higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

REPORT 191 PROGRAMMES

SYLLABUS

Electrotechnics

N6

SUBJECT CODE: 8080086

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Syllabus: Electrotechnics N6

1. General aims

To provide students with knowledge and skills that are used in an electrical industry.

To teach students how to calculate, draw and construct various electrical circuits according to electrical standards and procedures.

To enable students how to solve electrical problems and adhere to safety standards and procedures.

To prepare and empower students with skills to do maintenance and fault finding in electrical circuits and machinery at working environment.

2. Specific aims

2.1 To equip student with knowledge and skills required to maintain DC machines, operate them on their highest performance level.

2.2 To enable students to understand the theory of alternating current in order to apply their knowledge and skills correctly to all alternating current circuits including harmonics.

2.3 To enable student to understand operating principles and equivalent circuits of single phase transformers on load as well as without the load and fully understand the loading and conditions for transformers when connected in parallel

2.4 To equip student with skills on how to connect wattmeters in three-phase systems and determine the total power measured.

2.5 To enable students to understand the construction, operation and efficiency of single phase and three phase AC machines and their application.

2.6 To enable students to understand the process of how electricity is supplied to consumer from generation power stations and understand all factors affecting the efficiency of the short, medium and long transmission line.

3. Prerequisite

Student must meet the following requirements

Passed Electrotechnics N5

4. Duration

Full-time: 6 hours per week for a period of 10 weeks (One Trimester)

Part-time: This instructional offering may also be offered part-time.

5. Evaluation

5.1 Evaluation is conducted continuously by means of Two Formal Tests. Learner must obtain a minimum Trimester mark of at least 40% in order to qualify to write final examination.

The learner must obtain at least 40% on the final examination.

The promotion mark will be calculated as follows:

Promotion Mark **= 40%** of (Trimester mark) **+ 60%** of (Exam mark)

5.2 The examination in Electrotechnics N5 (Engineering Studies - Report 191) will be conducted as follows:

Modules 1 to 5 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:

Remembering	Understanding	Applying	Analysing	Evaluating	Creating
5 – 10	5 – 10	40 – 45	20 – 25	5 – 10	5 - 10

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

Module	**Calculation questions**	**Theory questions (drawings included)**	**Total percentage**
DC machines	±10%	±5%	±15%
AC Theory	±13%	±2%	±15%
Transformers	±10%	±5%	±15%
AC machines	±25%	±5%	±30%
Generation and supply of AC power	±20%	±5%	±25%
TOTAL	**±78%**	**±22%**	**100%**

Module 1: Direct Current Machines

General aim

Upon completion of this module, learners should be able to demonstrate understanding of speed control calculations, load sharing of generators working in parallel, and efficiency testing of DC machines using direct and indirect methods.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:
1.1 Speed control of DC motors	1.1.1 Explain normal speed, below normal speed and above normal speed of DC motors.
	1.1.2 Explain how speed control of a DC motor is achieved by: • Varying the voltage across the armature • Series-parallel control method • Ward-Leonard control system • Varying the value of the main magnetic flux/ field current
	1.1.3 Perform calculations with regards to speed control of shunt and series motors. Speed control being achieved by inserting a resistor in: • Series with the shunt field • In series with the armature • In parallel with the series field
	1.1.4 Interpret the magnetisation curve of a DC motor
	1.1.5 Determine the speed, current, EMF, torque of a DC motor (after inserting the resistor) by using the formulae
	1.1.6 Interpret the following conditions: • Flux suddenly changes • Current drawn from the mains is to remain unchanged • The ohmic voltage drops are negligible

1.2 Load sharing of generators working in parallel	1.2.1 Explain with the aid of a diagram the procedure to parallel two generators
	1.2.2 Explain how the total load is shared by the two generators
	1.2.3 Perform calculations to determine the portion of total load supplied by each generator
	1.2.4 Show by means of circuit diagrams how the following generators are used to supply a common load • Two shunt generators • Two series generators • Two compound generators
1.3 Efficiency testing of DC machines	1.3.1 List, classify and calculate the different losses that occur in DC machines
	1.3.2 Determine the efficiency of any small DC machine by using the following direct method • Rope brake • Prony brake
	1.3.3 Determine the efficiency of large shunt and compound wound machines by using the following indirect methods • Summation of losses or Swinburne method • Regenerative or Hopkinson back-to-back method
	1.3.4 State the condition for maximum efficiency and also calculate maximum efficiency

Module 2: Alternating current theory

General aim

Upon completion of this module, learners should be able to demonstrate understanding of three-phase unbalanced star and delta-connected loads, unbalanced star-connected loads with no neutral connection and the application of a complex wave to various RLC circuits.

LEARNING CONTENT	**LEARNING OUTCOMES** **The student must be able to:**
2.1 Unbalanced three-phase loads	2.1.1 Calculate the phase currents, line currents, power per phase, impedance and total power drawn by three-phase unbalanced star and delta-connected loads.
	2.1.2 Use vector diagrams to determine the line currents drawn by three-phase unbalanced star and delta-connected loads
2.2 Unbalanced star-connected load with a missing neutral	2.2.1 Explain the impact of a missing neutral on a three-phase circuit
	2.2.2 List the common causes of a missing neutral
	2.2.3 Calculate the potential difference between the star point of the load and the neutral point of the supply
	2.2.4 Determine the potential difference across each phase of the load
	2.2.5 Determine the current flowing through each line or phase of the load
2.3 Complex waves	2.3.1 Explain the concept "complex wave"
	2.3.2 Draw a complex wave comprising of the fundamental component together with any harmonic component
	2.3.3 List the causes and effects of harmonic components on circuits
	2.3.4 Write the mathematical expression of complex waves
	2.3.5 Calculate the following after a complex wave is applied across a series or

		parallel or series-parallel circuit: • Expression for current • Expression for voltage • RMS value of current • RMS value of voltage • Average value of current • Av value of voltage • Power drawn by circuits • Power factor of circuits • Energy consumed by circuits
	2.3.6	Calculate the power drawn by circuits that resonate at the frequency of any of the harmonic components

Module 3: Transformers

General aim

Upon completion of this module, learners should be able to demonstrate understanding of the equivalent circuit diagrams and vector diagrams of single-phase transformers on no-load and full-load, voltage regulation of transformers, efficiency of transformers, three-phase transformer connections, heat run tests on transformers, autotransformers, effects of harmonic currents and harmonic voltages on transformers.

LEARNING CONTENT	LEARNING OUTCOMES The student must be able to:	
3.1 Equivalent circuit diagrams of a single-phase transformer	3.1.1	Draw the equivalent circuit diagram and vector diagram of a transformer on no-load
	3.1.2	Draw the equivalent circuit diagram and vector diagram of a transformer on full-load
	3.1.3	Determine the equivalent resistance, reactance and impedance of a transformer referred to primary side and secondary side, using any of the following: • Method of referring with primary values, secondary values and transformer ration • From given percentage or per unit values • Results obtained from the short-circuit test

3.2 Voltage regulation of a transformer	3.2.1	Define voltage regulation of a transformer
	3.2.2	Calculate the voltage regulation of transformers supplying loads working at unity, lagging and leading power factor using any of the following: • Method of referring with primary values, secondary values and transformer ration • From given percentage or per unit values • Results obtained from the short-circuit test
3.3 Efficiency of transformers	3.3.1	List, classify and calculate the various losses that occur in a transformer
	3.3.2	Explain with the aid of circuit diagrams how the open-circuit and short-circuit tests are conducted on a single-phase transformer
	3.3.3	Determine the efficiency of a transformer at any load
	3.3.4	Determine the maximum efficiency of a transformer
3.4 Transformer connections	3.4.1	Draw circuit diagrams to illustrate the following types of transformer connections: • Star/star • Delta/delta • Star/delta • Delta/star • Open delta • Scott connection
3.5 Heat run tests on transformers	3.5.1	State the function of heat run tests
	3.5.2	Explain using a suitable circuit diagram how the open-delta heat run test is conducted
	3.5.3	Explain using a circuit diagram how the Sumpner back-to-back test is conducted
3.6 Harmonics in transformers	3.6.1	State the effects of harmonic voltages and harmonic currents on transformers
3.7 Autotransformers	3.7.1	Draw circuit diagrams to illustrate a step-down and a step-up transformer
	3.7.2	State the advantages and disadvantages of an autotransformer

Module 4: AC machines

General aim

Upon completion of this module, learners should be able to demonstrate understanding of the EMF equation of a synchronous alternator, parallel operation of alternators, voltage regulation of alternators, starting of synchronous motors, operation of synchronous motors under conditions of constant load and varying excitation, constant excitation and varying load, hunting of synchronous motors, energy flow in induction motors, torque developed by the rotor of an induction motor, construction of circle diagrams and the interpretation of a circle diagram.

LEARNING CONTENT	LEARNING OUTCOMES **The student must be able to:**	
4.1 The EMF equation of a synchronous alternator	4.1.1	Define and calculate distribution factor, pitch factor and form factor
	4.1.2	Calculate the open-circuit voltage generated by single-phase and three-phase synchronous alternators
4.2. Parallel operation of alternators	4.2.1	State the factors to be satisfied before two alternators are made to operate in parallel
	4.2.2	Calculate the synchronising power of two single-phase alternators working in parallel or two three-phase alternators working in parallel
4.3 Voltage regulation of alternators	4.3.1	Define voltage regulation of an alternator
	4.3.2	Explain by means of circuit diagrams how the open-circuit and short-circuit tests are conducted on an alternator
	4.3.3	Determine the voltage regulation of an alternator using the ampere turn and synchronous impedance methods
	4.3.4	Determine the voltage regulation of alternators operating at the following power factors: • Unity • Lagging • leading
	4.3.5	Explain the concept of infinite busbars

4.4 Synchronous motors	4.4.1 Explain how synchronous motors are started
	4.4.2 State the characteristics and applications of synchronous motors
	4.4.3 Explain by means of vector diagrams the operation of a synchronous motor under the condition of constant excitation, varying load
	4.4.4 Explain by means of vector diagrams the operation of a synchronous motor under the condition of constant load, varying excitation
	4.4.5 Calculate using vector diagrams, the generated EMF, load angle, power developed and the torque developed by a synchronous motor
	4.4.6 Explain the concept of hunting of a synchronous motor and also its causes and effects
	4.4.7 Explain what are V-curves with regards to synchronous motors
4.5 Three-phase induction motors	4.5.1 Explain using the energy flow diagram, the flow of energy from the supply to the motor's output
	4.5.2 Calculate the rotor current and rotor copper loss at any condition of slip
	4.5.3 Calculate the torque developed by the rotor
	4.5.4 State the condition for maximum torque and also calculate maximum torque
	4.5.5 Draw the circuit diagram, simplified circuit diagram and the vector diagram of an induction motor
	4.5.6 Explain how by using a double cage rotor improves the starting torque of an induction motor
	4.5.7 Explain braking of induction motors by the methods of plugging and DC injection
	4.5.8 Use the results obtained from the no-load and locked rotor tests conducted on an induction motor to construct the circle diagram for the following conditions: • Maximum output • Full-load • Maximum torque

	4.5.9 Determine from the circle diagram the following: • Line current of the motor • Constant losses • Stator copper loss at standstill • Rotor copper loss at standstill • Stator copper loss • Rotor copper loss • Total losses • Rotor output • Rotor input • Efficiency • Slip • Power factor • Torque in synchronous watts • Input power • Torque developed

Module 5: Generation and supply of AC power

General aim

Upon completion of this module, learners should demonstrate understanding of the detrimental effects of a poor power factor, methods used to improve poor power factor, drawing of power triangles before and after power factor correction using capacitor banks or synchronous condensers, determine the efficiency of medium transmission lines using the nominal 'T' and nominal $'\pi'$ methods.

LEARNING CONTENT	LEARNING <u>OUTCOMES</u> **The student must be able to:**
5.1. Power factor correction	5.1.1 State the effects of a poor power factor and the methods used to improve power factor
	5.1.2 Draw the power triangle (vector diagram) of a plant before and after power factor correction
	5.1.3 Determine the rating of capacitor banks required to improve power factor to any desired value
	5.1.4 Determine the size of individual capacitors required to build single-phase and three-phase (star and delta-connected) capacitor banks

	5.1.5	Draw the power triangle (vector diagram) of a plant before and after the installation of a synchronous condenser
	5.1.6	Determine the overall power factor of a plant after the installation of a synchronous condenser working at either unity power factor or a leading power factor
	5.1.7	Draw the vector diagram to determine the final connected load of a plant by combining the power triangles of all known loads
	5.1.8	Calculate the final connected load of a plant
5.2 Medium transmission lines	5.2.1	Define voltage regulation of a transmission line
	5.2.2	Draw circuit diagram and determine the efficiency of transmission lines using the nominal 'T' method
	5.2.3	Draw circuit diagram and determine the efficiency of transmission lines using the nominal 'π' method