higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

REPORT 191 PROGRAMMES

SUBJECT SYLLABUS

ELECTROTECHNICS N4

SUBJECT CODE: 8080074

IMPLEMENTATION: JANUARY 2021

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Syllabus: Electrotechnics N4

1. General Aims

To provide students with knowledge and skills that are used in an electrical industry.
To develop students' ability to solve electrical problems and adhere to safety standards and procedures.

2 Specific Aims

- The student should obtain a thorough background of the necessity for Electrotechnics as it is applied in industry.
- The student should be able to classify individual electrical components into various stages as found in electrical apparatus on his/her own.
- The teaching of this subject is aimed at:

  - Introduction to the application of technological principles such as design procedures; and
  - The relationship between Electrotechnology and other scientific subjects.

3. Pre-requisite

Student must meet at least one of the following requirements.

3.1 Completed National N3 certificate with Electrotechnology N3 or Electrical Trade Theory N3.
3.2 Passed grade 12 with at least level 4 (50% or D symbol) in Mathematics and Natural Science or Electrical subjects.
3.3 Completed NCV level 4 in any engineering programme.
3.4 Passed senior certificate for adult learners with at least level 4 (50% or D symbol) in Mathematics and Physical Science.

4. Duration

Full-time: 7.5 hours per week. This instructional offering may also be offered part-time.

5. Evaluation

5.1 Evaluation is conducted continuously by means of two formal tests at College level. Learner must obtain a minimum ICASS mark of at least 40% in order to qualify to write the final examination and a mark will be calculated together in a ratio of 40:60 to derive the promotion mark. The learner must obtain at least 40% on the final examination.

The promotion mark will be calculated as follows:
Promotion Mark **= 40%** of (ICASS mark) **+ 60%** of (Exam mark)

5.2 The examination in Electrotechnics N4 (Engineering Studies - Report 191) will be conducted as follows:

Modules 1 to 7 MARKS: 100

DURATION: 3 HOURS

CLOSED BOOK: Formula sheet is attached to the question paper
Scientific calculators allowed
No programmable calculators allowed
No references allowed.
No external examination papers or memoranda allowed

5.3 Weighting:

The following weights are consequently awarded to each category:

Knowledge and Understanding	Applying	Analysing / Synthesis and Evaluating
30 – 40	30 – 40	20 – 25

6. Learning content

THEORETICAL BACKGROUND

It is essential that this subject should be illustrated and evaluated within the context of practical case studies.

TECHNICAL BACKGROUND

It is essential that this subject should be illustrated and evaluated within the context of technical skills and simulation of practical environment.

7. Mark allocation in the examination as an indication of the weighting of the different modules

MODULES	WEIGHTING
1. Principles of Electricity	**30**
2. DC-machines	**20**
3. AC-Theory	**20**
4. Transformers	**10**
5. AC-machines	**10**
6. Generation and supply of AC-Power	**5**
7. Measuring Instruments	**5**
TOTAL	**100**

Module 1: Principles of Electricity
General aim

On completion of this module, the student should be able to explain the theoretical and practical application of the following concepts: electrical circuits, electromagnetism, magnetic circuits, Inductance in DC-circuits, Capacitors in DC-circuits, Kirchhoff's Laws and Norton's Theorems.

LEARNING CONTENT	**LEARNING OUTCOMES** **The student must be able to:**
1.1 Electric circuits	1.1.1 Explain the difference between EMF (Electro-Motive Force) and terminal voltage.
	1.1.2 Draw labelled circuit diagrams of resistive series-, parallel- and series/parallel networks and determine by calculation: ▪ Electro-Motive Force; ▪ Terminal voltage; ▪ Voltage drops; ▪ Current flowing in each branch; ▪ Values of resistors; ▪ Power and energy.
1.2 Resistivity	1.2.1 List the factors that will affect the resistance of a conductive material and explain the effect of each factor.
	1.2.2 Calculate the following with regards to conductive material: ▪ Resistance; ▪ Resistivity; ▪ Length; ▪ Cross-sectional area ▪ Current; and ▪ Voltage drop.
	1.2.3 Explain reasons for connecting conductors in parallel.
	1.2.4 Calculate the following with regards to parallel connected conductor materials; ▪ Resistance; ▪ Resistivity; ▪ Length; ▪ Cross-sectional area ▪ Current; and ▪ Voltage drop.

1.3 Temperature coefficient of resistance	1.3.1	Define the temperature coefficient of resistance and explain the effect of positive and negative temperature coefficient of resistance.
	1.3.2	Calculate the following items when temperature of resistance is at 0^{0}C and when temperature coefficient of resistance is at an initial temperature: ▪ Temperature coefficient of resistance ▪ Initial or final temperature; and ▪ Initial or final resistance.
1.4 Kirchhoff's Laws	1.4.1	State Kirchhoff's first- and second Laws. (Voltage- and Current Laws). The use of relevant network diagrams to enhance your description is imperative.
	1.4.2	Draw relevant labelled circuit diagrams and determine by calculation regarding Kirchhoff's Laws: ▪ EMF; ▪ Terminal voltage; ▪ Voltage drops; ▪ Current; ▪ Values of resistors ▪ Power and energy.
1.5 Norton's Theorem	1.5.1	State Norton's Theorem and use relevant network diagrams to enhance your description.
	1.5.2	Draw relevant labelled circuit diagrams and determine by calculation regarding Norton's Theorem: ▪ Load resistance; ▪ Load current; ▪ Load voltage; ▪ Short circuit current; ▪ Open circuit resistance; The use of relevant network diagrams is imperative, and sources are limited to TWO.
1.6. Magnetism and Electromagnetic Induction	1.6.1	List the characteristics of magnetic field lines and the applications of electromagnetic induction.
	1.6.2	State the following Laws and rules and use relevant sketches where applicable to enhance your description: ▪ Right-hand rule to determine the direction of magnetic field lines around a current carrying conductor; ▪ Right-hand grip rule; ▪ Fleming's left-hand rule; ▪ Fleming's right-hand rule; ▪ Lenz's Law; and ▪ Faraday's Law
	1.6.3	Calculate the following regarding a magnetic circuit: ▪ MMF; ▪ Number of turns;

	▪ Current; ▪ Reluctance; ▪ Magnetic field strength; ▪ Magnetic flux; and ▪ Flux density.
	1.6.4 Calculate the following regarding a current carrying conductor: ▪ Force exerted; ▪ Length of conductor; ▪ Flux density; and ▪ Current carrying capacity.
	1.6.5 Calculate the following regarding electromagnetic induction: ▪ EMF; ▪ Magnetic flux; ▪ Inductance; ▪ Current; ▪ Time; and ▪ Number of turns.
1.7 Capacitors	1.7.1 Define the following concepts: ▪ Capacitance ▪ Farad ▪ Coulomb;
	1.7.2 Explain with the aid of suitable graphic representations the charge- and discharge characteristics
	1.7.3 Draw labelled circuit diagrams of capacitor series-, parallel- and series/parallel networks and determine by calculation: ▪ Total capacitance; ▪ Accumulated charge; and ▪ Voltage drops.

Module 2: Direct-Current Machines
General aim

On completion of this module, the student should be able to explain and apply the construction, operation of DC-Machines including performing all relevant calculations.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:	
2.1 Construction of DC-machines	2.1.1	Draw DC-machine that will illustrate the construction and label the main parts
	2.1.2	List and explain the function of each component of a DC-machine.
	2.1.3	Explain and show by means of labelled sketches the difference between lap- and wave-wound armature winding constructions.
	2.1.4	Explain the different applications of lap-wound and wave-wound machines.
2.2 Operation of DC-machines	2.2.1	Explain the principle of operation of a DC-motor and DC-generator.
	2.2.2	Explain the function of the brushes in DC-machines and list different types of brushes in use and why such brushes are used.
	2.2.3	Define and list the effects of armature reaction in DC-machines.
	2.2.4	Describe the methods used in minimising the effects of armature reaction in DC-machines.
	2.2.5	Describe the effects of commutation in DC-machines.
	2.2.6	Describe the methods of improving commutation in DC-machines.
2.3 Field winding of DC-machines	2.3.1	Draw and label circuit diagrams for the following self-excited DC-machines: ▪ Series wound; ▪ Shunt wound; ▪ Long shunt compound wound; and ▪ Short shunt compound wound.
	2.3.2	Calculate the following quantities with regards to series-wound DC-motors and generators, shunt-wound DC-motor and generator, long shunt compound wound DC-motor and generator and short shunt compound wound DC-motor and generator: ▪ EMF; ▪ Speed; ▪ Magnetic flux; ▪ Number of poles; ▪ Number of parallel paths; ▪ Armature conductors;

		▪ Terminal voltage; ▪ Supply current; ▪ Field current; ▪ Armature current; ▪ Field resistance; and ▪ Armature resistance.
2.4 Characteristics and applications of DC-machines	2.4.1	List the characteristics of DC-motors and DC-generators.
	2.4.2	Describe applications of series, shunt, short shunt compound and long shunt compound DC-motors and generators.
2.5. DC-motor starters	2.5.1	Explain the purpose of a DC-motor starter.
	2.5.2	Draw and label circuit diagrams to illustrate how a face-plate starter is connected in a DC-series and shunt DC-motor.
	2.5.3	Calculate the following quantities with regards to DC-motor starters: Starting current; Starter resistance; and Terminal voltage.
2.6 No-load / Open Circuit characteristics of DC-motor	2.6.1	Draw a no-load characteristic curve of a DC-motor, using the field current and EMF generated.
	2.6.2	Calculate the critical resistance and the value of voltage to which the machine will excite under no- load from the no-load characteristic curve of a DC-motor

Module 3: Alternating-current Theory

General aim

On completion of this module, the student should be able to explain the generation of EMF, series and parallel RLC circuits and power in single-phase AC- circuits.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:
3.1 Generation of EMF	3.1.1 Illustrate by means of a graphic representation the generation of an alternating quantity of voltage and current with respect to time.
	3.1.2 Calculate the following quantities with regard to an alternating quantity: ▪ Maximum value; ▪ RMS value (Root Mean Square); ▪ Average value; ▪ Instantaneous value; ▪ Frequency; ▪ Time; ▪ Period; ▪ Angular velocity; ▪ Form-factor; and ▪ Crest-factor.
	3.1.3 Define with regard to an alternating quantity: ▪ Period; ▪ Cycle; ▪ Instantaneous value; ▪ Form-factor; and ▪ Crest-factor.
3.2 RLC-circuits	3.2.1 Draw phasor diagrams and wave forms of voltage versus current relationship in single-phase circuit when an alternation quantity is applied to a: ▪ Resistor; ▪ Inductor; and ▪ Capacitor.
	3.2.2 Draw a circuit diagram for series and parallel RLC-circuits and calculate the following: Resistance; Inductance; Inductive reactance; Capacitance; Capacitive reactance; Impedance; Voltage drops; Supply voltage; Current; Phase angle; Power; and Power factor.

3.3 Power in AC-circuits	3.3.1	Describe and calculate: True power; Apparent power; Reactive power; and Power factor.
	3.3.2	Describe the effects of low power factor.
	3.3.3	Describe methods of improving low power factor.

Module 4: Transformers
General aim

On completion of this module, the student should be able to explain and apply principle of operation of single-phase transformer, construction of single-phase transformers and perform relevant calculations for the following quantities: current~~s~~, voltages, turns ratio, flux, power and power factor.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:
4.1 Basic construction of a single-phase transformer	4.1.1 Draw and label the basic construction of a single-phase transformer.
4.2. Basic operation of a single-phase transformer	4.2.1 Explain the basic operation of a single-phase transformer
	4.2.2 Describe the characteristics of an ideal transformer.
	4.2.3 Use the transformer equation to calculate the following quantities with regard to single-phase transformers; ▪ Turns ratio; ▪ Voltages; ▪ Number of turns; ▪ Flux density; and ▪ Power.
4.3 Transformer on no-load	4.3.1 Draw and label circuit diagram and vector diagram of a transformer with no-load.
	4.3.2 Calculate the following with regards to a transformer with no load: ▪ No load current; ▪ Core loss current; ▪ Magnetising current; ▪ Power; and ▪ Power factor.
4.4 Transformer cooling	4.4.1 Describe the methods used for the cooling of transformers.
4.5 Transformer losses	4.5.1 List types of transformer losses that can occur in a transformer.

Module 5: AC-machines
General aim

On completion of this module, the student should be able to explain and apply the principle of operation of single-phase and three-phase motors, construction of single phase- and three phase induction motor.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:	
5.1 Basic construction of induction motor	5.1.1	Describe the three main parts of an induction motor.
	5.1.2	Describe the two types of rotors of a three-phase induction motor
5.2 Basic operation of an induction motor	5.2.1	Explain the basic operation of a three-phase induction motor.
	5.2.2	Define slip. Explain the function of slip. Calculate the following with regards to an induction motor: ▪ Slip; ▪ Frequency; ▪ Poles; ▪ Synchronous speed; and ▪ Rotor speed.
	5.2.3	Describe the applications of an induction motor.
5.3 Motor starters	5.3.1	▪ Draw labelled circuit diagrams for a single-phase induction motor that makes use of: ▪ Resistance starting; ▪ Capacitor starting; and ▪ Capacitor start capacitor run.
	5.3.2	Explain how to reverse the rotation of an induction motor.

Module 6: Generation and supply of AC power

General aim

On completion of this module, the student should be able to explain power generation, transmission and distribution of AC-power to consumers.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:	
6.1 Generation	6.1.1	Describe different types of power stations.
	6.1.2	Explain reasons for power stations to be far away from load centres.
6.2. Transmission	6.2.1	Explain reasons for transmission of power at high voltage.
6.3. Distribution	6.3.1	Describe and draw diagrams of types of feeders and explain the advantages and disadvantages of each type of feeder.

Module 7: Measuring instruments
General aim

On completion of this module, the student should be able to explain the principle of extending the range of measuring instruments, calculate series- and shunt resistance values and resistive values with the aid of the ammeter-voltmeter method.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:	
7.1 Instrument shunt- and series additional components.	7.1.1	Explain the purpose of shunt and series resistors in measuring instruments.
	7.1.2	Calculate the resistor values required when voltage and/or current is measured in order to extend the range of the volt meter and ammeter: ▪ Shunt resistors; and ▪ Series resistors.
7.2 Measurement of resistance	7.2.1	Apply short- and long shunt voltage-ammeter method to calculate the following; ▪ Apparent resistance value; ▪ Exact resistance value; and ▪ Percentage error value.
	7.2.2	Apply the results of Wheatstone Bridge experiment to calculate the value of the unknown resistor