basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY: ELECTRONICS

EXAMINATION GUIDELINES

GRADE 12

2021

These guidelines consist of 18 pages.

TABLE OF CONTENTS

1. INTRODUCTION

The *Curriculum and Assessment Policy Statement (CAPS)* for Electrical Technology: Digital outlines the nature and purpose of the subject Electrical Technology. This guides the philosophy underlying the teaching and assessment of the subject in Grade 12.

The purpose of these Examination Guidelines is to:

- Provide clarity on the depth and scope of the content to be assessed in the Grade 12 National Senior Certificate (NSC) Examination in Electrical Technology.
- Assist teachers to adequately prepare learners for the NSC examinations.

This document deals with the final Grade 12 external examinations. It does not deal in any depth with the School-based Assessment (SBA), Performance Assessment Tasks (PATs) or final external practical examinations as these are clarified in a separate PAT document which is updated annually.

These Examination Guidelines should be read in conjunction with:

- *The National Curriculum Statement (NCS) Curriculum and Assessment Policy Statement (CAPS):* Electrical Technology
- The National Protocol of Assessment: *An addendum to the policy document, the National Senior Certificate: A qualification at Level 4 on the National Qualifications Framework (NQF), regarding the National Protocol for Assessment (Grades R–12)*
- The national policy pertaining to the programme and promotion requirements of the National Curriculum Statement, Grades R–12
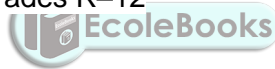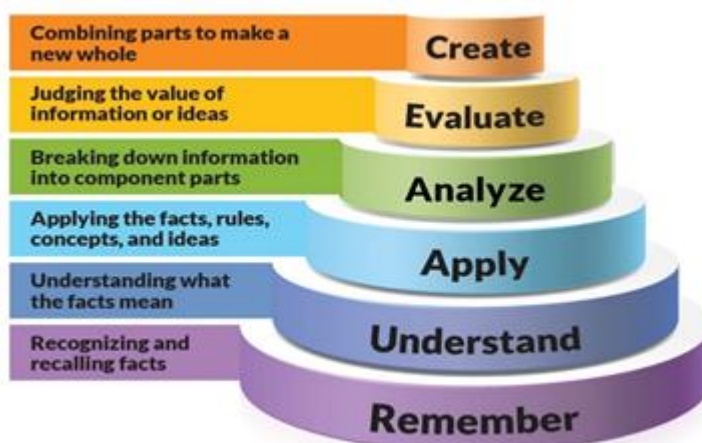
2. ASSESSMENT IN GRADE 12

2.1 Structure/Format of the Question Paper:

QUESTION	TOPIC	MARKS	TIME
	GENERIC – ALL		
1	Multiple-choice Questions	15	14 min.
2	Occupational Health and Safety	10	9 min.
	GENERIC – ELECTRONICS and POWER SYSTEMS		
3	RLC Circuits	35	32 min.
	GENERIC – ELECTRONICS AND DIGITAL ELECTRONICS		
4	Semiconductor Devices	45	40 min.
5	Switching Circuits	50	45 min.
	SPECIFIC		
6	Amplifiers	45	40 min.
	TOTAL	**200**	**180 min.**

2.2 Cognitive Levels

Bloom's Taxonomy consists of six levels, as shown below.

DESCRIPTION OF COGNITIVE LEVEL	LEVEL	EXPLANATION	SKILLS DEMONSTRATED	ACTION VERBS
CREATING	4	The learner creates new ideas and information using the knowledge previously learned or at hand. At the extended abstract level, the learner makes connections, not only within the given subject area, but also beyond it and generalises and transfers the principles and ideas underlying the specific instance. The learner works with relationships and abstract ideas.	• Generating • Planning • Producing • Designing • Inventing • Devising • Making	devise, predict, invent, propose, construct, generate, make, develop, formulate, improve, plan, design, produce, forecast, compile, originate, imagine

DESCRIPTION OF COGNITIVE LEVEL	LEVEL	EXPLANATION	SKILLS DEMONSTRATED	ACTION VERBS
EVALUATING	4	The learner makes decisions based on in-depth reflection, criticism and assessment. The learner works at the extended abstract level.	• Checking • Hypothesising • Critiquing • Experimenting • Judging • Testing • Detecting • Monitoring	combine, integrate, modify, rearrange, substitute, compare, prepare, generalise, rewrite, categorise, combine, compile, reconstruct, organise, justify, argue, prioritise, judge, rate, validate, reject, appraise, rank, decide, criticise
ANALYSING	3	The learner appreciates the significance of the parts in relation to the whole. Various aspects of the knowledge become integrated, the learner shows a deeper understanding and the ability to break down a whole into its component parts. Elements embedded in a whole are identified and the relations among the elements are recognised.	• Organising • Comparing • Deconstructing • Attributing • Outlining • Finding • Structuring • Integrating	analyse, separate, order, explain, connect, classify, arrange, divide, compare, select, infer, break down, contrast, distinguish, draw, illustrate, identify, outline, point out, relate, question, appraise, argue, defend, debate, criticise, probe, examine, investigate, experiment
APPLYING	2	The learner has the ability to use (or apply) knowledge and skills in other familiar situations and new situations.	• Implementing • Carrying out • Using • Executing	apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover, construct, manipulate, prepare, produce, draw, make, compile, compute, sequence, interpret
UNDERSTANDING AND ROUTINE APPLICATIONS		The learner grasps the meaning of information by interpreting and translating what has been learned.	• Exemplifying • Comparing • Explaining • Inferring • Classifying	summarise, describe, interpret, calculate, contrast, associate, distinguish, estimate, differentiate, discuss, extend, comprehend, convert, explain, give example, rewrite, infer, review, observe, give main idea
REMEMBERING	1	The learner is able to recall, remember and restate facts and other learned information.	• Recognising • Listing • Describing • Identifying • Retrieving • Recalling • Naming	list, define, tell, describe, identify, show, know, label, collect, select, reproduce, match, recognise, examine, quote, name

BASIC SKILLS LINKED TO THE SUBJECT:

The following skills are measured in the question paper. Visibility of these skills gives an indication of the overall skills required in the subject:
- Ability to follow instructions
- Identifying labels/labelling/making drawings/diagrams/schematic representations
- Plotting and interpretation of graphs/data
- Working out and interpreting calculations ,
- Organising/Recording and categorising data
- Extraction and/or manipulation and/or evaluation of data
- Explaining functional operation of circuits and/or components

NOTE:

CALCULATIONS	WAVEFORMS/FLOWCHARTS/CIRCUITS
Generally the criteria used for calculations are as follows: • Correct formula • Substitution of values • Simplifying of values • Answer and correct units	Waveforms will be assessed according to the following criteria: • Type of waveform (input/output) • Correct labelling • Correct plotting of values (correct values, proportional plotting) • Labelling and units on Y-axis • Labelling and units on X-axis • Phase relationship

3.   ELABORATION OF CONTENT FOR GRADE 12 (*CAPS*)

TOPIC	PRESCRIBED CONTENT	MARKS
Multiple-choice	Covers all content	15
Occupational health and safety	**OHS Act, 1993 (Act 85 of 1993)** • Definitions • Purpose of the Act • General duties of employers to their employees • General duties of employers and self-employed persons to persons other than their employees • General duties of manufacturers and others regarding articles and substances for use at work • Duty to inform • General duties of employees at work • Duty not to interfere with, damage or misuse devices/items • Functions of health and safety representatives • Report to inspector regarding certain incidents • Victimisation forbidden • Offences, penalties and special orders of court **Safety Revision** • Unsafe actions • Unsafe conditions • Dangerous practices • Risk analysis • Human rights in the workplace • Work ethics • Revision of emergency procedures (Grade 10)	10

RLC circuits (generic)	• Effect of alternating current on R, L and C components in series and parallel circuits.	
	• Describe/Define/Explain the following concepts and terminologies of RLC series and parallel circuits in words (not formulae):	
	➢ Impedance	
	➢ Inductive reactance	
	➢ Capacitive reactance	
	➢ Power factor	
	➢ Phase angle	
	➢ True power,	
	➢ Resonant frequency	
	➢ Q-factor	
	➢ Bandwidth	
	• Calculating the following in RLC series and parallel circuits containing ONE resistor, ONE capacitor and ONE inductor:	
	➢ Frequency	
	➢ Inductance	
	➢ Inductive reactance	
	➢ Capacitance	
	➢ Capacitive reactance	
	➢ Impedance	
	➢ True power	
	➢ Power factor	
	➢ Phase angle	
	➢ Voltage drop	
	➢ Total current	
	➢ Capacitive current	
	➢ Inductive current	
	➢ Q-factor	
	➢ Bandwidth	
	➢ Resonant frequency	
	• Drawing of the phasor and wave representation of RLC circuits	
	• Applications of RLC circuits	
	• Conditions of series and parallel resonant circuits	
	• Drawing of phasor diagrams of series, parallel and resonant circuits	
	• Drawing of the characteristics curve and phasor diagram of resonant circuits	
	• Illustrate the effect of changing frequency in an RLC circuit toward resonance	
	Calculations	
	• Series RLC circuits containing ONE resistor, ONE capacitor and ONE inductor	
	• Parallel RLC circuits containing ONE resistor, ONE capacitor and ONE inductor	(35)

Semi-conductor devices	**The field-effect transistor**
	 • Basic construction, draw symbols, explain the functional operation and characteristics of all prescribed FETs
	 • Types of FET (NFET, JFET, MOSFET)
	 • Characteristics curves and typical operating voltages
	 • Application as a switch
	 • Application as an amplifier
	
	 Unijunction and Darlington transistor
	 • Basic construction, draw symbols and explain the functional operation and characteristics of the UJT and Darlington transistor
	 • Characteristics curves and typical operating voltages
	 • Application as a switch
	 • Application as a saw-tooth generator
	 • Application as an amplifier
	
	 Introducing integrated circuits
	 • **The 741 op amp**
	    ➢ Basic construction, draw symbols and explain the functional operation of the 741 op amp.
	    ➢ Typical operating voltages
	    ➢ Characteristics of an ideal op amp and application as an amplifier.
	    ➢ Gain: Identify, explain and differentiate between open-loop and closed-loop gain
	    ➢ Application as an inverting amplifier
	    ➢ Application as an non-inverting amplifier
	
	 Calculations
	 • Inverting amplifier
	    ➢ Output voltage $V_{OUT} = V_{IN} \times \left(-\dfrac{R_F}{R_{IN}} \right)$
	
	    ➢ Gain $A_V = \dfrac{V_{OUT}}{V_{IN}} = -\left(\dfrac{R_F}{R_{IN}} \right)$
	 • Non-inverting amplifier
	    ➢ Output voltage $V_{OUT} = V_{IN} \times \left(1 + \dfrac{R_F}{R_{IN}} \right)$
	
	    ➢ Gain $A_V = \dfrac{V_{OUT}}{V_{IN}} = \left(1 + \dfrac{R_F}{R_{IN}} \right)$
	
	 • **Integrated circuits – the 555 timer**
	    ➢ Basic construction, symbols and the functional operation of the 555 timer.
	    ➢ Characteristic curves and typical operating voltages
	    ➢ Application as a timer
		(45)

Switching circuits	**Principle of operation of switching circuits using operational amplifiers and 555 timers.**	
	NOTE:	
	• In multivibrators, use the 741 op amp **and** 555 timer.	
	• In Schmitt trigger, comparator, summing amplifier, differentiator and integrator use **only** the 741 op amp.	
	Multivibrators	
	• **Bistable multivibrator**	
	➢ Circuit diagram, function of components and operation. (Identify, draw and explain)	
	➢ Measurements and drawing of input and output waveform	
	• **Mono-stable multivibrators**	
	➢ Circuit diagram, function of components and operation. (Identify, draw and explain)	
	➢ Measurements and drawing of input and output waveforms.	
	• **Astable multivibrators**	
	➢ Circuit diagram function of components and operation. (Identify, draw and explain)	
	➢ Measurements and drawing of input and output waveforms	
	• **Schmitt trigger**	
	➢ Circuit diagram, function of components and operation. (Identify, draw and explain)	
	➢ Output waveform in relation to the input waveform as displayed on an oscilloscope. (Identify, draw and explain)	
	• **Comparator and summing amplifier**	
	➢ Circuit diagram, function of components and operation. (Identify, draw and explain)	
	➢ Output waveform in relation to the input waveform as displayed on an oscilloscope. (Identify, draw and explain)	
	• **Calculations:**	
	➢ $V_{out} = V_{in} \times Gain$	
	➢ $V_{out} = V_{in1}\left(\frac{R_f}{R_{in1}}\right) + V_{in2}\left(\frac{R_f}{R_{in2}}\right) + \ldots + V_{inN}\left(\frac{R_f}{R_{inN}}\right)$	
	➢ Measurements of input and output waveforms.	
	• **Differentiator and integrator**	
	➢ Circuit diagram, function of components and operation. (Identify, draw and explain)	
	➢ Output waveform in relation to the input waveform as displayed on an oscilloscope. (Identify, draw and explain)	
	➢ Influence of time constant on the output waveform. (Identify, draw and explain)	(50)

Amplifiers	**Amplifier theory**	
	• Determination of a typical load line by means of Ohm's law (drawing the load line, explain Q-point, effects of changing the supply voltage and the load resistance of the circuit)	
	• Basic concepts of class A, B, C and AB amplifiers (explain, differentiate, describe and draw waveforms)	
	• Principles of negative feedback/the decibel and log (explain, list/name effects of negative feedback)	
	Resistor capacitor-coupled amplifier (NPN transistor)	
	• Basic operation	
	• Circuit diagram (function/purpose of the components)	
	• Frequency response curve (explain, draw, label)	
	• Gain and loss in decibel calculations (voltage, current and power)	
	• Different types of biasing	
	• Input and output characteristic curves	
	• Input and output waveforms (draw the output waveforms using EGD approach)	
	Transformer-coupled amplifier (NPN transistor)	
	• Basic operation	
	• Circuit diagram (function/purpose of the components)	
	• Frequency-response curve (explain, discuss, draw and label)	
	• Input and output characteristic curves	
	• Input and output waveforms (draw the output waveforms using EGD approach)	
	Push-pull amplifier (NPN/PNP transistor)	
	• Basic operation	
	• Circuit diagram (function and purpose of the components)	
	• Input and output characteristic curves of class A, class B, class AB and class C (define, explain, differentiate, compare, draw)	
	• Input and output waveforms (draw the output waveforms using EGD approach)	
	• Gain and loss in decibel calculations (voltage, current and power gain and loss attenuation)	
	• Typical biasing	
	Radio-frequency amplifier	
	• Basic operation	
	• Circuit diagram (function/purpose of components, amplifier and feedback circuit)	
	• Input and output characteristic curves	
	• Input and output waveforms (draw the output waveforms using EGD approach)	
	• Frequency-response curve (analyse, draw, identify, label)	
	• Gain and loss in decibel calculations	
	• Biasing	

	Hartley and Colpitts oscillator (NPN of FET transistor) • Basic operation • Circuit diagram (function/purpose of components, amplifier and feedback circuit) • Output waveform (draw the output waveforms using EGD approach) • Tank circuit (draw, explain, differentiate and operation) **RC phase-shift oscillator (NPN of FET transistor)** • Basic operation • Circuit diagram (function/purpose of the components, amplifier and feedback circuit) • Output waveform (draw the output waveform using EGD approach) • Feedback circuit (compare, differentiate, purpose/function, explain, discuss)		(45)
	TOTAL	**200**

4.   PREPARING LEARNERS FOR THE NSC: ELECTRICAL TECHNOLOGY

Learners do not intuitively know how to answer a question paper successfully. Teachers need to prepare learners to have the skills needed to negotiate a question paper successfully.

This preparation process starts in Grade 10 and culminates in Grade 12. Learners need to be coached in some of the following skills, which will help them in answering the question paper effectively:

Manipulation of formulae: The learners must learn how to use the standard formula, manipulate the formula correctly, correctly substitute values and remember to always add a value/unit with an answer.

Prefixes and units: Learners must have a clear understanding of the conversion and uses of units and abbreviations, such as kilo, milli, micro, nano, etc. Teachers should drill leaners on this skill.

Learners must be taught on how to approach a question paper and ANSWER BOOK.

Planning the answers: Learners must know how to answer in a chronological order of sequence and know how much space should be taken up by a typical answer. Do not break questions up and answer it haphazardly out of order. Ensure the numbering convention in the question paper is followed in the ANSWER BOOK.

Open spaces in the ANSWER BOOK: Teachers should encourage learners to answer ALL questions, including subquestions, and not leaving open spaces. Even when learners are unsure of the expected response, they are urged to answer to the best of their ability. This may lead their train of thoughts in the correct direction leading the learner to a correct or partially correct answer. Where learners leave an open space to proceed with the question paper, they should be taught to return to that space when the rest of the question paper is completed.

Teachers are urged to pay attention to Bloom's Taxonomy and should prepare learners to answer basic recall questions as well as more complex and intricate sentence-type questions, e.g. the paragraph- type answers such as the operation of a transformer.

Learners should be coached to regularly read questions and answers to homework and tests aloud in the class.

Teachers must encourage learners to engage in intelligent debate and discussion around subject content and on how an answer should be constructed. Learners must know how to structure their sentences in order to communicate what they are trying to say.

Learners must learn how to list facts. Answers are assessed on the principle of a single mark for a single fact.

Teachers must show the learners the difference between a sketch, a symbol and what a block diagram represents.

Below is an example of a sketch. It was drawn freehand and is a resemblance of a real-world device. Marks are awarded for drawings WITH LABELS. A drawing cannot be assessed without labels.
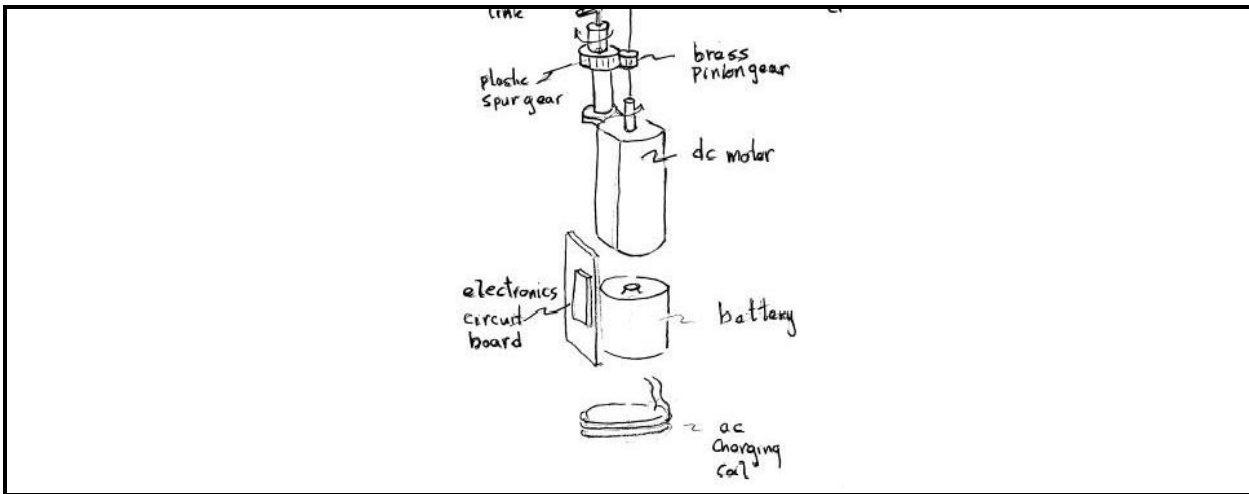

FIGURE 1: SKETCH

Symbols: Symbols are simple representations of electronic devices and relates to the theory of how the device works and not necessarily to the appearance of the device. Without labelling and a title, it cannot be marked effectively.
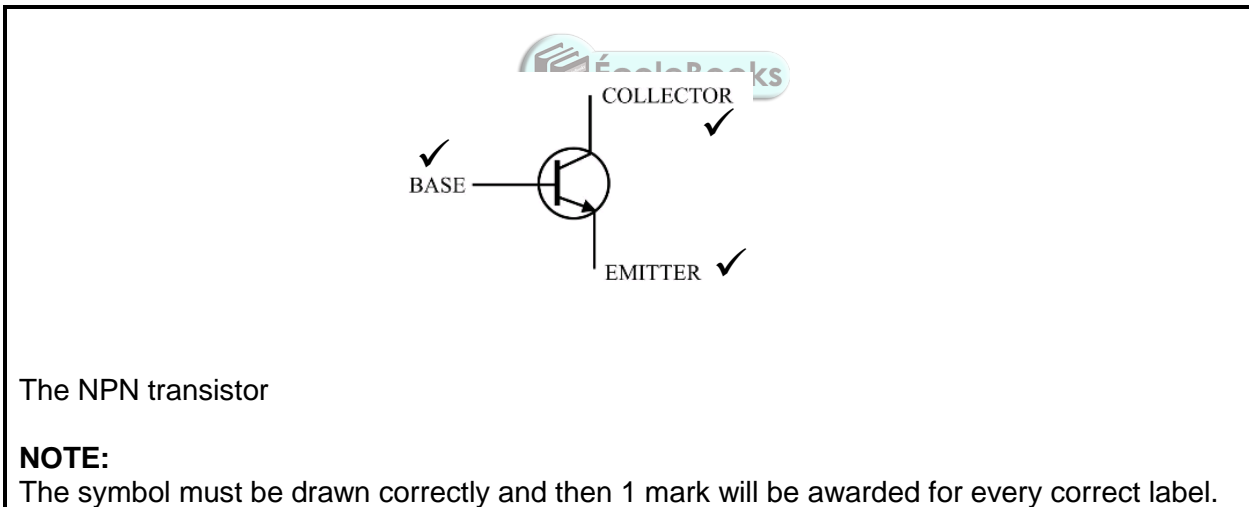

The NPN transistor

NOTE:
The symbol must be drawn correctly and then 1 mark will be awarded for every correct label.

FIGURE 2: SYMBOL AND HOW IT IS MARKED

Block diagrams: Block diagrams are used extensively in Electrical Technology. It usually relates to processes and how devices operate. They are representative of the operation of a system/device and may not contain any physical resemblance to the device. Note that block diagrams may be given semi-complete, requiring the learner to fill or complete the other sections.
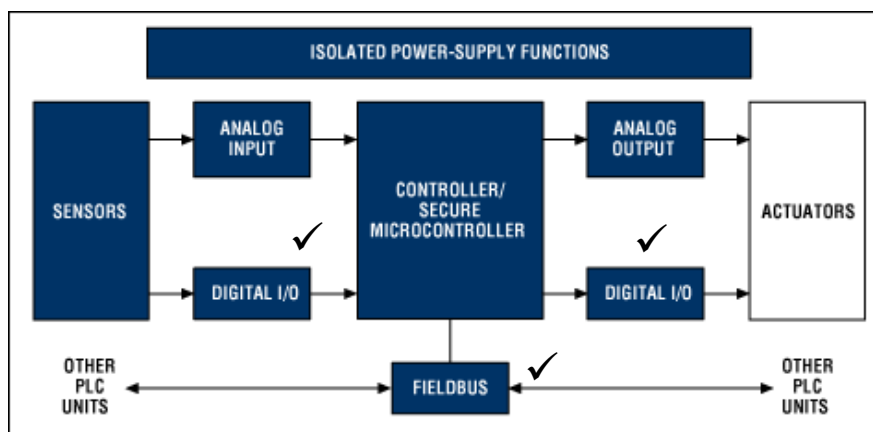

FIGURE 3: BLOCK DIAGRAM

All sketches, symbols, diagrams and waveforms must always be labelled and have a caption.

Learners must be shown how to interpret and use waveforms to support their answers.

Ladder logic: Ladder logic diagrams must be labelled and have each of the operands identified.
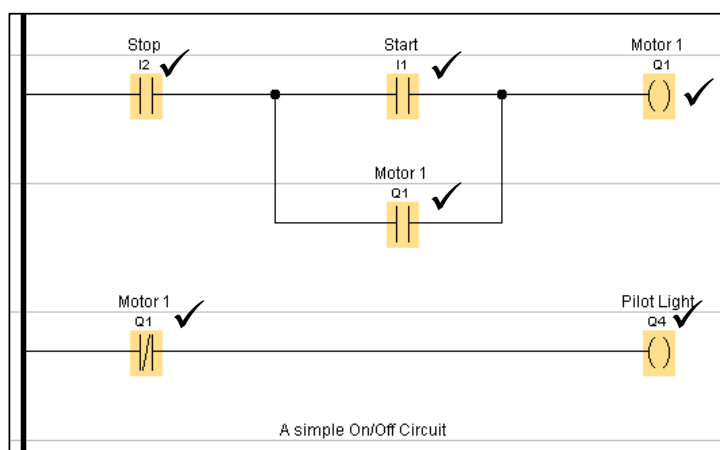

FIGURE 4: LADDER LOGIC

Sketches, diagrams and waveforms should be clear, not too small and easily interpretable.

Guard against small and illegible drawings.

Circuit diagrams: Circuit diagrams are marked on the following premise:

- The circuit or portion of the circuit must be correct.
- All components must have labels.
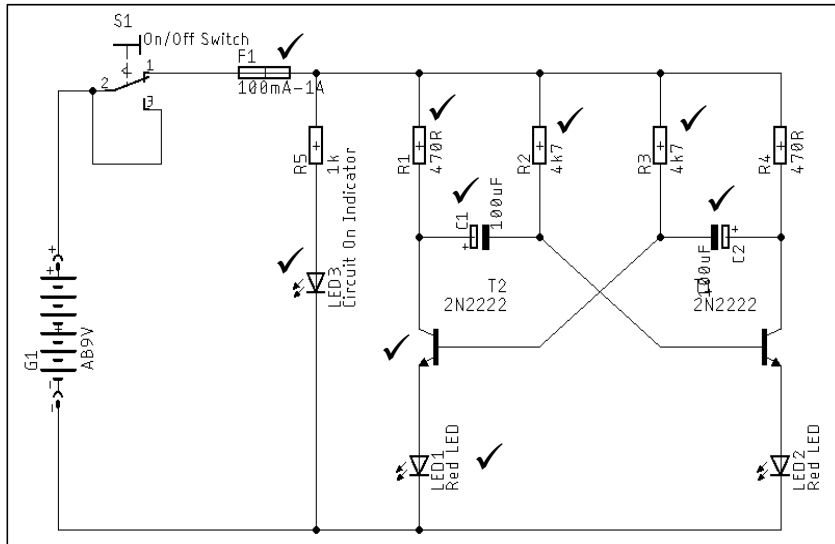- Note that whole circuits or portions of a circuit may be given and interrogated.

FIGURE 5: CIRCUIT DIAGRAM

Calculations:

Calculations should be done showing ALL steps.
Values must be placed correctly.
Units allocated to the calculation must be shown.
Wrong units will result in the answer being marked wrong.
No units will result in the answer being marked wrong.

It is good practice to draw a line underneath the final answer ending it in a small arrow. This indicates that the calculation is done.

$$F_r = \frac{1}{2\pi\sqrt{LC}} \qquad \checkmark$$

$$= \frac{1}{2\pi\sqrt{0.15 x 47 x 10^{-6}}} \qquad \checkmark$$

$$= 59.94 \, Hz \qquad \checkmark$$

FIGURE 6: A CALCULATION AND HOW TO MARK IT

Lines must be drawn between questions.

Rough work should be labelled as rough work and have a line drawn through it.

Power factor (Cosθ): When using the power factor, learners should note whether they are given the power factor or the phase angle. Learners use the power factor as an angle, resulting in their answers being incorrect.

Phasor diagrams should always include an arrow showing its direction of rotation. As a phasor is a rotating vector and always rotates anticlockwise, it is required of learners to show this when doing graphical representations of phasors.
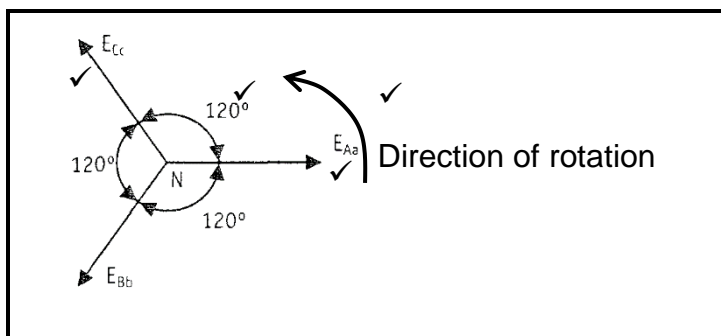

FIGURE 7: PHASOR DIAGRAM

Input and output waveforms: It is common in Electrical Technology to enquire from the learner what the result of an input waveform in a circuit may have on the output of the circuit. This is because the principle of input, process, output forms the cornerstone of how electric and electronic circuits operate.

By placing input and output waveforms directly underneath each other, in a synchronised fashion, the manner in which a circuit will affect a waveform is easily illustrated. The same applies to digital circuits.
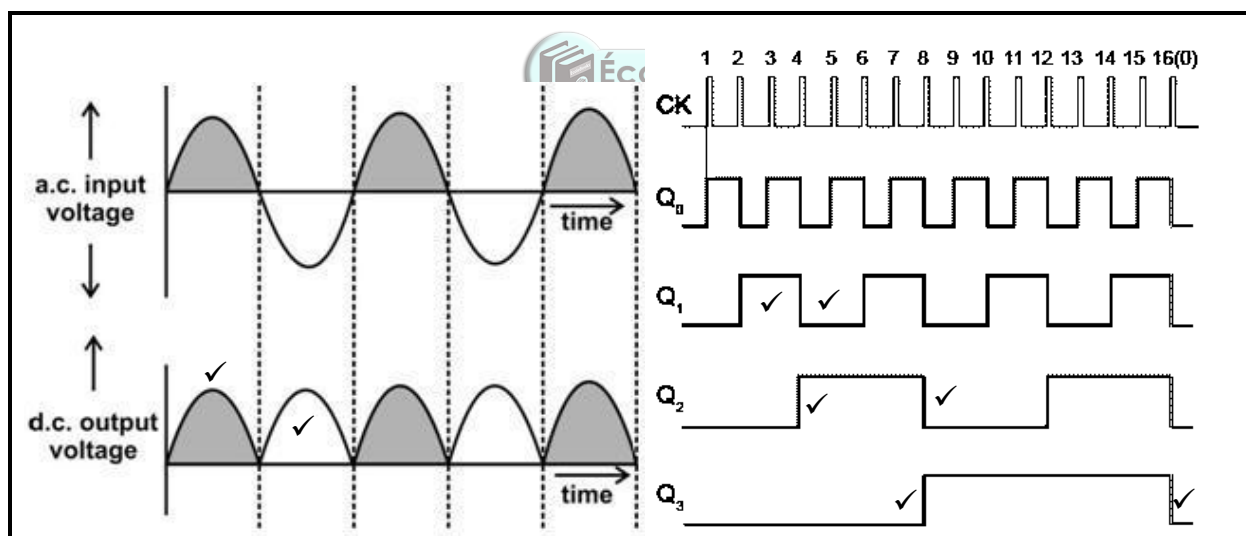

FIGURE 8: INPUT AND OUTPUT WAVEFORMS

5. FORMULA SHEET: DIGITAL ELECTRONICS

NOTE: This formula sheet is only a guide and may not contain ALL the formulae as in the prescribed textbook and/or *CAPS* policy document.

RLC CIRCUITS

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$P = V \times I \cos\theta$$

$$BW = \frac{f_r}{Q}$$

Series

$$I_T = \frac{V_T}{Z}$$

$$V_L = I X_L$$

$$V_C = I X_C$$

$$V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{V_C}{V_S} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$\cos\theta = \frac{R}{Z}$$

$$\cos\theta = \frac{V_R}{V_T}$$

Parallel

$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I_R = \frac{V_R}{R}$$

$$I_L = \frac{V_L}{X_L}$$

$$I_C = \frac{V_C}{X_C}$$

$$\cos\theta = \frac{I_R}{I_T}$$

$$Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{I_L}{I_S} = \frac{I_C}{I_S} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

SEMICONDUCTOR DEVICES

Gain $A_V = \dfrac{V_{OUT}}{V_{IN}} = -\left(\dfrac{R_F}{R_{IN}}\right)$ *Inverting amplifier*

$V_{OUT} = V_{IN} \times \left(-\dfrac{R_F}{R_{IN}}\right)$ *Inverting amplifier*

Gain $A_V = \dfrac{V_{OUT}}{V_{IN}} = \left(1 + \dfrac{R_F}{R_{IN}}\right)$ *Non-inverting amplifier*

$V_{OUT} = V_{IN} \times \left(1 + \dfrac{R_F}{R_{IN}}\right)$ *Non-inverting amplifier*

SWITCHING CIRCUITS

$V_{OUT} = -(V_1 + V_2 + V_3)$ Summing amplifier

$$V_{OUT} = V_{IN}1 \times \left(-\frac{R_F}{R_1}\right) + V_{IN}2 \times \left(-\frac{R_F}{R_2}\right) + \dots V_{IN}N \times \left(-\frac{R_F}{R_N}\right)$$

AMPLIFIERS

$$I_C = \frac{V_C}{R_C}$$

$$V_{CC} = V_{CE} + I_C R_C$$

$$A = \beta_1 \times \beta_2$$

$$P_O = I^2 \times Z_O$$

$$A_i = 20\log\frac{I_O}{I_i}$$

$$A_V = 20\log\frac{V_O}{V_i} \quad \textbf{OR} \quad A_{v(dB)} = 20\log A_V$$

$$A_P = 10\log\frac{P_O}{P_i}$$

       Please turn over

6.   CONCLUSION

It is envisaged that these Examination Guidelines will serve as an instrument to strengthen and empower teachers to set valid and reliable assessment items in all their classroom activities.

This Examination Guidelines document is meant to articulate the assessment aspirations espoused in the CAPS document. It is therefore not a substitute for the CAPS document which teachers should teach to.

Qualitative curriculum coverage as enunciated in the CAPS cannot be over-emphasised.