INTRODUCTION

A. What is Electrical Principles and Practice about?

This subject covers the basics of electrical principles and practice and is designed as an introduction to the field of learning. Level 2 is based on the assumption that the student has no previous electrical background. Level 3 is a continuation of the curriculum.

B. Why is Electrical Principles and Practice important in the Electrical Infrastructure Construction programme?

This subject deals with trade specific skills, knowledge, values and attitudes in order for the students to understand how electricity is applied in practice.

C. How do the Electrical Principles and Practice Learning Outcomes link with the Critical and Developmental Outcomes

Electrical Principles and Practice covers a substantial portion of the theoretical knowledge component. Its application is outcomes based, and relates to the following Critical and Developmental Outcomes:

Students will learn how to:

- **Identify and solve problems:** Recognize principles of electricity and react appropriately
- **Work effectively with others:** When solving problems
- **Organize and manage their activities and themselves:** Apply planned procedures for using, storing and looking after equipment, tools, test equipment, drawings and parts
- **Collect, organize 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 content.

D. Factors that contribute to achieving the Electrical Principles and Practice Learning Outcomes

- An understanding of technical (electro-mechanical) principles
- Analytical ability
- The ability to do mathematical calculations and manipulations
- Hand-skills (practical skills)
- Practical improvisation abilities.
ELECTRICAL PRINCIPLES AND PRACTICE – LEVEL 3
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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 all of the assessment requirements set out hereunder are adhered to.

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: 50442

Students should be able to demonstrate understanding and apply the fundamentals of electricity, understand magnetism and electromagnetism, Direct Current (DC) and Alternating Current (AC), apply knowledge of and practically use measuring instruments and electric machines.

Exit Level Outcome: Demonstrate understanding of the principles of electricity, magnetic theories and electric machines.

Associated Assessment Criteria:

- The principles of electricity are described as they relate to performing maintenance and testing.
- Elementary formulae for calculating electrical data are selected and used in order to inform decision-making in relation to testing of electrical equipment.
- Measuring instruments are described in terms of their operating principles and uses.
- Electric machines are identified and illustrated by making use of sketches.

3 ASSESSMENT

Information provided in this document on internal and external assessment aims to inform, assist and guide lecturers to effectively plan the teaching of the subject.

The Assessment Guidelines accompanying this document provide detailed information for planning and conducting 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 (constitutes 50 percent of the final mark)

A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. A practical component, the Integrated Summative Assessment Task (ISAT), will be included in the external assessment.

4 WEIGHTED VALUES OF TOPICS

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>WEIGHTED VALUE</th>
<th>*TEACHING HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fundamentals of electricity</td>
<td>15 %</td>
<td>17</td>
</tr>
<tr>
<td>2. Magnetism and electromagnetism</td>
<td>20 %</td>
<td>22</td>
</tr>
<tr>
<td>3. Direct Current (DC) and Alternating Current (AC) circuits</td>
<td>30 %</td>
<td>33</td>
</tr>
<tr>
<td>4. Measuring instruments</td>
<td>15 %</td>
<td>16</td>
</tr>
<tr>
<td>5. Electric machines</td>
<td>20 %</td>
<td>22</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100</strong></td>
<td><strong>110</strong></td>
</tr>
</tbody>
</table>

*Teaching Hours* refers to the minimum hours required for face to face instruction and teaching. This excludes time spent on revision, tests and internal and external examinations and assessment. The number of 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>
</tr>
</thead>
<tbody>
<tr>
<td>Examination mark:</td>
<td>Student’s mark/100 x 50 = a mark out of 50 (b)</td>
</tr>
<tr>
<td>Final mark:</td>
<td>(a) + (b) = a mark out of 100</td>
</tr>
</tbody>
</table>

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

6 PASS REQUIREMENTS

A student must obtain at least fifty (50) percent in ICASS and fifty (50) percent in the examination to achieve a pass in this subject.

7 SUBJECT AND LEARNING OUTCOMES

On completion of *Electrical Principles and Practice Level 3* the student should have covered the following topics:

- Topic 1: Fundamentals of electricity
- Topic 2: Magnetism and electromagnetism
- Topic 3: Direct Current (DC) and Alternating Current (AC) circuits
Subject Outcome 1.1: Explain fundamental concepts of electricity

Learning Outcomes: The student should be able to:
- Distinguish the fundamental concepts and terms used in electricity
  *Range: Structure of an atom, atomic number, atomic mass, electrons, free electrons, charge, electromotive force, current, potential difference and resistance.*
- Explain the effect of temperature on materials
  *Range: metals, carbon, insulator, alloys and semiconductor.*

Subject Outcome 1.2: Calculate resistance of a material

Learning Outcomes: The student should be able to:
- Define resistivity.
- State the factors that influence the resistance of a material and perform calculations.
  *Range: Length, cross-sectional area, resistivity and temperature.*
- Explain the temperature coefficient of resistance
- Distinguish between positive, negative and low temperature coefficient of resistance.
- Perform calculations to determine resistance using the formula,
  *Range: \( R_t = R_0 (1 + \alpha_0 t) \) and \( R_t = R_0 [1 + \alpha_0 (t - \theta)] \)

Subject Outcome 2.1: Explain magnetic circuits

Learning Outcomes: The student should be able to:
- State and explain the two fundamentals laws of magnetism.
- Define the following terms and use the appropriate formulae to perform calculations.
  *Range: magnetic flux, magnetic flux density, magnetomotive force (m.m.f), magnetic field strength.*
- Compare electrical and magnetic quantities.

Subject Outcome 2.2: Explain electromagnetism

Learning Outcomes: The student should be able to:
- Explain how magnetic fields are produced by electric currents.
- Apply the right hand grip or screw rule to determine the direction of magnetic field around a current carrying conductor and a solenoid.
- List and explain the applications of electromagnets.
  *Range: bell, relay and lifting magnets.*
- List the factors affecting the force of a current-carrying conductor.
- Calculate the magnitude of the force of a current-carrying conductor in a magnetic field.
- Calculate the force of attraction or repulsion between two-parallel current-carrying conductors.
- Define Ampere.
- Explain the operation of a simple DC motor.

**Subject Outcome 2.3: Explain electromagnetic induction**

**Learning Outcomes:** The student should be able to:
- Explain the principles of electromagnetic induction.
- State the laws of electromagnetic induction.
- Calculate the e.m.f. induced in a conductor.
- Determine the direction of the induced e.m.f. by using Fleming’s right hand rule and Lenz’s law.

**Topic 3: Direct Current (DC) and Alternating Current (AC) circuits**

**Subject Outcome 3.1: Explain and perform calculations using series-parallel network circuits**

**Learning Outcomes:** The student should be able to:
- Calculate total resistance, current and voltage drop for given circuits using different methods.
  *Range: series, parallel and series-parallel combination of resistors.*
- Apply Kirchhoff’s laws in electric circuit calculations.
- Conduct a practical circuit experiment to verify calculations within the range.

**Subject Outcome 3.2: Explain and perform calculations on the grouping of electrical cells**

**Learning Outcomes:** The student should be able to:
- Explain concepts such as e.m.f. of cells, internal resistance, terminal voltage and grouping of cells.
  *Range: series, parallel and series-parallel*
- Perform calculations for typical circuits involving the grouping of cells using practical examples.
- Explain the difference between primary and secondary cells.
- List examples and applications of primary and secondary cells.
- Sketch and explain lead-acid batteries as follows:
  - Names of the various parts
  - The operating principles
  - Function of the separators
  - Maintenance and safety precautions to be taken
  - Testing procedure
  - Factors affecting battery capacity
Subject Outcome 3.3: Perform calculations for capacitors in series-parallel

Learning Outcomes: The student should be able to:
- Explain how a capacitor can store charge.
- List common types of capacitors.
- Explain and calculate capacitance, charge, electric field strength and energy stored in a capacitor.
- Calculate total capacitance, charge on each capacitor and potential difference across each capacitor when capacitors are connected in series, parallel and series-parallel.

Subject Outcome 3.4: Perform calculations for inductors in series-parallel

Learning Outcomes: The student should be able to:
- Explain inductance, self inductance and mutual inductance.
- Calculate energy stored in a magnetic circuit.
- Calculate the value of e.m.f. induced in a coil.
- List the factors that affect the inductance in an inductor.
- Calculate total inductance in series, parallel and series-parallel circuits.

Subject Outcome 3.5: Explain single and three-phase systems

Learning Outcomes: The student should be able to:
- Describe single and three-phase supply systems.
- Understand the concept of phase angle between waveforms.
- Explain the following terms for a sine wave.
  Range: Cycle, period, frequency, instantaneous value, peak value and peak to peak value.
- Explain and compare star and delta connections.
- Explain and calculate line voltage, line current, phase voltage and phase current in a typical scenario.
- Calculate power in single and three-phase systems.

Subject Outcome 3.6: Explain and perform calculations with transformers

Learning Outcomes: The student should be able to:
- Explain the principle of operation of a transformer.
- Explain the rating of a transformer.
- List the advantages, disadvantages and applications of auto-transformers.
- Distinguish between different types of transformers and explain related terminology.
  Range: Turns ratio, step-up and step up transformers.
- Use the ideal transformers equation to perform calculations (single-phase).
- List losses in a transformer and calculate efficiency.
- Explain how three-phase transformers are constructed.
- Sketch the different possible transformer connections and identify their uses.
  Range: Delta-delta, delta-star, star-delta and star-star.
- Use transformer equations to perform calculations (three-phase).
• List and explain the methods of cooling of dry type and oil immersed type transformers.
  
  **Range:**
  
  *Dry type – Natural air and forced air.*
  
  *Oil immersed type - self, forced air and forced oil cooled transformer.*
  
• Explain the function of the conservator, breather and Buchholz relay of a transformer.

### Topic 4: Measuring instruments

**Subject Outcome 4.1: Sketch and explain the fundamentals of measuring instruments**

**Learning Outcomes:** The student should be able to:

• List and explain the devices that an analogue instrument consists of.
  
  **Range:** *Deflecting, controlling and damping devices.*
  
• Describe the operation of moving-iron instruments.
  
  **Range:** *Attraction and repulsion type.*
  
• Describe the operation of moving-coil instruments.
  
  **Range:** *Permanent-magnet and dynamometer type.*
  
• List the advantages and disadvantages of moving-iron and moving-coil instruments.
  
• Explain how power in single and three-systems is measured.
  
• Calculate the value of the series resistor to extend the range of a voltmeter.
  
• Calculate the value of the shunt resistor to extend the range of an ammeter.

**Subject Outcome 4.2: Explain how to use and care for hand-held measuring instruments**

**Range:** *Ammeter, Voltmeter, multimeter, voltage testers, clamp-meter and insulation resistance meter.*

**Learning Outcomes:** The student should be able to:

• Distinguish between analogue and digital meters.
  
• State the advantages of using digital meters.
  
• Explain the concept of parallax error.
  
• Set up and demonstrate the measuring instruments in the range for use in a practical situation.
  
• Explain the correct care and storage of the instruments in the range.

### Topic 5: Electric machines

**Subject Outcome 5.1: Sketch and explain DC machines**

**Learning Outcomes:** The student should be able to:

• Explain the functions of a motor and a generator.
  
• Explain the construction of a DC machine.
  
• Distinguish between lap and wave windings.
  
• Explain armature reaction.
  
• List and explain types of DC generators.
Range: separately excited, self excited, shunt, series, compound generator

- Calculate terminal voltage and generated e.m.f. of a generator using the formula
  \[ V = E - I_aR_a \]
- List and explain types of DC motors.

Range: Series, shunt and compound motors

- Calculate back e.m.f. of a motor using the formula
  \[ E = V - I_aR_a \]
- List losses in DC machines

Range: Copper loss, iron (or core) loss, friction and windage losses and brush contact loss

- List the characteristics and applications of DC motors.
- Explain the purpose of a DC motor starter.
- Explain how speed of DC motors can be controlled.

**Subject Outcome 5.2: Sketch and explain AC machines**

**Learning Outcomes:** The student should be able to:

- List and explain types of single-phase AC motors
  
  Range: Split-phase, capacitor-start capacitor-run, permanent capacitor, capacitor-start induction-run, resistance-start induction-run, universal and shaded pole motors

- List the applications, advantages and disadvantages of the motors in the range.
- Explain how a three-phase induction motor operates.
- List the advantages and applications of three-phase induction motors.
- List the applications, advantages and disadvantages and applications of squirrel cage rotors and wound rotor motors.
- List and explain types of motor starters.
  
  Range: Direct on-line, star-delta and auto-transformers.

- State and explain how motors are protected in a circuit.

7 RESOURCE NEEDS FOR THE TEACHING OF ELECTRICAL PRINCIPLES AND PRACTICE – LEVEL 3

8.1 Physical resources

Well equipped classrooms and workshops are essential for this practically 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 must possess 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 for the acquisition of new skills and updating of 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 coming from industry into the educational environment of a FET college.

8.3 Financial resources

The institution should make provision for:

• consumables for use during practicals
• maintenance of physical resources and
• purchasing of new equipment.