should be discussed thoroughly. There should be enough exercises on this subtopic.

(b) The block diagram of the microcontroller should be drawn and explained to the learners. Learners should practise drawing the block diagram themselves.

(c) Teachers should expose learners to the different types of registers and the function thereof within the CPU and be strict on the proper use of circuit symbols.

(d) Teachers should explain the ROM memory with reference to CPU of the microcontroller to learners.

(e) Teachers should explain to learners the differences between synchronous and asynchronous serial communication.

(f) Worksheets with different scenarios and the answers of these should be given to learners for practice. Teachers should give learners more exercises on designing the flow chart and be strict on the proper use of circuit symbols. There should be enough exercise on this subtopic.

(g) Learners must be informed of the importance of learning definitions, formulae, circuit diagrams and symbols.

(h) Learners must draw with understanding. Assignments on block diagrams should be given to learners.

(i) Learners need more exposure to the simulations that can be used, to enhance learning and conceptual understanding of the curriculum.

4.2 ELECTRONICS

The following report should be read in conjunction with the Electronics question paper of the November 2018 examinations.

4.2.1 PERFORMANCE TRENDS (2018)

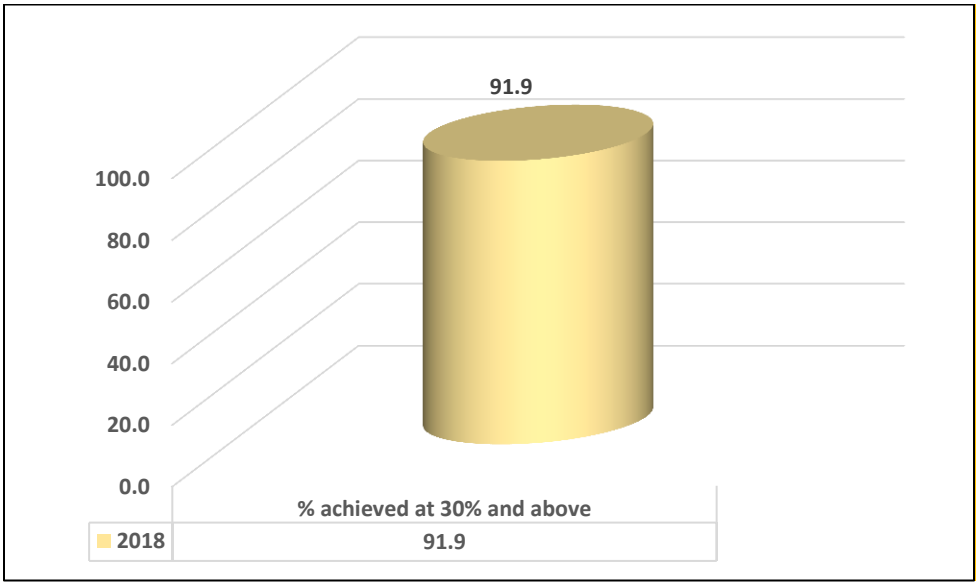
In 2018, 1 077 candidates wrote the Electronics examination. Although the pass rate of 91,9% at the 30% level is pleasing, it is disappointing that only 21,8% of the candidates were able to achieve at the 50% level and above.

Table 4.2.1 Overall Achievement Rates in Electrical Technology – Electronics

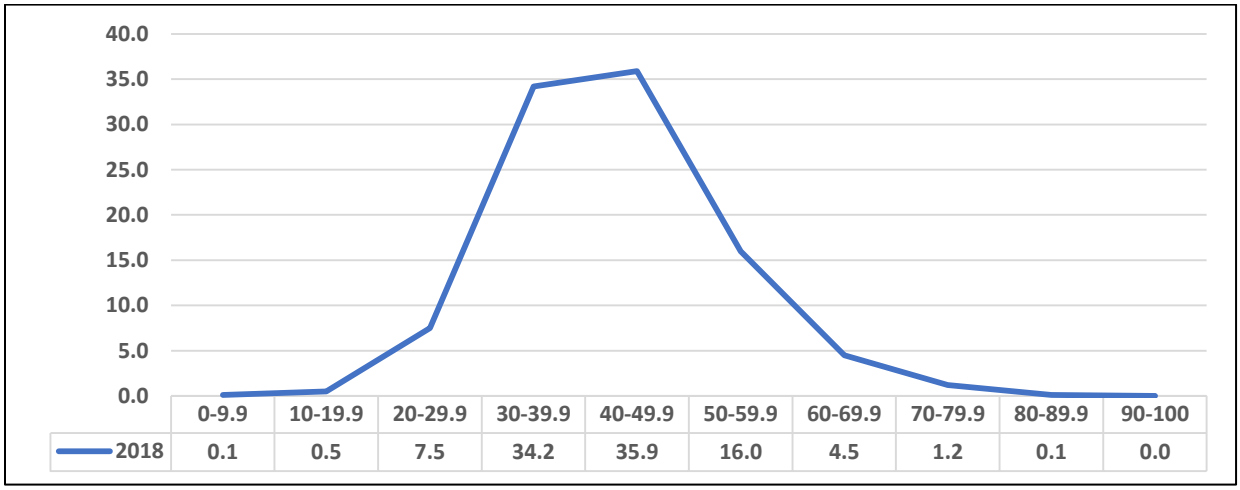
Year	No. Wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	1 077	990	91,9

The poor performance of learners in 2018 can be attributed to the introduction of the new curriculum and both teachers and learners need to become familiar with the content and assessment style of the subject. Following the suggestions made in this report will improve the interpretation and application of content stipulated in the CAPS policy document.

Graph 4.2.1 Overall Achievement Rate in Electronics (Percentage)



Graph 4.2.2 Performance Distribution Curve in Electronics (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	0.1	0.5	7.5	34.2	35.9	16.0	4.5	1.2	0.1	0.0

It is evident from the graph that the majority of candidates' performances is spread from 30% to 49,9%. An area of concern is low performance in the 60% to 100% range.

4.2.2 OVERVIEW OF LEARNER PERFORMANCE IN PAPER 1

General Comments

(a) In general, the overall performance of candidates on the paper was very poor. This is disappointing considering that the 2018 paper was regarded as very fair to the full range of candidates.

(b) Q1 and Q2 were well answered but consisted of only 50 out of 200 marks, which is 25% of the entire paper.

(c) Q3, Q4 and Q5 were poorly answered. These questions comprised the majority of the marks, i.e. a total of 150 out of 200 marks which is 75% of the total.

(d) Candidates' language use to answer questions was very poor. Even though the level of language used in the question paper was simple and unambiguous, candidates' responses tended to show that they did not actually understand the requirements of questions.

(e) It is evident that many candidates lack proper content knowledge and the necessary skill to answer the questions. It appears that candidates did not prepare themselves well for this examination.

(f) Judging from the answers presented, it is evident that candidates did not read the questions carefully before they answered, therefore giving the wrong answers. Low cognitive questions could not be answered.

(g) Many candidates seemed to struggle to answer questions of a narrative nature.

(h) Manipulation of formulae with regard to calculations is a challenge for candidates. The application of mathematics and expressing their responses requires attention.

(i) Marks were lost for the omission of units in the calculations and/or wrong substitution and the omission of labels in the drawings.

(j) The huge volume of circuit diagrams, output waveforms and characteristic curves is a challenge for most students.

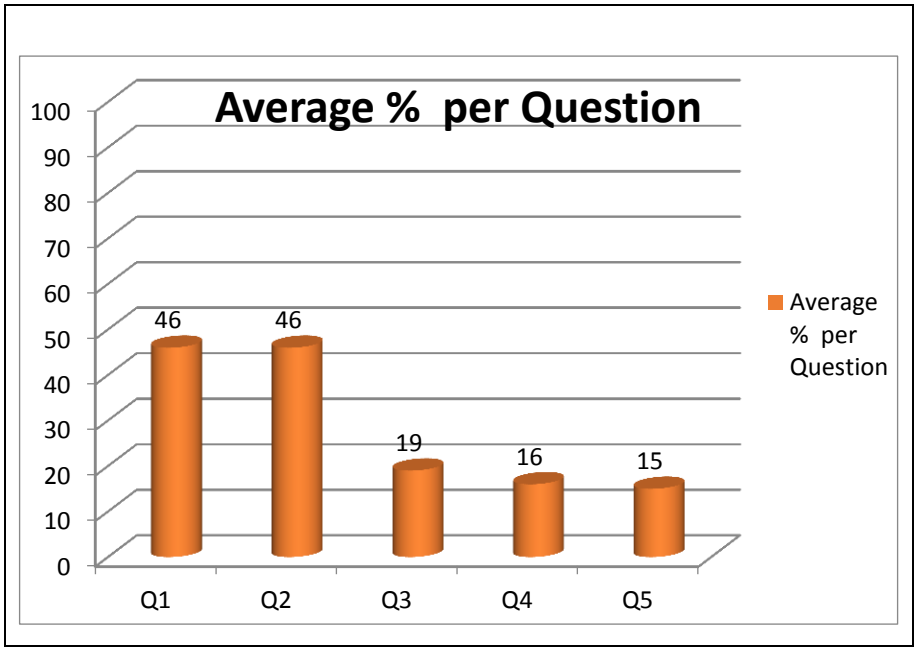
(k) The deeper understanding of presenting waveforms in an EGD (Engineering Graphics and Design) approach from circuits and drawing them on answer sheets taking the correlation between input and output waveforms is a new concept and a vast improvement over the past Electrical Technology approach. This is preparing candidates to think as engineers would, however, teachers still need to apply this approach in their teaching.

(l) There were numerous questions in the final question paper that were similar in nature to the exemplar question paper. However, performance was very poor and it would seem that learners did not work through the exemplar question paper in preparation for the final question paper.

4.2.3 DIAGNOSTIC QUESTION ANALYSIS OF ELECTRONICS

The following graph is based on data from a random sample of learners. 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 learners.

Graph 4.2.3.1 Average Marks per Question Expressed as a Percentage



Q1	Occupational Health and Safety
Q2	RLC Circuits
Q3	Semi-Conductor Devices
Q4	Switching Circuits
Q5	Amplifiers

It is evident from the graph above that the responses from the learners to QUESTION 1 and QUESTION 2 was fair; however, the responses to QUESTIONS 3 to 5 is of great concern and needs urgent attention from teachers and learners.

4.2.4 ANALYSIS OF LEARNER PERFORMANCE THE QUESTION PAPER.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

Common Errors and Misconceptions

(f) In Q1.1 candidates did not explain the severity of the injury or damage but merely referred to it as an injury at work.

(g) In Q1.2 candidates stated the general duties but not with regard to a product. Candidates responded generally to questions based on 'Safety' instead of being specific to the equipment or scenario depicted.

(h) In Q1.3 candidates knew the consequences of horseplay, but could not explain why it was an unsafe act.

(i) In Q1.4 candidates wrote procedures to be followed when helping a person shocked by electricity instead of procedures to protect themselves.

(j) In Q1.5 candidates defined risk analysis instead of qualitative analysis.

Suggestions for Improvement

(f) Teachers must stress with learners the full definitions of the terms, e.g. 'major incident'. Teachers should focus on the definitions in the prescribed textbook. Definitions should be emphasised in both daily assessment and formal assessment.

(g) Learners must be taught to read the whole question before attempting to answer it. Learners could not express themselves when trying to answer the question.

(h) Teachers must ensure that learners know the difference between an unsafe act and an unsafe condition and the general safety regulations that apply to a workshop.

(i) Teachers should make sure that learners understand the concept of both qualitative risk analysis and quantitative risk analysis. These topics should be included in both daily and formal assessment.

(j) The chapter on occupational health and safety should be taught by teachers and should not be given to learners as self-study work. The use of educational videos on health and safety issues will go a long way to improve learner understanding on health and safety issues.

QUESTION 2: RLC CIRCUITS

Common Errors and Misconceptions

(a) Q2.1 was poorly answered because candidates did not fully understand the concept of impedance in an AC circuit. Candidates confused resistance for impedance and many left out the reference to an AC circuit.

(b) In Q2.2 the 'phase relationship' between voltage and current waveforms was not illustrated and drawn properly. Candidates could not distinguish between leading and lagging waveforms.

(c) In Q2.3.1 and other sections manipulation of formulae caused a huge problem for the majority of learners. Candidates did not write the correct symbols and some of the units were left out.

(d) In Q2.6.2 candidates did not understand the leading or lagging concept with reference to the current or voltage in RLC circuits.

(e) In Q2.7 candidates could not describe how the value of the resistance affects the bandwidth of an LC tuned circuit.

Suggestions for Improvement

(a) More activities on the manipulation of formulae must be given to learners.

(b) The higher-order understanding of application of circuits and concepts must be revised regularly and thoroughly.

(c) For calculation purposes, learners must be taught the selection of the correct formula, manipulation where necessary, correct substitution, the use of the calculator and including the correct unit for the answer.

(d) Teachers must explain the terms *leading* and *lagging* with reference to current and voltage in RLC circuits.

(e) Teachers should investigate practical implication and application of RLC circuits which include the bandwidth.

(f) Learners must be advised to use their own (the same) calculators often to familiarize themselves with how it operates (work) and then work out many examples on the topic to reinforce the mechanics of the application.

QUESTION 3: SEMICONDUCTOR DEVICES

Common Errors and Misconceptions

(a) In Q3.2 candidates struggled to correctly explain how the FET was modified to overcome leakage current between its gate terminal and channel.

(b) In Q3.3 to Q3.5 candidates could not explain the application and operation of the circuits.

(c) In Q3.4 covering the 'UJT CHARACERISTICS curve', candidates struggled to identify the saturation region on the curve and could not interpret the characteristic curve to explain the operation of the component.

(d) In Q3.7 candidates could not differentiate between the concepts of 'closed loop' and 'open loop'.

(e) In Q3.8 candidates were unable to identify the correct op-amp configuration in order to select the correct formulae for the calculation.

(f) Candidates lost a lot of marks for using wrong units when doing the calculations.

(g) Questions requiring learners to do any type of explanation were poorly answered.

(h) There was a lack of knowledge and insight into the construction and operation of semiconductor devices.

Suggestions for Improvement

(a) The construction and operation of all components must be explained thoroughly.

(b) Teachers are advised to make a summary of different components and circuits with characteristics and operating principles and give it to the learners for revision. Learners must be encouraged to draw characteristic curves of components and circuits.

(c) Teachers must include the characteristic curves in their explanations of the working principles and operating voltages of all components.

(d) Learners need more exposure to the simulations and practical circuits that can be used, to enhance learning and conceptual understanding of the curriculum.

(e) During the explanation of circuits emphasise that the correct formulae must be used in the calculations.

(f) Teachers must ensure that learners always use the units correctly. An answer without a unit is not valid and a mark is lost although the calculated answer is correct.

(g) Teachers must assess the learners informally during teaching and ask explanatory questions so that the learners get used to transferring the knowledge obtained into words.

QUESTION 4: SWITCHING CIRCUITS

Common Errors and Misconceptions

(a) Questions requiring learners to do any type of explanation were poorly answered. There was a lack of knowledge and insight into the basic operation of circuits. Candidates struggled to explain the nature of change at the output when a certain input signal is applied to the circuit. See Q4.2.3, Q4.3.3, Q4.4.3, Q4.5.3, Q4.6.2, Q4.7.2, Q4.7.3, Q4.9.2.

(b) Candidates struggled to explain the effects of changing certain component values and their effect on the circuit in the questions mentioned above.

(c) In Q4.3.2, Q4.4.1, Q4.5.2, Q4.6.3, Q4.7.4, Q4.8.1, Q4.8.2 and Q4.9.1 candidates were required to draw the output wave for many different types of circuits. However, they were unable to do so, showing that they lacked the basic knowledge of circuit operation in this section.

(d) Candidates lost marks for not labelling their diagrams or for labelling them incorrectly on the provided answer sheets.

(e) Some candidates were not able to use the answer sheet with the given information correctly, e.g. specific trigger points on the input of Q4.5.2 were given to guide the learner responses, but they did not project construction lines down in order to draw the correct corresponding output signal.

(f) In Q4.7.1 candidates lost marks because they did not include the prefixes in their substitution of the calculation.

(g) The majority of the candidates did not attempt the questions on switching circuits using operational amplifiers and timers. They could not correctly identify the different multivibrators in order to correctly interpret the question.

(h) In Q4.9.2 candidates struggled to correctly respond to the question as the textbook only supplied the response to a passive integrator and they had to apply that knowledge for the given circuit.

(i) Candidates were confused between the different circuits and their input and output waveforms as well as its operation.

Suggestions for Improvement

(a) Learners need more exposure to the simulations that can be used to enhance learning and conceptual understanding of the curriculum. Electrical Technology is an applied subject therefore it is good practice to consolidate the theory with some practical simulations, experiments and demonstrations.

(b) The changing of component values affects the characteristics and the operating point of a circuit. This should be shown and explained by the teacher during practical sessions.

(c) When explaining the operation of the different circuits, teachers also need to build the different circuits and demonstrate these to learners by displaying the different waveforms on the oscilloscope. Thereafter the learners must build these circuits practically, as prescribed by the *CAPS* policy document and not focus on the circuits and simulations in the prescribed PAT only.

(d) Teachers must emphasise the importance of correct labelling during teaching and when discussing the marked assessment tasks with the learners.

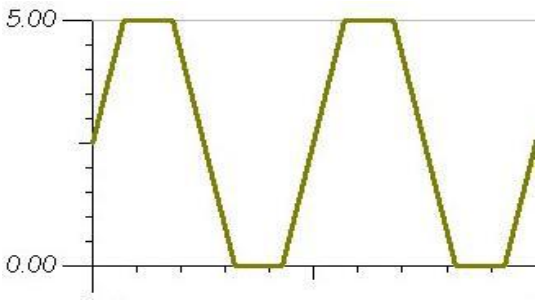
(e) Teachers must emphasise the integration of EGD and Electronics, especially when drawing the output waveforms. Similar answer sheets must be used in the assessment tasks for learners to familiarise themselves with them.

(f) Teachers must emphasise the importance of using the correct prefixes in all calculations and showing them in the substitution. This must be strictly applied during the year in informal tasks and during the marking of all assessment tasks. Learners should know that they lose marks if these are not in place even if all the steps are correctly followed.

(g) Teachers must ensure that multivibrator circuits using both operational amplifiers and timers are covered theoretically and practically according to the *CAPS*.

(h) The correct response to the question is as follows:

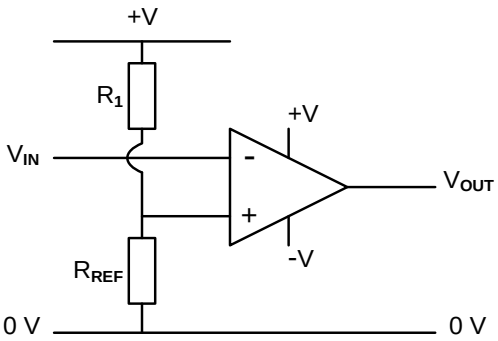
If the RC time constant is short, the output will rise in a linear manner until reaching the maximum output voltage and remain there until the input falls again. This results in the output having straight sloping leading and trailing edges with flat tops and bottoms. It will resemble a triangular wave with its top and bottom peaks cut off.



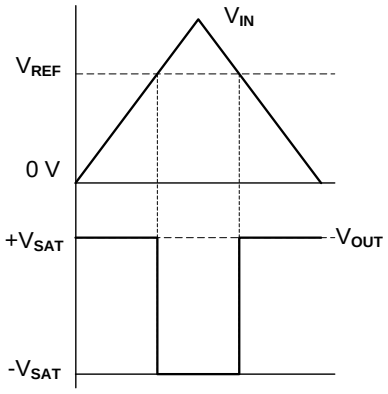
(i) Teachers can assist learners in summarising the circuits with relevant input and output waveforms and operation, e.g.

INVERTING COMPARATOR

CIRCUIT DIAGRAM



INPUT AND OUTPUT WAVEFORMS



OPERATION

A comparator compares the two voltages appearing at the two input terminals (V_{IN} and V_{REF}). When one of its two input voltages is greater than the other, the output will go into one of the two saturation states ($+V_{SAT}$ or $-V_{SAT}$). E.g. shown on the waveform above, when V_{IN} is smaller than V_{REF}, the output is at $+V_{SAT}$. The moment when V_{IN} is bigger than V_{REF}, the output will immediately change to $-V_{SAT}$. The moment when V_{IN} falls below V_{REF}, the output will immediately change back to $+V_{SAT}$.

QUESTION 5: AMPLIFIERS

Common Errors and Misconceptions

(a) In Q5.1 candidates did not know the reason for biasing the transistor.

(b) In Q5.2.3 candidates could not identify the biasing points on the load line.

(c) In Q5.3.2 candidates' responses to the operation of the RC-coupled amplifier were vague and incomplete.

(d) In Q5.4.2 the half power points definition is incorrect in the prescribed textbook. This caused confusion with candidates.

(e) In Q5.4.3 the description on voltage gain of the RC-coupled amplifier at low frequencies was incorrect and vague.

(f) In Q5.5.1 the concept of impedance matching in a transformer coupled amplifier was not understood by candidates.

(g) In Q5.5.3 the response curve drawn by candidates was not labelled and some had the incorrect shape or the incorrect labelling.

(h) In Q5.6.4 candidates did not know the purpose of R_1 and R_2 in the Colpitts Oscillator.

(i) In Q5.7.2 candidates had problems explaining why the total phase shift in an oscillator is zero.

(j) In Q5.9 the concept of damped oscillation posed a problem to many candidates.

Suggestions for Improvement

(a) Teachers are advised to focus on this concept by using calculations simulations, and transistor characteristics (including drawing of the load line on the graph) to enable learners to develop visual understanding of this abstract concept.

(b) Teachers must explain to learners how the biasing of a transistor and the different values of R_B will determine the Q-point of the transistor on the load line.

(c) 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.

(d) Regarding the half power points definition, teachers must replace this with the following correct definition: Half power points are the points at which the output power has dropped to half of its peak value, which is at a level of -3 dB.

(e) Teachers must explain to the learners how the lower, middle range and higher frequencies affects the gain of a RC-coupled amplifier circuit with reference to the frequency response curve.

(f) Teachers need to emphasise the concept of maximum power transfer and the need for it.

(g) Teachers must make sure that learners are able to draw a labelled frequency response curve of each amplifier circuit as prescribed in the CAPS policy document.

(h) The teachers must explain the function of all components in the circuit diagram to the learners. Learners must practice drawing and labelling these circuits.

(i) Teachers must clearly explain the purpose of the feedback circuit and the amplifier circuit in an oscillator e.g. LC oscillator and RC-Oscillator circuits.

(j) Teachers must explain the cause of decrease in amplitude of the output waveforms during the operation of oscillator circuits to the learners.

4.3 POWER SYSTEMS

The following report should be read in conjunction with the Power Systems question paper of the November 2018 examinations.

4.3.1 PERFORMANCE TRENDS (2018)

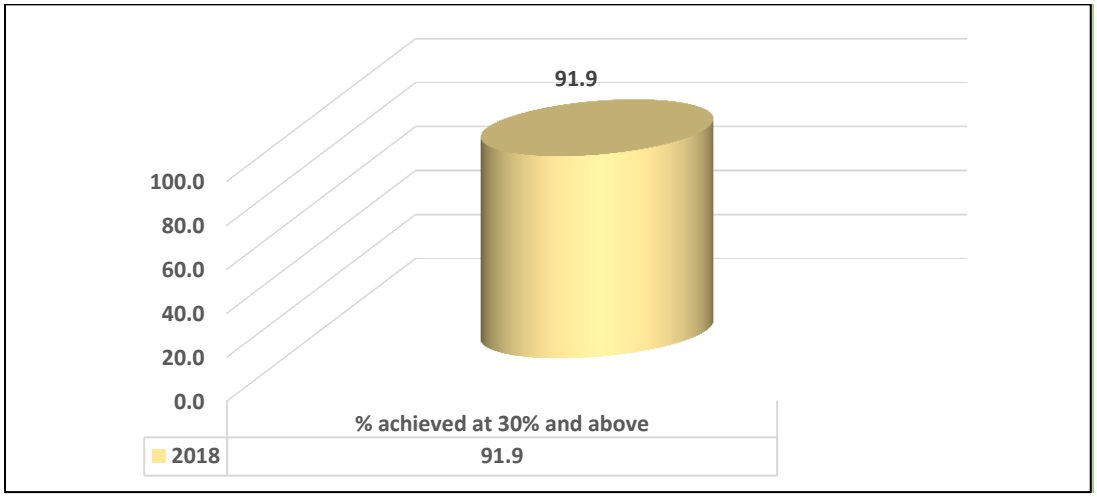
In 2018, 5 228 learners sat for the Power Systems examination. Although the pass rate of 91,9% at the 30% level is pleasing, it is noted that 33,0% of the candidates were able to achieve at the 50% level and above.

Table 4.3.1 Overall Achievement Rates in Electrical Technology (Power System)

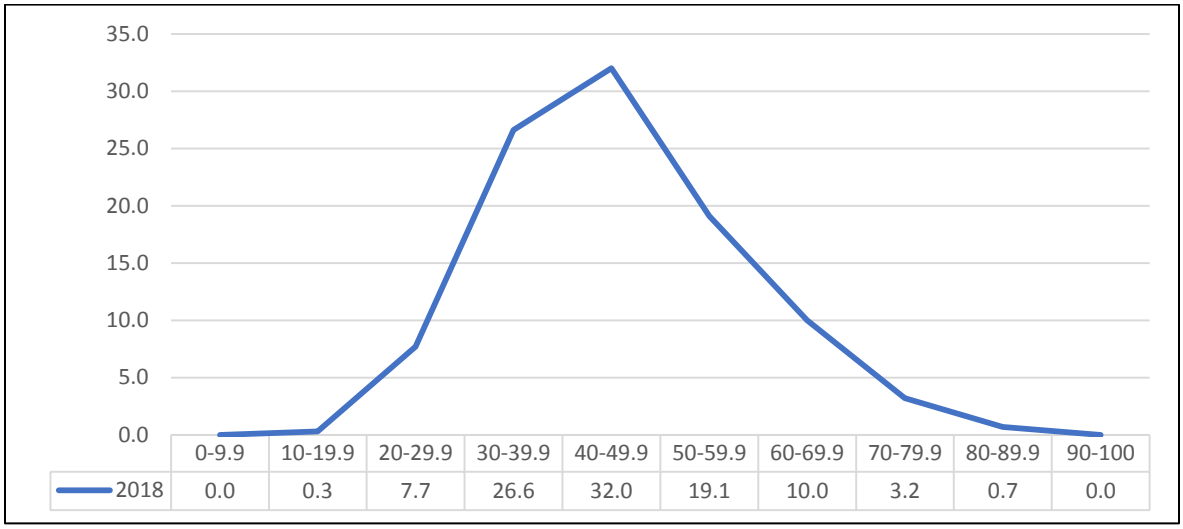
Year	No. Wrote	No. achieved at 30% and above	% achieved at 30% and above
2018	5 228	4 806	91,9

The performance of candidates in 2018 can be attributed to the stability in the curriculum and that teachers and learners are becoming familiar with the assessment style of the subject. However, there is still room for improvement in the performance of the candidates in the challenges surrounding conceptual understanding and interpretation of questions, manipulation, or changing the subject, of identified formula in all questions with calculations, identification of formulae from the given formula sheet, using the integration of the Engineering Graphics and Design (EGD) approach, labelling of ladder logic diagram and omission of units in the calculations are addressed.

Graph 4.3.1 Overall Achievement Rates in Power Systems (Percentage)



Graph 4.3.2 Performance Distribution Curves in Power Systems (Percentage)



4.3.3 OVERVIEW OF LEARNER PERFORMANCE

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

Common Errors and Misconceptions

(a) In Q1.1 candidates did not explain the severity of the injury or damage, but merely referred to it as an injury at work.

(b) In Q1.2 candidates stated the general duties but not with regard to a product. Candidates responded generally to questions based on 'Safety' instead of being specific to the equipment or scenario depicted.

(c) In Q1.3 candidates knew the consequences of horseplay, but could not explain why it was an unsafe act.

(d) In Q1.4 candidates wrote procedures to be followed when helping a person shocked by electricity instead of procedures to protect themselves.

(e) In Q1.5 candidates defined risk analysis instead of qualitative analysis.

Suggestions for Improvement

(a) Teachers must stress with learners the full definitions of the terms, e.g. 'major incident'. Teachers should focus on the definitions in the prescribed textbook. Definitions should be emphasised in both daily assessment and formal assessment.

(b) Learners must be taught to read the whole question before attempting to answer it. Learners could not express themselves when trying to answer the question.

(c) Teachers must ensure that learners know the difference between an *unsafe act* and an *unsafe condition* and the general safety regulations that apply to a workshop.

(d) Teachers should make sure that learners understand the concept of both qualitative risk analysis and quantitative risk analysis. These topics should be included in both daily and formal assessment.

(e) The chapter on occupational health and safety should be taught by teachers and should not be given to learners as self-study work. The use of educational videos on health and safety issues will go a long way to improve learner understanding on health and safety issues.

QUESTION 2: RLC CIRCUITS

Common Errors and Misconceptions

(a) Q2.1 was poorly answered because candidates did not fully understand the concept of impedance in an AC circuit. Candidates confused resistance for impedance and many left out the reference to an 'AC'' circuit.

(b) In Q2.2 the 'phase relationship' between voltage and current waveforms was not illustrated and drawn properly. Candidates could not distinguish between leading and lagging waveforms.

(c) In Q2.3.1 and other sections manipulation of formulae caused a huge problem for the majority of learners. Candidates did not write the correct symbols and some of the units were left out.

(d) In Q2.6.2 candidates did not understand the leading or lagging concept with reference to the current or voltage in RLC circuits.

(e) In Q2.7 candidates could not describe how the value of the resistance affects the bandwidth of an LC tuned circuit.

Suggestions for Improvement

(a) More activities on the manipulation of formulae must be given to learners.

(b) The higher-order understanding of application of circuits and concepts must be revised regularly and thoroughly.

(c) Teachers must explain the terms *leading* and *lagging* with reference to current and voltage in RLC circuits.

(d) Teachers should investigate practical implication and application of RLC circuits which include the bandwidth.

(e) Learners must be advised to use their own (the same) calculator often to familiarize themselves with its operation then work out many examples on the topic to reinforce the mechanics of the application.

QUESTION 3: THREE PHASE AC GENERATION (SPECIFIC)

Common Errors and Misconceptions

(a) In Q3.2 most candidates did not provide the definitions instead they gave formulae.

(b) In Q3.3 most candidates provided advantages for the consumers instead of advantages for the supplier when power factor improves.

(c) In Q3.4.1 most candidates did not provide the disadvantages of single phase AC generation; instead they provided the advantages of three phase AC generation.

(d) In Q3.7.1 most candidates could not substitute correctly. In the following calculation:

They wrote $P_T = P_1 + P_2$
$= 1,2 + 2,3$
$= 3,5\ kW$

instead of $P_T = P_1 + P_2$
$= 1200 + 2300$
$= 3,5\ kW$

NOTE: 1 000, 10^3 or 'k' represents a number and not a unit and should therefore be written in all calculations.

Suggestions for Improvement

(a) 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 for learners to familiarize themselves. This can also be done for other sections where similar misconceptions exist.

(b) This content must be taught as two separate sections i.e. advantages for the consumers and advantages for the supplier. This will enable learners to write out responses without being confused.

(c) The correct reading of the question with understanding is crucial in questions of this nature. Learners will tend to write answers to questions not asked only if they did not read the questions accurately. The skill of reading the questions with understanding can be honed throughout the year though practice. Learners should be taught to analyse the question before they attempt to answer it. In interpreting and understanding of questions, focus should be placed the following verbs: 'explain' why, 'define' the term, 'describe' how and 'explain' operations.

d) Calculations count for approximately 50% of the marks in the question paper. Learners should be taught 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).

$$P_T = P_1 + P_2$$
$$= 1{,}2\,k + 2{,}3\,k$$
$$= 3{,}5\ kW$$

OR

$$P_T = P_1 + P_2$$
$$= 1200 + 2300$$
$$= 3{,}5\ kW$$

OR

$$P_T = P_1 + P_2$$
$$= 1{,}2 \times 10^3 + 2{,}3 \times 10^3$$
$$= 3{,}5\ kW$$

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.

QUESTION 4: THREE-PHASE TRANSFORMER (SPECIFIC)

Common Errors and Misconceptions

(a) In Q4.1 candidates confused losses occurring in transformers to those of motors.

(b) In Q4.4 the working principle of a transformer is a challenge to candidates.

(c) In Q4.6 the challenge was that candidates did not know the purpose of the Bucholtz relay.

(d) In Q4.7.2 learners used the transformation ratio formula to calculate the number of turns and used line values instead of phase values.

(e) Many candidates have problems relating to whether a transformer is a step-up or step-down transformer.

Suggestions for Improvement

(a) Teachers must tabulate losses in transformers and motors on a chart and display it on a wall for learners to read or refer to when necessary. A video from YouTube regarding losses in transformers versus losses in motors can also be used to benefit learners.

(b) Teachers must revise the following topics from Grade 11 as an introduction to transformers in Grade 12: Magnetic Induction, Lenz's Law, and Self and Mutual Induction. The principle of operation of the transformer must be summarised in point form and given to the learners. This method can be used with other circuits.

(c) Teachers must cover the Bucholtz relay in theory and demonstrate the purpose during simulations. Videos can be also used to demonstrate the operation if this relay is not available.

(d) Teachers must show learners when to use line values and phase values when doing calculations. Phase values are always used when calculating the transformation ratio and the number of turns.

(e) Teachers must tabulate the information below in the chart:

Step-up	Step-down
➢ $N_{sec} > N_{pri}$	➢ $N_{sec} < N_{pri}$
➢ $V_{sec} > V_{pri}$	➢ $V_{sec} < V_{pri}$
➢ $I_{sec} < i_{pri}$	➢ $I_{sec} > I_{pri}$
➢ $\frac{N_{sec}}{N_{pri}} > 1$	➢ $\frac{N_{sec}}{N_{pri}} < 1$

QUESTION 5: THREE-PHASE MOTORS AND STARTERS (SPECIFIC)

Common Errors and Misconceptions

(a) In Q5.1 most candidates failed to interpret and analyse the name plate.

(b) The determination in Q5.1.4 of the total number of poles proved to be a difficult task for candidates. Those who attempted it could only calculate the number of pole pairs per phase.

(c) In Q5.1.5 candidates could not differentiate whether the 7,5 kW on the nameplate is an input power or output power. This was evidence when they were substituting for the calculation of efficiency. The 7,5 kW is an output power the motor can deliver to drive the load. Candidates had to calculate the input power by adding the output power and losses.

(d) Most candidates could not explain the purpose of no-volt protection in Q5.2; instead they just said its purpose is to protect.

(e) In Q5.5.1 candidates could not identify the type of the control circuit.

(f) In Q5.5.4 candidates could not explain the operation of the motor control circuit.

Suggestions for Improvement

(a) The name plate is the integral part of any electrical machine. Teachers need to explain each specification on the nameplate of the machine before the machine can be used in a three-phase or single-phase application.

(b) Teachers need to encourage learners to understand the formula in relation to theory. The formula provided in the formula sheet could be used to calculate the pole pairs per phase. To get the total number of poles per phase learners should multiply 'pole pairs per phase' by 2; and to get the total poles for a three phase motor they should you multiply the 'total pole per phase' by 3 phases.

(c) Teachers need to explain each specification on the name plate of the machine before the machine can be used in a three-phase or single-phase application. The 7,5 kW (output power), as one of the specifications, can be explained as well as how it differs to the input power.

(d) This challenge in Q5.2 might be attributed to lack of practical work at school. Teachers must communicate the application of theory using digital media, e.g. the internet or videos.

(e) The control circuits, as stipulated in the CAPS, must be drawn on the chart with components, function and the operation in sequential form.

QUESTION 6: PROGRAMMABLE LOGIC CONTROLLERS (PLCs) (SPECIFIC)

Common Errors and Misconceptions

(a) In Q6.4.1 and Q6.4.2 most candidates could not draw the ladder logic diagram and the truth table correctly. For the ladder logic, the input symbols were not inverted as in the first response from the marking guideline. For the truth table most candidates could not write the logic input (0 and 1) correctly in the table and as a result, it affected the output 'F' Q6.4.1 is drawn incorrectly, it will negatively affect Q6.4.2, because this is a follow-up question.

(b) In Q6.10.2 most candidates could not draw the ladder logic diagram, instead they just replaced the input and output symbols with logic symbols. Others drew it from the right-hand side to left-hand side, others from the bottom to the top.

(c) In Q6.10.3 most candidates could not state the function MC1/NO1 as used in the logic circuit. Candidates could not understand the latching concepts.

(d) In Q6.10.4 most candidates could not state why N/C contact of MC3 is connected in series with the star contactor. Candidates lack basic conceptual knowledge, practical knowledge and skills in this regard.

(e) In Q6.13 most candidates did not explain the purpose of the braking resistor with reference to regenerative braking.

Suggestions for Improvement

(a) The teacher needs to revise the logic gate, truth table and symbols for each gate and program these gates using the PLC unit for better understanding:

- NOT gate
- AND and NAND gate
- OR and NOR gate
- Exclusive OR gate (XOR)

(b) 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, program the ladder logic diagram by using the PLC unit. Note that ladder logic diagrams are drawn from:

- Left power rails with input instruction to write power rails with output instruction
- Top to bottom with rungs connected between two power rails.

Also note that it is important to understand the sequence in which ladder logic is executed, i.e.

- From left to right, and
- Top to bottom.

The ladder logic diagram drawn should use the Engineering Graphics and Design (EGD) approach and not crude freehand drawings.

(c) 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
- The purpose of latching
- Type of contact used for latching, which is normally open contact (N/O).

(d) Teachers should assist learners to:

- Identify the interlocking contacts which are connected in series with delta (which is MC2.N/C) and star MC3.N/C) coils
- The purpose of interlocking
- Correct symbols used for interlocking
- Explain the concept of series connection as used in interlocking circuit.
- Perform the practical experiment.

(e) With regard to Q.6.13 teachers must inform learners of the purpose or function of the braking resistor during the process of regenerative braking. 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 though verbal or visual ways.