higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

REPORT 191 PROGRAMMES

SYLLABUS

Electrical Trade Theory

N2

Implementation: May 2021

1. INTRODUCTION

1.1 General Aims

This subject provides an introduction to the basics of Electrical Trade Theory and introduces the learning at an elementary level. It is assumed that students have no previous electrical background and knowledge. Students learn how to plan and prepare for an electrical installation job in accordance with job requirements, relevant standards and appropriate workplace procedures to enable them to understand electrical installation and maintenance.

Electrical Trade Theory N2 will equip students with relevant theoretical knowledge to enable them to integrate meaningfully into:

- electrical apprenticeship;
- electrical learnership;
- electrical contracting environment;
- industrial environment; and
- power utility environment

1.2 Specific Aims

Electrical Trade Theory strives to assist students to obtain trade-specific skills, knowledge, values and attitudes so that they can explain how electricity is applied. Students should be able to acquire in-depth knowledge of the following content:

1.2.1 Safety precautions
1.2.2 Fire and fire fighting
1.2.3 Hand and power tools
1.2.4 Direct current theory
1.2.5 Conductors and insulating materials
1.2.6 Wiring of premises
1.2.7 Testing of a single phase
1.2.8 Magnetism and electromagnetism
1.2.9 Renewable energies

2. Admission requirement

Passed grade 9 or equivalent

3. Duration

The duration of the subject is one trimester on full time, part time or distance learning mode.

4. Evaluation

Candidates must be evaluated continually as follows:

4.1 ICASS Trimester Mark

4.1.1 **Two** formal class tests for full time and part time students (or **Two** assignments for distance learning students only)

4.1.2 Obtain a minimum of 40% in order to qualify to write the final examination.

4.1.3 Assessment marks are valid for a period of one year and are referred to as ICASS Trimester marks.

4.1.4 Calculation of trimester mark

Weight of test or assignment 1 = 30% of the syllabus

Weight of test or assignment 2 = 70% of the syllabus

4.2 Examination

4.2.1 The examination shall consist of 100 % of the syllabus

4.2.2 Duration shall be 3 hours

4.2.3 Minimum pass percentage shall be 40%

4.2.4 Closed book examination

4.2.5 Knowledge, understanding, application and evaluation are important aspects of the subject and should be weighted as follows:

Knowledge	Understanding	Application	Evaluation
60%	20%	15%	5%

4.3 Promotion Mark

The promotion mark consisting of the combination of the Trimester and Examination marks, shall be a minimum of 40%

4.4 Weight value of modules

Module	Description	Weight Value (%)
1.	Safety precautions	10
2.	Fire and Fire fighting	5
3.	Hand and power tools	5
4.	Direct Current theory	30
5.	Conductors and insulating materials	5
6.	Wiring of premises	25
7.	Testing of a single phase	5
8.	Magnetism and electromagnetism	10
9.	Renewable energies	5
TOTAL		**100%**

5. General Information

5.1 The regulations as prescribed in the SANS 10142-1 as amended, must be used in conjunction with each relevant section of work. All symbols and measurements must be in accordance with International Electrical Committee (IEC) and System International of Unites (SI) standards

5.2 Practical examples and values must be used in all calculations.

5.3 Neat, fully labelled and large drawings must be presented where such is required.

5.4 Students should be encouraged to provide in their answers the number of facts according to the number of marks allocated

5.4 All calculations should in engineering notation are restricted to a maximum of three decimal places.

1. Subject aims

1.1 General aims

To equip learners with relevant theoretical knowledge to enable the learners to integrate meaningfully into:

1.1.1 an electrical apprenticeship
1.1.2 an electrical learnership
1.1.3 an electrical contracting environment
1.1.4 a power utility environment

1.2 Specific aims

Learners should acquire in-depth knowledge of the following subject outcomes:

1.2.1 Alternating current circuit theory
1.2.2 Conductors, insulators and cables
1.2.3 Electrical reticulation
1.2.4 Switchgear and protective devices
1.2.5 Batteries
1.2.6 Direct current machines
1.2.7 Alternating current machines
1.2.8 Transformers
1.2.9 Earthing
1.2.10 Measuring instruments
1.2.11 Renewable energy

2. Prerequisite

Learners must satisfy the following requirements:

2.1 Passed N1

3. Duration

The duration of this instructional offering is one trimester full-time, part-time or distance learning mode.

4. Evaluation

4.1 Trimester mark

Learners will write TWO formal class tests and must obtain a minimum trimester mark of 40% in order to qualify to write the final examination. The trimester mark shall be calculated as follows:

Trimester mark = 30% of Test 1 + 70% of Test 2

4.2 Examination mark

The examination for this instructional offering will be conducted at the end of each trimester and as follows:

Modules 1- = 100 marks
Duration = Three hours
Minimum pass mark = 40%
Closed book examination
Scientific (non-programmable) calculators are allowed
A formula sheet is to accompany the question paper

4.3 Promotion mark

The promotion mark shall be calculated as follows:

Promotion mark = 40% of Trimester mark + 60% of Examination mark

5. Assessment

Recall, understanding, application and evaluation are important criteria necessary to assess the learner's knowledge and understanding of the subject outcomes and shall be weighted as follows during any assessment:

Recall	Understanding	Application	Evaluation
55%	15%	20%	10%

6. Mark allocation and weight value

Module	Calculation type question	Theory and drawing type question	Weight value
1	07	05	12
2	03	09	12
3	00	08	08
4	00	10	10
5	00	10	10
6	00	10	10
7	00	08	08
8	05	05	10
9	00	10	10
10	03	03	06
11	00	04	04
TOTALS	**18%**	**82%**	**100%**

7. General information

7.1 The regulations as prescribed in the South African National Standard (SANS 10142-1) as amended, must be used with each relevant section of this curriculum.

7.2 All symbols and units of measurement must be in accordance with the following:

7.2.1 IEC (International Electro-technical Commission)
7.2.2 SI (International System of units)

7.3 Practical examples, realistic values and current data must be used in all calculations and explanations.

7.4 Neat, fully labelled and large drawings must be presented when such is required. The learner's artistic ability is not to be evaluated.

7.5 Learners should be encouraged to provide in their answers the number of facts according to the number of marks allocated.

7.6 For calculation type questions the following must be done:

7.6.1 State the formula used

7.6.2 Show the substitution

7.6.3 Round off all answers correct to three decimal places

7.6.4 Show the SI unit

Module 1: Alternating current circuit theory

General aim

Upon completion of this module, learners should be able to demonstrate understanding of dynamically and statically induced emfs, the power triangle and star and delta connections in a three-phase system

LEARNING CONTENT	LEARNING OUTCOMES The learner must be able to:
1.1 Dynamically induced emf	1.1.1 Calculate the magnitude of an emf induced in a rotating conductor
	1.1.2 Calculate the magnitude of instantaneous currents and emfs
	1.1.3 Define the following terms: • Instantaneous value • Average value • RMS value • Form factor • Maximum value
	1.1.4 Calculate the form factor of a sinusoidal wave
1.2 Statically induced emf	1.2.1 Explain how emfs can be statically induced (self and mutually induced)
1.3 The power triangle	1.3.1 Calculate the three powers in single-phase and three-phase circuits
	1.3.2 Define power factor
	1.3.3 Calculate power factor
1.4 Three-phase circuits	1.4.1 Draw circuit diagrams to illustrate star and delta connections
	1.4.2 State the relationship between phase and line values in a star and delta connected system

Module 2: Conductors, insulators and cables

General aim

Upon completion of this module, learners should be able to demonstrate understanding of conductors and their properties, insulators and their properties, cables and their properties, conductor and cable joints, methods of installing cables and the factors to be considered when selecting a cable for a particular application.

.LEARNING CONTENT	**LEARNING OUTCOMES** **The learner must be able to:**
2.1 Conductors	2.1.1 State the purpose of a conductor
	2.1.2 State the properties and uses of the following conductors: • Gold • Silver • Copper • Aluminium • carbon
	2.1.3 State the methods used to join conductors
	2.1.4 State the requirements of a good conductor joint
2.2 Insulators	2.2.1 State the function of an insulator
	2.2.2 State the properties and uses of the following insulators: • PVC • XLPE • Glass • Ceramic • Asbestos • Porcelain • Mica • Bakelite • Silicone • Magnesium oxide
2.3 Cables	2.3.1 Define the following: • Cable • Flexible cable • Flexible cord
	2.3.2 Draw and label the following: • A PVC-insulated, wire-armoured cable

	• PILCSWA cable • PILCSTA cable • XLPE-insulated cable
	2.3.3 State the functions of each part of a PVC-insulated, wire-armoured cable
	2.3.4 State the advantages and disadvantages of the following cables: • PVC-insulated • Paper-insulated • XLPE-insulated
	2.3.5 State the requirements of a good cable joint
	2.3.6 State the basic steps that must be followed when making a cable joint
	2.3.7 Identify low voltage and high voltage cable joints
	2.3.8 Explain how a simple low-voltage resin joint is made
	2.3.9 State the factors to be considered when selecting a cable for a particular application.
	2.3.10 State the methods used to install cables and state also the advantages and disadvantages of each method.

Module 3: Electrical reticulation

General aim

Upon completion of this module, learners should be able to demonstrate understanding of a typical reticulation system which comprises of generation, transmission, distribution and utilisation, why transmission lines have no neutral conductors, advantages and disadvantages of the various distribution systems.

LEARNING CONTENT	**LEARNING <u>OUTCOMES</u>** **The learner must be able to:**
3.1 Reticulation networks	3.1.1 State what is an electrical reticulation network
	3.1.2 Name the sections that make up an electrical reticulation network
	3.1.3 Draw a typical electrical reticulation network and state the typical voltage at

	each stage
	3.1.4 State the functions of the step up and step down transformers
3.2 Generation	3.2.1 Name the different types of power stations found in our Country
	3.2.2 State why power stations are situated far away from major load centres
3.3 Transmission	3.3.1 State the advantages and disadvantages of high voltage transmission
	3.3.2 State why there is no neutral conductor in a high voltage transmission line
3.4 Distribution	3.4.1 Name the different types of supply systems
	3.4.2 State the advantages and disadvantages of the various supply systems
	3.4.3 Draw simple diagrams to illustrate radial and ring feeders

Module 4: Switchgear and Protective devices

General aim

Upon completion of this module, learners should be able to demonstrate understanding of the different types of switchgear, the various types of faults that could occur in electrical systems, the protective devices used to protect against the harmful effects of these faults, how these protective devices operate.

LEARNING CONTENT	**LEARNING <u>OUTCOMES</u>** **The learner must be able to:**
4.1 Switchgear	4.1.1 State the purpose of electrical switchgear
	4.1.2 Name the switchgear used for the following functions: • Isolating • Control • Protection
4.2 Switchgear- Isolating	4.2.1 Explain the difference between a disconnector and a switch disconnector
4.3 Switchgear-control	4.3.1 Explain the operation and application of the following: • Relays

	• Contactors • Timers • Day-night switch
4.4 Protective devices	4.4.1 State the protective device used to protect against the harmful effects of the following faults: • Short-circuits • Overloads and over-currents • Earth leakage current • High voltage surges • Lightning discharges • Transient faults in overhead lines • Phase imbalance
	4.4.2 With the aid of fully labelled diagrams explain the operation of the protective devices used to protect against the faults mentioned in 4.4.1 above.

Module 5: Batteries

General aim

On completion of this module, learners should be able to demonstrate understanding of the different types of batteries and their uses; construction, operation, care and maintenance of gel, lead acid and lithium-ion batteries.

LEARNING CONTENT	**LEARNING <u>OUTCOMES</u> The learner must be able to:**
5.1 Gel batteries	5.1.1 Explain the construction of a gel battery
	5.1.2 State the application of gel batteries
	5.1.3 Explain how a gel battery is charged
	5.1.4 Describe the care and maintenance of gel batteries
5.2 Lead-acid battery	5.2.1 Describe the construction of a lead-acid battery
	5.2.2 Explain the operation of a lead-acid battery
	5.2.3 Describe the care and maintenance of lead-acid batteries

	5.2.4 State the advantages and disadvantages of lead-acid batteries
	5.2.5 Explain the term relative density and state how it is measured
	6.2.6 State the factors that influence the capacity of lead-acid batteries
	6.2.7 Explain the following: • Open-circuit voltage test • Load test
6.3 Lithium-ion batteries	6.3.1 Describe the construction of a lithium-ion battery
	6.3.2 Describe the operation of a lithium-ion battery
	6.3.3 State the advantages and disadvantages of a lithium-ion battery
	6.3.4 Describe the care and maintenance of lithium-ion batteries

Module 6: Direct current machines

General aim

On completion of this module, learners should be able to demonstrate understanding of the construction of DC machines, the operation of motors and generators, circuit diagrams of the different types of self-excited machines.

LEARNING CONTENT	**LEARNING <u>OUTCOMES</u> The learner must be able to:**
6.1 Function and construction	6.1.1 State the functions of motors and generators in terms of energy conversion
	6.1.2 Draw a cross-section of a simple two-pole DC machine and show the following labels: yoke, terminal box, field poles, pole shoes, field windings, interpoles, compensating windings, air-gap and armature
	6.1.3 Make a simple sketch of the armature assembly and clearly show the following: shaft, bearings, cooling fan, armature core and commutator
	6.1.4 Make a simple sketch of a brush-gear and clearly show the following: brush

		holder, brush and spring
6.2 Operation of DC motors	6.2.1	Explain with the aid of suitable diagrams, the operation of a DC motor
	6.2.2	Explain armature reaction
	6.2.3	Draw fully labelled circuit diagrams of a shunt, series and compound motor
	6.2.4	Explain the concept 'back emf' and also state how it makes a motor self-regulating
	6.2.5	State the function of a face-plate starter
	6.2.6	Explain with the aid of a suitable diagram how a face-plate starter is used to start the following motors • Series motor • Shunt motor
	6.2.7	Show by means of fully labelled circuit diagrams how the direction of rotation of the following DC motors can be changed: • Series motor • Shunt motor • Long-shunt motor • Short-shunt motor
6.3 Operation of DC generators	6.3.1	Explain with the aid of diagrams the operation of a DC generator
	6.3.2	Explain with the aid of simple sketches, the concept commutation
	6.3.3	State how sparking between the commutator and brush can be reduced or how commutation can be improved
	6.3.4	Explain with the aid of circuit diagrams the difference between separately and self-excited generators
	6.3.5	Draw fully labelled circuit diagrams of a shunt, series and compound generator

Module 7: Alternating current machines

General aim

On completion of this module, learners should be able to demonstrate understanding of the operation of the different types of single-phase motors and three-phase induction motors, how the direction of rotation of these motors is achieved and how these motors are tested.

LEARNING CONTENT	LEARNING OUTCOMES The learner must be able to:
7.1 Types of AC machines	7.1.1 Name the two major categories of AC machines
7.2 Single-phase motors	7.2.1 State the different types of single-phase motors
	7.2.2 With the aid of suitable diagrams, explain the construction and operation of the following motors: • Split phase motors • Capacitor-start induction-run motors • Capacitor-start capacitor-run motor • Shaded pole motors • Universal motors
	7.2.3 State the applications of these motors
	7.2.4 State how the direction of rotation of these motors can be reversed
	7.2.5 Explain how single-phase motors are tested
7.3 Three-phase induction motors	7.3.1 Explain the construction and operation of a three-phase induction motor
	7.3.2 Show by means of circuit diagrams how the stator windings are connected
	7.3.3 State the applications of this motor
	7.3.4 Explain by means of circuit diagrams how this motor is tested
	7.3.5 State the advantages and disadvantages of three-phase motors over single-phase motors

Module 8: Transformers

General aim

On completion of this module, learners should be able to demonstrate understanding of the function and construction of a transformer, the operation of a transformer on and off-load, the four three-phase transformer configurations.

LEARNING CONTENT	LEARNING OUTCOMES The learner must be able to:
8.1 Function and construction of a single-phase transformer	8.1.1 State the function of a transformer in terms of voltage and current
	8.1.2 Describe with the aid of a diagram the construction of a single-phase transformer
8.2 Operation	8.2.1 Explain with the aid of a circuit diagram the operation of a single-phase transformer
	8.2.2 Draw the equivalent circuit diagram of a transformer working at no-load
	8.2.3 Draw the vector diagram of a transformer working at no-load
	8.2.4 State why transformers are rated in kVA and not kW.
	8.2.5 Calculate transformer rating and turns ratio of single-phase transformers (ideal transformers only)
	8.2.6 Using the no-load vector diagram, calculate the magnetising and core-loss components of the no-load current
	8.2.7 State the functions of the magnetising and core-loss components
8.3 Three-phase transformers	8.3.1 State the four common three-phase transformer configurations
	8.3.2 Draw circuit diagrams to show how three single-phase transformers are connected

	to form one of the following three-phase transformers: • Star/star • Star/delta • Delta/delta • Delta/star
	8.3.3 Name the three-phase transformer used for distribution purposes in residential areas and state why.
	8.3.4 Calculate transformer rating and turns ratio of three-phase transformers (ideal transformers only)

Module 9: Earthing

General aim

On completion of this module, learners should be able to demonstrate understanding of leakage current, the earthing chain, bonding to earth, touch voltage, floating earth, earthing of overhead lines and the earthing of underground cables.

LEARNING CONTENT	LEARNING <u>OUTCOMES</u> The learner must be able to:
9.1 The earthing chain	9.1.1 Explain what is leakage current
	9.1.2 State the purpose of earthing
	9.1.3 State the function of the earthing chain
	9.1.4 Show by means of a drawing how leakage current from any part of the installation is directed to ground
	9.1.5 Explain the following concepts: • bonding to earth • floating earth • touch voltage
9.2 Earthing of overhead lines	9.2.1 Explain earthing of overhead lines
9.3 Earthing of underground cables	9.3.1 Explain the earthing of wire armoured cables

	9.3.2 Explain the earthing of lead-sheathed cables

Module 10: Measuring instruments

General aim

On completion of this module, learners should be able to demonstrate understanding of how measuring instruments are connected to low and high voltage circuits and how the range of a galvanometer is extended.

LEARNING CONTENT	**LEARNING <u>OUTCOMES</u>** **The learner must be able to:**
10.1 Low-voltage measurement	10.1.1 Show by means of circuit diagrams how the following measuring instruments are connected to a low-voltage circuit: • Ammeter • Voltmeter • Wattmeter • Power factor meter • Frequency meter • Energy meter
10.2 High-voltage measurement	10.2.1 Show by means of circuit diagrams how the following measuring instruments are connected to a high-voltage circuit: • Ammeter • Voltmeter • Wattmeter • Power factor meter • Frequency meter • Energy meter
10.3 Range extension	10.3.1 Explain what is a galvanometer
	10.3.2 Explain how a galvanometer can be used to measure bigger currents
	10.3.3 Explain how a galvanometer can be used to measure bigger voltages
10.4 Digital measuring instruments	10.4.1 Explain what is a digital measuring instrument
	10.4.2 Explain how you would use a digital instrument

	10.4.3	Describe the care and maintenance of digital and analogue measuring instruments
	10.4.4	State the advantages and disadvantages of digital measuring instruments

Module 11: Renewable energy

General aim

On completion of this module, learners should be able to demonstrate understanding of the different types of renewable energy, how renewable energy sources are used to produce electricity, layout of a typical power plant using renewable energy sources.

LEARNING CONTENT	**LEARNING <u>OUTCOMES</u>** **The learner must be able to:**	
11.1 Renewable energy	11.1.1	Explain the difference between renewable an non-renewable energy sources
	11.1.2	Explain how renewable energy sources are used to produce electricity (excluding solar energy)
	11.1.3	Draw a layout of a typical power plant in which the prime-mover is operated by a source of renewable energy