education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

ELECTRO TECHNOLOGY

NQF Level 3

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ELECTRO TECHNOLOGY LEVEL 3

CONTENTS

INTRODUCTION

A. What is Electro Technology about?

This subject covers the fundamentals of electro-technical control technology and practical experience and is designed develop students to be an asset to the electrical drive technology field. It will equip the student with machine installation and control related skills for the manufacturing industry. Workshop and field work procedures that conform to safety regulations and safe working practices will be learned.

B. Why is Electro Technology important in the Mechatronics programme?

This subject contains trade specific skills, knowledge, attitudes and values so that learners can maintain, repair and install electro-technical mechatronic drive and related control sub-systems in practice.

C. The link between Electro Technology Learning Outcomes and the Critical and Developmental Outcomes

The application of this subject is OBE orientated and relates to the following critical and developmental outcomes:

- Identify and solve problems in which responses display that responsible decisions using critical and creative thinking have been made.
- Work effectively with others as a member of a team, group organization, community.
- Organise and manage oneself and one's activities responsibly and effectively.
- Collect, analyse, organise and critically evaluate information.
- Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation.
- Use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
- Demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.
- Contribute to the full personal development of the learner.

D. Factors that contribute to achieving Electro Technology Learning Outcomes

- An understanding of technical (electrical, electronic, and electro-magnetic) principles.
- Analytical ability.
- Ability to do mathematical calculations and manipulations.
- Hand-skills (specifically assembly and installation work).
- Practical improvisation abilities.

1 DURATION AND TUITION TIME

This is a one-year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided the student meets all the assessment requirements.

Students with special education needs (LSEN) must be catered for in a way that eliminates barriers to learning.

2 SUBJECT LEVEL FOCUS

- Describe the fundamentals of drive technology and related control methods and circuits
- Describe and apply related electrical safety technology
- Install and test electro-technical systems that employ electric drives, switches and control technology
- Design relay ladder logic-related control circuits as used in electric drive control technology
- Maintain and commission installations that employ electric drives, switches and control circuits.

3 ASSESSMENT REQUIREMENTS

3.1 Internal assessment (50 percent)

3.1.1 Theoretical component

The theoretical component forms 40 percent of the internal assessment mark.

Internal assessment of the theoretical component in Electro Technology Level 3 takes the form of observation, class questions, group work, informal group competitions with rewards, individual discussions with students, class, topic and semester tests and internal examinations. Lecturers can observe students when marking exercises from the previous day and asking class questions.

Assignments, case studies and tests can be completed at the end of a topic. Tests and internal examinations must form part of the internal assessment.

3.1.2 Practical component

The practical component forms 60 percent of the internal assessment mark.

Practical components include applications and exercises. All practical components must be indicated in a Portfolio of Evidence (PoE).

Internal assessment of the practical component in Electro Technology Level 3 takes the form of assignments, practical exercises, case studies and practical examinations in a simulated business environment.

Students may complete practical exercises daily. Assignments and case studies can be completed at the end of a topic. Practical examinations can form part of internal practical assessment.

- **Some examples of practical assessments include, but are not limited to:**
  - Presentations (lectures, demonstrations, group discussions and activities, practical work, observation, role-play, independent activity, synthesis and evaluation)
  - Exhibitions by students
  - Visits undertaken by students based on a structured assignment task
  - Research
  - Task performance in a “Structured Environment”

- **Definition of the term "Structured Environment"**

For the purposes of assessment, "Structured Environment" refers to a simulated workplace or workshop environment. Activities in the simulated workplace or environment must be documented in a logbook with a clear listing of the competencies to be assessed. The following information must be contained in the logbook:

- Nature of department or environment in which practical component was achieved
- Learning Outcomes
- Activities in the environment with which to achieve the Learning Outcomes
- Time spent on activities
- Signature of facilitator or supervisor and student

For the logbook to be regarded as valid evidence, it must be signed by an officially assigned supervisor.

- **Evidence in practical assessments**

All evidence pertaining to evaluation of practical work must be reflected in the student's Portfolio of Evidence. The assessment instruments used for the purpose of conducting these assessments must be part of the evidence contained in the PoE.

3.1.3 Processing of internal assessment mark for the year

A year mark out of 100 is calculated by adding the marks of the theoretical component and the practical component of the internal continuous assessment (ICASS).

3.1.4 Moderation of internal assessment mark

Internal assessment is subjected to internal and external moderation procedures as set out in the *National Examinations Policy for FET College Programmes*.

3.2 External assessment (50 percent)

A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. A practical component will also be assessed.

External assessment details and procedures are set out in the *Assessment Guidelines: Electro Technology Level 3.*

4 WEIGHTED VALUES OF TOPICS

	TOPICS	WEIGHTED VALUE
1	Describe the fundamentals of drive technology and related control methods and circuits.	20%
2	Describe and apply related electrical safety technology.	20%
3	Install and test electro-technical systems that employ electric drives, switches and control technology.	30%
4	Design relay ladder logic related control circuits as used in electric drive control technology.	20%
5	Maintain and commission installations that employ electric drives, switches and control circuits.	10%
	TOTAL	**100**

5 CALCULATION OF FINAL MARK

Internal assessment mark: Student's mark/100 x 50 = a mark out of 50 (a)

Examination mark: Student's mark/100 x 50 = a mark out of 50 (b)

Final mark: (a) + (b) = a mark out of 100

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, reporting, moderation and verification purposes.

6 PASS REQUIREMENTS

A student must obtain at least fifty percent in the internal continuous assessment and fifty percent in the examination.

7 SUBJECT AND LEARNING OUTCOMES

On completion of Electro Technology Level 3, the student should have covered the following topics:

Topic 1: Describe the fundamentals of drive technology and related control methods and circuits.
Topic 2: Describe and apply related electrical safety technology.
Topic 3: Install and test electro-technical systems that employ electric drives, switches and control technology.
Topic 4: Design relay ladder logic related control circuits as used in electrical drive control technology.
Topic 5: Maintain and commission installations that employ electrical drives, switches and control circuits.

7.1 Topic 1: Describe the fundamentals of drive technology and related control methods and circuits.

7.1.1 Subject Outcome 1: Describe and apply drive technology.

Range: Fundamentals: magnetism in motors/generator principles (Faraday and Lenz's laws). Electric drive types: DC drives: Series, compound , shunt and permanent magnet type. AC drives: Induction, universal type coupling methods including belt-, gear- and direct drives.

Learning Outcomes:
The student should be able to:

- Describe
  - the fundamental operation of rotary and linear AC/DC electric drives.
  - the basic construction of electric drives.
  - the application of the various drive types.
  - the importance of name plates and indicate the information given.
  - how different terminal connections (series, shunt and compound field) can be made to connect motors.
  - the IP rating on various motor types.
  - the various mounting methods and procedure of electric drives.
  - the energy conversion that takes place in an electric drive.
- Draw and interpret various drive symbols.
- Identify
  - and describe various drive couplings employed in electric drive applications.
  - various motor types in accordance with their connection terminals.
  - electric drive parts and explain their purpose and operation.
  - and select an electric drive using all the characteristics above.
- Select
  - the correct drive by means of the name plate.
  - a motor in accordance with its mounting method.
  - a motor in accordance with its IP rating.
- Determine
  - drive speed by means of calculation and coupling methods.
  - electric drive efficiency by calculation.

7.1.2 Subject Outcome 2: Describe and apply control methods.

Range: Speed control, reversal of direction, direct on line starting, resistance starting. Relay/contactor control circuits (timer, sequential starting, latching, sequential/cascaded control and safety circuits. Sensors. Limit switches and proximity switches.

Learning Outcomes:
The student should be able to:

- Explain
  - and identify the various electric drive control methods.
  - what is meant by main and related control circuits.
  - the wiring and terminal marking of relays/contactors/timers/counters/indication and protection devices encountered with drive control.
  - how sensors can be used in the control of electrical drive control.
- Design, draw and explain basic relay/contactor control circuits and related components.
- Identify and
  - explain the operation of various sensors commonly used in electric drive control applications.
  - and select control gear for drive control circuits.
  - and select correct electric drive for given application.
  - and select relevant sensors for various control applications.
- Design and draw basic electric drive control circuits.

7.2 Topic 2: Describe and apply related electrical safety technology

7.2.1 Subject Outcome 1: Explain and select general electrical safety technology

Range: SABS 0142
Learning Outcomes:
The student should be able to:

- Explain
  - the protection methods employed against direct and indirect protection.
  - how low voltage protection is achieved.
  - the protection devices used against over current.
  - how protection is achieved against leakage current.
  - what is meant by the term protective insulation.
  - what is meant by earthing and bonding.
  - protection by isolation.
  - the importance of earth electrodes
- Identify and list the various components used for protection in an electrical application.
- Select correct protection components in accordance to their required ratings.

7.2.2 Subject Outcome 2: Describe and apply safety technology in drive control circuits.

Range: Safety functions: Stop function, emergency stop/halt functions, reset, start and restart, related response times. Machine safety related to SABS 0142.

Learning Outcomes:

The student should be able to:

- Explain
  - the safety function with respect to electric drive control.
  - the safety related parameters related to safety functions.
  - what is meant by a two handed control in machine control safety circuits.
  - various safety interlocking systems and their related circuit diagrams.
  - the fault finding safety procedures to employ when working on electrical drives and related control circuits.
  - related design and application regulations with respect to safety in the SABS 0142 Code of Practice.
- List possible failures in closed loop and in open loop control circuits.
- Apply electric drive safety when installing, testing, maintaining and fault finding.
- Apply relevant SABS 0142 Code of Practice when working on electrical drive systems.

7.3 Topic 3: Install and test electro-technical systems that employ electric drives, switches and control technology

7.3.1 Subject Outcome 1: Plan, install and test electric drive control sub-systems

Learning Outcomes:

The student should be able to:

- Explain
  - the planning procedure for installing electric drive related control circuits
  - the relevant installation regulations with respect to SABS 0142
  - the various procedures for testing an electric drive control sub-system
- Read and interpret electrical diagrams and instructions
- Plan for the installation of electric drive control sub-systems
- Draw up
  - a tool list.
  - and list the required safety considerations
- Identify and draw up
  - a materials list
  - a tool list
  - work processes
- Perform the installation in accordance with SABS 0142 Code of Practice.
- Test the installation for operation.
- Apply relevant safety tests as recommended by the SABS0142.

7.4 Topic 4: Design relay ladder logic related control circuits as used in electric drive control technology

7.4.1 Subject Outcome 1: Describe and apply relay logic control circuits

Range: Sequential starting of conveyor belt systems, indication of system on/off, cascaded timers, automatic off/on circuits- clock /timer/counter control, sorting, testing, and transporting control circuits, direction of drive reversal, pick and place control.

Learning Outcomes:

The student should be able to:

- Explain
  - the related control symbols.
  - the importance of understanding relay logic control application circuits.
  - what is meant by final drive control components and list these components
- Design and draw a basic control circuit diagram in conjunction with the main electric drive circuit.
- Show all terminal connections for the components used.
- Show how all the components are labelled in a cubicle/installation diagram and a wiring diagram.

7.5 Topic 5: Maintain and commission installations that employ electric drives, switches and control circuits

7.5.1 Subject Outcome 1: Explain and apply diagnostic procedures for electric drive control sub-systems

Range: rating plate, motor not starting –dead/hum/slow/protection devices trip, wrong direction, bearing noise; interrupted motor protection switch, burning signs evident, motor is burnt; (contactor/relay does not pick up, sticking relay, worn out/ burnt contacts, sparking contacts; closed switch no flow, contact sparking, high resistance, coil not energised, contacts not operating, relay hum; wiring low voltage, protection devices tripping, line heats up.

Learning Outcomes

- Explain
  - how the rating plate can be used in fault diagnosis.
  - the procedure to follow when the motor does not start (dead motor).
  - the starting procedure when a motor does not start (motor not dead).
  - the procedure to follow when a motor starts but gets hot or /hums when running.
  - the procedure to follow when a motor starts and thermal trip takes place after a while.

  - the procedure to follow when a motor has bearing noise.
  - the procedure to rectify a motor going in the wrong direction prior to commissioning.
  - various fault related to protection switches and thermal over-current relays.
  - the various procedures related to contactor/relay faults.
  - the various procedures related to switching devices.
  - related procedures to follow with respect to wiring.
- Apply the various related procedures whilst repairing, maintaining and commissioning electric drive related circuits.
- Make correct diagnoses and repair systems.
- Fill out a fault report including identification, actions taken and the total cost of labour and materials.

7.5.2 Subject Outcome 2: Commission faults that occur in electric sub-systems

Range: Linear drives: failure to observe installation instruction, improper electrical wiring, emergency stop engaged, safety device tripped, faults in installation and alignments. Rotary drives: Improper electrical wiring, wrong direction, low starting current, e/stop engaged, failure to observe installation instructions, fault in assembly of output element (gears, spindle, shaft, belt drive), safety devices tripped, faults in installation and alignment. No noise damping, fan does not start simultaneously, external; cooling not connected, motor at insufficient speed. Energy control section: Switching device- incorrect coil voltage, voltage type, wiring, setting for timers. Counters Control devices- incorrect switch position, improper wiring, contact reversal, contact stuck. Protective device- links/fuses not inserted, incorrect settings, protection systems tripped. Energy supply section: Energy generation- too complex for this level. Energy storage- batteries, generating plant standby, large capacitors –to be commissioned in accordance with code and regulations. Energy distribution- cable faults, solder termination dry, terminals screwed connections loose, defective insulation. Signal section: Mechanical position switches- wrong switch position, contact stuck/burnt, wire open circuit, insulation open. Proximity switches- wrong position, wire break, insulation open, contact stuck, sensor contaminated (dust, chemicals, etc), sensor reversed, cable reversed, magnetic field disturbance, adjustment needed. Pressure switches: missing seals, improper assembly, electrical terminals reversed, incorrect pressure adjustment, insulation stripped, incorrect pressure range.

Learning Outcomes

- List the three possible places where commissioning faults can occur.
- List possible faults that can occur
  - in the energy control section.
  - in the energy supply section.
  - in the electric drive section (linear/rotary).
  - in the signal section.
- Diagnose and repair various commissioning related faults that occur in electric sub systems.

8 RESOURCE NEEDS FOR THE TEACHING OF ELECTRO TECHNOLOGY LEVEL 3.

8.1 Physical resources

- **Infrastructure (building infrastructure, fixtures and networks)**
  - Building to be appropriately designed for workshop types and/or laboratory type presentations that comply with building regulations and safety standards.
  - The tables below show broadly the laboratory /work area requirements, related training equipment for allocated students and the relevant facilitator training that may be required for the delivery of this vocational training

	Mechatronics (Vocational Training)	
1	**MECHANICAL FUNDAMENTALS LAB/WORKSHOP**	for 20 learners
1a	**Classroom Facilities**	
	Workplaces	20
	Teaching	20
	General facilities	20
1b	**Hand Tools**	
	Workbenches, double	10
	Technical drawing	20
	Basic handtools	20
	Safety and house keeping	20
	Measurement and marking	10
	Sheet metal work	10
1c	**Power Tools**	
	Work benches, double	10
	Cutting and forming	10
	Drilling and tapping	10
	Welding and joining	10
	Electrical soldering	10
1d	**Machining**	
	Drilling	1
	Turning	1
	Milling	1
1e	**Training of facilitator**	
	Mechanical	1
2	**ELECTRICAL INSTALLATION AND MACHINE LABORATORY**	
2a	**Electrical installation**	
	Safety and protection	2
	Industrial installation and control	2
	Domestic circuit installation and testing	2

2b	**Electrical Machines**	
	DC machines	2
	AC machines	2
2c	**Commissioning and training**	
	Teacher training - electrical	1
3	**MOTION AND CONTROL LABORATORY**	
3a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	General	1
	Computer hardware	10
3b	**Pneumatics**	
	Advanced pneumatics	5
	Workstation pneumatics	2
	Software pneumatics	20
3c	**Electro-pneumatics**	
	Basic electro-pneumatics	5
	Advanced electro-pneumatics	5
	Measurement in pneumatics	2
	Workstation – electro-pneumatics	2
3d	**Hydraulics**	
	Basic hydraulics	5
	Workstation hydraulics	1
	Software hydraulics	20
3e	**Electro-Hydraulics**	
	Basic electro-hydraulics	2
	Advanced electro-hydraulics	2
	Workstation electro-hydraulics	1
3f	**Sensor Technology**	
	Proximity sensors	2
	Distance and displacement sensors	2
	Force and pressure sensors	2
	Workstation sensor technology	2
3f	**Basic and Advanced PLC**	
	Basic PLC	10
	Advanced PLC	2

3g	**Fieldbus and electric drives**	
	Fieldbus profibus-DP	2
	Electro-servo drives	2
	Electro-stepper drives	2
3h	**Commissioning and training**	
	Teacher training – Motion and control	1
4	**ELECTRONIC AND SOFTWARE LAB**	
4a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	Computer hardware	20
4b	**Courses**	
	Desktop laboratory	20
	Electrical engineering	20
	Electronics	20
	Project work	20
4c	**Advanced Courses**	
	Digital Electronics	3
	Microcomputer	3
	Power Electronics	3
	Electrical Machines	3
	Communication Technology	3
4d	**E-learning**	
	Electronics	3
	Mechatronics	20
4e	**Commissioning and Training**	
	Teacher training	1
5	**CNC AND CIM/ FMS LABORATORY**	
5a	**Classroom facilities**	
	Workplace	20
	General	20
	Computer hardware	1
5b	**CNC Manufacturing**	
	CNC trainers and CAD/ CAM	1
6	**COMPUTER LABORATORY**	
6a	**Classroom facilities**	
	Workstations	20
	Computer hardware	20
	Software (Microsoft office)	20
	Internet access	20

7	**CENTRAL TOOL STORE**
8	**ABLUTIONS**

8.2 Equipment and machinery

The equipment as indicated above is the suggested minimum although other equipment can be used to obtain the same outcomes. Access by the learner and facilitator to the above listed equipment and machinery is essential. Machinery and laboratory equipment as listed above is essential in the delivery of vocational training for Mechatronics.

8.3 Human resources

- The minimum qualification requirements for educators responsible for teaching this subject will be qualification as a mechatronic mechanician/ technician/ technologist, or in one or more of the following sub-fields: electrician, electrician (signals), millwright, IT specialist.
- Facilitators should ideally be qualified as educators capable of teaching up to NQF level 6 at least. They should be creative and have a sound knowledge of learner centred education.
- It is essential that educators working in this environment attend seminars and upgrading workshops in order to be updated and re-skilled with the latest developments in technology.
- The recommended number of students for workshop practice is 20.

8.4 Financial resources

The institution should make provision for workshop practice consumables during practical work, maintenance of physical resources, purchasing of new equipment and finance to hire external providers.