NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

ELECTRICAL PRINCIPLES AND PRACTICE

NQF LEVEL 2

IMPLEMENTATION: JANUARY 2013
INTRODUCTION

A. What is Electrical principles and Practice about?
This subject covers the basics of electrical principles and practice and introduces the field of learning at Level 2; it is assumed that students have no previous electrical background and knowledge.

The content of this subject was revised to address gaps and shortcomings in the first version of the curriculum. The Department of Higher Education and Training worked in close collaboration with the Department of Public Enterprise, stakeholders and role players from both industry and FET Colleges who all provided valuable input and participated in the revision process.

B. Why is Electrical principles and Practice important in the learning programme?
Electrical Principles and Practice transfers trade specific skills, knowledge, values and attitudes so that students can explain how electricity is applied in practice.

C. How do the Learning Outcomes link with the Critical and Developmental Outcomes?
Electrical Principles and Practice covers the basic electrical theory and the application of this subject content is outcomes-based orientated and relates to the following Critical and Developmental Outcomes.

Students will be able to:
• **Identify and solve problems:**
  Recognise principles of electricity and react appropriately.
• **Work effectively with others:**
  Solve electricity-related problems.
• **Organise and manage their activities and themselves:**
  Apply planned procedures for using, storing and looking after equipment, tools, and test equipment, drawings and parts.
• **Collect, organise and evaluate information and take appropriate action:**
  Use media centres to collect information.
• **Communicate effectively:**
  Use common names for electrical equipment, tools, test equipment, drawings and parts.
• **Use science and technology:**
  Use and apply science and technology principles in both theory and practice.
• **Demonstrate understanding of subject content through the application of acquired knowledge:**
  Solve problems by using subject contents.

D. Which factors contribute to achieving the Learning Outcomes?
Students require:
• An understanding of technical (electro-mechanical) principles
• Analytical ability
• An ability to do mathematical calculations and manipulations
• Hand skills (practical skills)
• Practical improvisation abilities
1. DURATION AND TUITION TIME

2. SUBJECT LEVEL OUTCOMES AND FOCUS

3. ASSESSMENT

3.1. Internal assessment

3.2. External assessment

4. WEIGHTED VALUES OF TOPICS

5. CALCULATION OF FINAL MARK

6. PASS REQUIREMENTS

7. SUBJECT AND LEARNING OUTCOMES

   Topic 1: SI Units of Measurement
   Topic 2: Electric and Magnetic Theories
   Topic 3: Direct Current (DC) and Alternating Current (AC) circuits
   Topic 4: Protection, Measuring and Testing Instruments
   Topic 5: Circuit Diagrams
   Topic 6: Electrical Materials, Components and Safety

8. RESOURCE NEEDS FOR THE TEACHING OF ELECTRICAL PRINCIPLES AND PRACTICE

   LEVEL 2

8.1 Physical resources

8.2 Human resources

8.3 Other resources
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 OUTCOMES AND FOCUS
SAQA Qualification ID: 50440
On completion of this subject the student will be able to:
Describe the fundamental concepts and principles of electricity and magnetic theory (direct and alternating current (DC and AC) and the materials and components used in the electric field
Associated Assessment Criteria:
• Basic SI units of measurement are recognised and used
• Elementary electrical formulas are used to calculate data in relation to the testing of electrical equipment.
• Principles of electricity and magnetism are explained in terms of its influence on maintenance and testing.
• Measuring instruments are described according to their uses.
• Electric components are described according to their operating principles and uses.
• Methods of building protection into electric circuits are described using examples.
• Terminology used in electrical diagrams is described by making use of examples.
  *Range: Terminology includes but is not limited to IEC and SI symbols, units and prefixes.*

3 ASSESSMENT
Information provided in this document on internal and external assessment aims to inform, assist and guide a lecturer to effectively plan the teaching of the subject.
The Assessment Guidelines accompanying this document provides detailed information to plan and conduct internal and external assessments.

3.1 Internal assessment (50 percent)
Detailed information regarding internal assessment and moderation is outlined in the current Internal Continuous Assessment (ICASS) Guideline document provided by the Department of Higher Education and Training (DHET).

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 Integrated Summative Assessment Task (ISAT) will also be assessed as a component of external assessment.
4 WEIGHTED VALUES OF TOPICS

<table>
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<tr>
<th>TOPICS</th>
<th>WEIGHTED VALUE</th>
<th>*TEACHING HOURS</th>
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<td>1. SI Units of Measurements</td>
<td>10</td>
<td>11</td>
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<td>2. Electric and Magnetic Theories</td>
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<tr>
<td>3. Direct Current (DC) and Alternating Current (AC) circuits</td>
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<td>4. Protection, Measuring and Testing Instruments</td>
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<td>5. Circuit Diagrams</td>
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<td>16</td>
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<tr>
<td>6. Electrical Materials, Components and Safety</td>
<td>10</td>
<td>11</td>
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<td></td>
<td><strong>100%</strong></td>
<td><strong>110</strong></td>
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*Teaching Hours refer to the minimum hours required for face to face instruction and teaching. This number excludes time spent on revision, test series and internal and external examination/assessment. The number of the allocated teaching hours is influenced by the topic weighting, complexity of the subject content and the duration of the academic year.

5 CALCULATION OF FINAL MARK

<table>
<thead>
<tr>
<th>Internal assessment mark:</th>
<th>Student’s mark/100 x 50 = a mark out of 50 (a)</th>
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<tbody>
<tr>
<td>Examination mark:</td>
<td>Student’s mark/100 x 50 = a mark out of 50 (b)</td>
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<tr>
<td>Final mark:</td>
<td>(a) + (b) = a mark out of 100</td>
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All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, moderation, verification as well as reporting purposes.

6 PASS REQUIREMENTS

A student must obtain at least fifty percent (50%) in the ICASS and fifty percent (50%) in the examination.

7 SUBJECT AND LEARNING OUTCOMES

On completion of *Electrical Principles and Practice*, the student should have covered the following topics:

- Topic 1: SI Units of Measurements
- Topic 2: Electric and Magnetic Theories
- Topic 3: Direct Current (DC) and Alternating Current (AC) circuits
- Topic 4: Protection, Measuring and Testing Instruments
Topic 5: Circuit Diagrams
Topic 6: Electrical Materials, Components and Safety

Topic 1: SI Units of Measurement

Subject Outcomes 1.1: Recognise and use basic SI units of measurement

Learning Outcomes: The student should be able to:

- Identify basic units of measurement used in engineering.
- Define the physical quantities that are measured by the SI units.
- Describe the rules when writing SI units of measurement.
- Convert scientific notation to decimal notation and vice versa (Convert answer to 3 decimal digits).
- List common prefixes used in engineering.
- Derive new units from the relationships between the SI units (i.e. the quantities they measure).
  
- Explain the theory and measure plane and solid angles.

Topic 2: Electric and Magnetic Theories

Subject Outcome 2.1: Explain fundamental concepts and basic principles of electricity

Learning Outcomes:

The student should be able to:

- Explain the fundamental concepts and terms used in electricity.
  
  Range: Atom, electron, free electron, ionized atom, positive and negative charge, conductors and insulators, potential difference, electromotive force, conventional and electron current flow, resistance and Ohm’s law, power, energy and (introduction to Kirchhoff’s laws).

- Explain the units of measurement of electric entities.
  
  Range: Potential difference, electromotive force, resistance, power and energy.

- Explain, with an illustration, the relationship between electrical entities using a series circuit containing a battery, switch and resistive component.

Subject Outcome 2.2: Perform calculations using Ohm’s law and Joule’s law (the power and energy formulae)

Learning Outcomes:

The student should be able to:

- Explain what Ohm’s law is and identify the formula used for calculations.
- Explain what Joule’s law is and identify the formula used for calculations.
- Perform calculations on resistance, energy and power using the correct formulae and units of measurement (SI units).
Subject Outcome 2.3: Explain the factors influencing electrical resistance of materials and perform calculations.

Learning Outcomes:
The student should be able to:
- Describe, with examples, electrical conductors and the types of material commonly used to manufacture it.
- List and explain, with examples, factors affecting electrical resistance (material, shape, size, length, and area or cross sectional area, temperature).
- Perform calculations to determine resistance using the formulae.

\[ R = \frac{\rho l}{A} \quad \text{and} \quad R_f = R_0 (1 + \alpha \Delta T) \]

Subject Outcome 2.4: Compare different electrical supply systems
Range: Direct current (DC), alternating current (AC), single and three phase AC supply systems.
Learning Outcomes:
The student should be able to:
- Explain, with examples, the difference between direct current (DC) and alternating current (AC).
- Explain, with examples, the following electrical supply systems:
  - Single phase supply systems
  - Three phase supply systems.
- Sketch sine wave voltage wave forms with different amplitudes and frequencies.
- Explain and sketch phase angle displacement in three-phase supplies.
- Explain, with examples, the use of different electrical supply systems in South Africa.
- Explain the advantages and disadvantages of different electrical supply systems.

Subject Outcome 2.5: Explain magnetism and electromagnetism theories
Range: magnetic poles, magnetic fields and field lines, flux, flux density, magnetic field around a current-carrying conductor and the solenoid, m.m.f, magnetic field strength and force on a current-carrying conductor.
Learning Outcomes:
The student should be able to:
- Explain the concepts and terms used in magnetism and electromagnetism.
- Explain the requirements for sketching magnetic field lines.
- Sketch magnetic field lines around bar and horseshoe magnets.
- Apply the right-hand grip or screw rule and Fleming’s left-hand rule to determine the magnetic field around a current-carrying conductor and a solenoid.
**Topic 3: Direct Current (DC) and Alternating Current (AC) circuits**

**Subject Outcome 3.1: Explain continuity and current flow.**
**Learning Outcomes:**
The student should be able to:
- Identify closed and open circuits from examples.
- Predict whether current flow is possible.

**Subject Outcome 3.2: Explain and perform calculations on the grouping of electrical cells**
*Range: series, parallel and series-parallel*
**Learning Outcomes:**
The student should be able to:
- Explain concepts such as electrical cells, emf of cells, internal resistance and grouping of cells.
- Perform calculations on typical circuits involving the grouping of cells using practical examples.

**Subject Outcome 3.3: Explain electric circuits and perform calculations**
**Learning Outcomes:**
The student should be able to:
- Describe different electric circuit combinations.
  *Range: series, parallel, series-parallel*
- Explain the principles of operation for a combination of resistors.
- Sketch the circuit diagrams from the information supplied, using IEC symbols.
- Use appropriate formulae to calculate voltages, total resistance and currents in all the circuit branches and volt drops across resistors.
- Apply Kirchhoff’s laws in electric circuit calculations.
- Conduct practical circuit experiments to verify calculations.

**Subject Outcome 3.4: Explain and perform calculations to implement load balancing in a three-phase supply system.**
**Learning Outcomes:**
The student should be able to:
- Use an example/typical scenario to explain the concept and advantages of load balancing.
- Calculate loads per phase using the information given and assuming all appliances are used simultaneously.
- Sketch the load per phase results to illustrate how the loads must be connected.

**Subject Outcome 3.5: Explain the construction and operating principle of single-phase transformers and perform basic turns-ratio calculations.**
**Learning Outcomes:**
The student should be able to:
- Explain with the aid of sketches/pictures, the design, construction and operation of transformers.
Range: windings, core, connections and cooling

- Distinguish between different types of transformers and explain terminology related to transformers.
  Range: turns-ratio, step-up and step-down transformers.
- Use the ideal transformer equation to perform calculations.

Topic 4: Protection, Measuring and Testing Instruments

Subject Outcome 4.1: Explain the importance of earthing electrical appliances and installations (single-phase).
Learning Outcomes:
The student should be able to:

- Explain the concept ‘earthing’ of electrical appliances and installations (single-phase) and the importance of earthing.
- Identify devices and systems which require earthing according to the SABS Code of Practice (SANS 10142).

Subject Outcome 4.2: Identify and explain the use of electrical measuring and testing instruments
Range: Ammeters, voltmeters, frequency meters, ohmmeters, insulation resistance meters, wattmeters, clamp-meters and continuity testers
Learning Outcomes:
The student should be able to:

- Distinguish between analogue and digital measuring instruments.
- Understand and know how to eliminate parallax error in reading analogue meters.
- List the advantages of digital meters compared to analogue meters.
- Explain the operation of moving-iron and moving coil instruments.
- List and describe, with examples, different electrical measuring and testing instruments used in practice.
- Sketch and explain how measuring and testing instruments are inserted in circuits.
- List the precautions when using measuring and testing instruments.
- Sketch and explain the basic design and operating principles of an insulation resistance tester.
- Indicate how instrument transformers are used to lower the voltage and current for the instrument (instrument transformers).
- Explain how the range of a voltmeter and ammeter can be increased.

Subject Outcome 4.3: Use, care for and store hand-held electrical test instruments
Range: Clamp-meter, ammeter, voltmeter, multimeter and insulation resistance meters
Learning Outcomes:
The student should be able to:

- Set the instruments for use.
- Select and read scaled readings from various analogue and digital instruments.
• Insert instruments correctly into circuits.
• Illustrate correct care for the instruments.
• Illustrate correct storage of the instruments

Topic 5: Circuit Diagrams

Subject Outcome 5.1: Draw circuit diagrams of electrical sub-circuits
Range: A luminaire circuit supplied from one circuit breaker, two or more luminaires supplied from one circuit breaker (including two-way and intermediate switching), two or more socket outlets supplied from one circuit breaker, a geyser circuit including isolator and ripple relay, a stove circuit including isolator (single-phase only).

Learning Outcomes:
The student should be able to:
• Explain the requirements of a typical electrical circuit.
• Draw different circuit diagrams that conform to standard practice (international standards).
• Compile a parts list from the circuit diagram that includes component ratings.

Topic 6: Electrical Materials and Components

Subject Outcome 6.1: Identify and explain materials and components most commonly used in the electrical field
Range:
Materials such as copper, steel, glass, porcelain, mica, plastics, bakelite, carbon, oil-impregnated paper, rubber, lead, aluminium and tin.
Components such as insulated cables, stranded conductors, flexible cables, steel-cored cables, armoured cables, conduiting and associated fittings, clamps, cleats and saddles, porcelain, glass and mica insulators, busbars, fuses, heating elements, switches, circuit breakers, protection devices, luminaires, capacitors and transformers

Learning Outcomes:
The student should be able to:
• Describe and explain electrical conductors and insulators.
• List and describe types, properties and application of materials used as electric conductors.
• List and describe types, properties and application of materials used as electric insulators.
• Illustrate with sketches/pictures and describe the most commonly used cables, cords, conductors and insulators and their use in the electrical field.
• Explain flexible connections.
• Identify meter boxes and distribution boxes and components found inside these boxes.

Subject Outcome 6.2: Describe the operating principles of the most commonly used electrical components and equipment.

Learning Outcomes:
The student should be able to:
• Describe the operating principle of protection devices / components to ensure safety in electricity

*Range: circuit breakers, isolators, surge protection devices (SPDs), lightning arrestors and earth leakage relays*

• Sketch and explain the operating principles of common electrical devices.

*Range: geysers, stoves, thermostats, simmerstats, prepaid meters, energy control units (ripple relay and radio controlled), incandescent and fluorescent lamps, compact fluorescent lamps and light dimmers.*

• Explain with practical examples types of DC sources

*Range: Leclanché dry cell, mercury or silver-oxide cells, rechargeable Ni-Cd or metal hydride cells.*

• Sketch and explain lead-acid batteries as follows:
  - Operating principles of the batteries
  - Proper use of the batteries
  - Maintenance of the batteries

8. RESOURCE NEEDS FOR THE TEACHING OF ELECTRICAL PRINCIPLES AND PRACTICE – LEVEL 2

8.1 Physical resources

Well equipped classrooms and workshops are essential for this practical orientated subject. If possible, using the facilities of employers in the electrical field, for training, is preferred.

8.2 Human resources

• Lecturing staff must have appropriate electrical qualifications and possesses the necessary knowledge, skills and reflexive approach to ensure that students' learning is kept up to date with the latest technologies and changing trends in their specialist field

• Continuous staff development with exposure to an industrial environment is necessary to acquire new skills and update their existing skills where new technologies have been introduced. Lecturers are required to spend a structured and routine period annually in an industrial environment for these purposes.

• Staff development in terms of updating teaching, learning and assessment skills is required on an ongoing basis, particularly for staff that moves from industry into the educational environment of an FET college.

8.3 Other resources –

• The institution should have funding available to provide the following:
  - consumables required to perform practical assignments and examinations
  - maintenance of physical recourses
  - purchasing of new equipment.