Unit 207E: Understand intermediate electrical science and principles

# Delivery guide

Unit information

This unit covers the fundamental science and principles relevant to electrical work. These principles underpin the knowledge understanding and performance requirements of all units within this qualification.

Learners may be introduced to this unit by asking themselves questions such as:

* What is the relationship of science and principles to electrical work?
* What is electricity?
* How is electricity generated, transmitted, and distributed to installations?

Learning outcomes

1. Understand fundamentalmathematical principles which are appropriate to electrical installation work
2. Understand the standard units of measurement used in electrical installation and design work
3. Understand basic mechanics and the relationship between force, work, energy and power
4. Understand the fundamental relationship between resistance, resistivity, voltage, current and power
5. Understand fundamental principles which underpin the relationship between magnetism, electricity, generation, and supply systems

Suggested resources

British Standards

*BS 7671:2018* *Requirements for Electrical Installations, IET Wiring Regulations*,18th edition (2018) London: Institution of Engineering and Technology. ISBN 978-1-78561-170-4

Websites

* [BBC Bitesize | Work, power and efficiency](https://www.bbc.co.uk/bitesize/guides/z8pk3k7/revision/1)
* [City & Guilds | SmartScreen](https://www.smartscreen.co.uk/)
* [Learning Lounge | Basic Electricity](https://www.learninglounge.com/com/2035138912)

Textbook

Tanner, P. (2018) The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365) London: Hodder Education. ISBN 978-1-51043-224-6

| **Learning outcomes** | **Criteria** | **Delivery guidance** |
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| 1. Understand fundamentalmathematical principles which are appropriate to electrical installation work | * 1. The appropriate mathematical principles which are relevant to electrical work tasks | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 1. * Learners to have an understanding of indices. * Learners to know how to transpose basic formulae. * Learners to understand area and volume. * Learners to understand basic trigonometry. |
| 1. Understand the standard units of measurement used in electrical installation and design work | * 1. The internationally recognised base and derived (SI) units of measurement for general quantities | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 2. * Learners to know how units are derived from the base units. * Learners to understand derived units such as area, volume, capacity, density, velocity, acceleration, force and pressure. |
| * 1. The values of base and derived SI units which apply specifically to electrical quantities | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 2 and to be familiar with the electrical SI units. * Learners to produce a chart with electrical units, their quantity symbol, unit name and unit symbol. |
| * 1. The appropriate electrical instruments for the measurement of different electrical quantities | * Learners to understand simple D.C circuits. * Learners to show by measurement that voltmeters are parallel connected. * Learners to show by measurement that ammeters are series connected. * Learners to be able to multiply the readings and check power value. * Learners to be able to introduce energy by introducing time from the above experiment. |
| 1. Understand basic mechanics and the relationship between force, work, energy and power | * 1. What is meant by mass and weight | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365),* Ch2, Section 2 and to know the difference between mass and weight. * Learners to understand the concept of weight being a force affected by gravity. * Learners to be able to state the acceleration of gravity value on our planet. * Learners to know the difference between a given mass against a weight on earth and on the moon. |
| * 1. The principles of basic mechanics as they apply to levers, gears, and pulleys | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 3. * Learners to know about class 1, 2 and 3 levers. * Learners to demonstrate, using simple ideas, the classes of levers, see-saws, wheelbarrows and tweezers. * Learners to know about small driven cogs and large driven cogs, and vice versa. * Learners to understand the mechanical advantage related to pulleys. |
| * 1. The main principles of mechanical principles and their inter-relationships | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 3. * Learners to understand where the mechanical principles come together, such as the forces required in moving a vehicle from a stationary position. * Learners to understand the work required to move or raise a mass. |
| * 1. Calculation of mechanical energy, power, and efficiency | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 3. * Learners to refer to worked examples from *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)* or similar textbooks. * Learners to refer to BBC Bitesize Work, power and efficiency. |
| 1. Understand the fundamental relationship between resistance, resistivity, voltage, current and power | * 1. The basic principles of electron theory | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to understand the structure of an atom, nucleus, protons, orbiting electrons, positive and negative charges. * Learners to understand outer shell free electrons loosely or tightly bound. * Learners to understand the electron structure of copper (29 protons). |
| * 1. Materials which are good conductors and insulators | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to know the materials used in the electrical industry, such as copper, aluminium, etc. * Learners to know types of cable insulation. * Learners to know about high voltage glass insulators. |
| * 1. What is meant by resistance and resistivity in relation to electrical circuits | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to know about resistivity and its unit. * Learners to be able to describe resistivity as the resistance across opposite faces of a 1m cube of material. * Learners to be able to describe resistance as the opposition to the flow of current. * Learners to know how to use the Greek letter ρ (rho) to indicate resistivity, and dependent on material. * Learners to show examples of the relationship R = ρ l/A. |
| * 1. The relationship between current, voltage and resistance in parallel and series D.C circuits | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to show formulae relating to Ohms law. * Learners to know the laws of series circuits. * Learners to know the laws of parallel circuits. |
| * 1. The values of current, voltage and resistance in parallel and series D.C circuits | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to understand simple D.C circuits. |
| * 1. The values of power in parallel and series D.C circuits | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to understand simple D.C circuits and the three formulae for calculating power. |
| * 1. What is meant by the term voltage drop in relation to electrical circuits | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 4. * Learners to be able to describe voltage drop as a drop in electrical voltage at the load of an electrical circuit due to the resistance of the conductors and the load current flowing. * Learners to know that, for public networks, BS 7671:2018 limits the voltage drop to 3% for lighting and 5% for everything else. |
| * 1. The chemical and thermal effects of electric currents | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Sections 4 and 5. * Learners to explain methods of producing an electromagnetic field (EMF). * Learners to understand chemical effects, including cells and batteries. * Learners to understand thermal effects such as thermo couples. |
| 1. Understand fundamental principles which underpin the relationship between magnetism, electricity, generation, and supply systems | * 1. The effects of magnetism in terms of attraction and repulsion | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 5. * Learners to understand the effects of magnetic fields when magnets are in close proximity to each other. * Learners to show, by a simple experiment with bar magnets, that like poles repel and unlike poles attract. * Learners to show the field plot when two fixed magnets are facing each other with like poles in the centre. * Learners to show the field plot when two fixed magnets are facing each other with unlike poles in the centre. |
| * 1. The difference between magnetic flux and flux density | * Learners to understand that lines of magnetic flux never cross, they have an assumed direction of leaving the North end and entering the South end and through the magnet to complete the magnetic circuit. * Learners to understand that the concentration of the magnetic flux per square metre is the flux density: B = Ф/A. |
| * 1. The magnetic effects of electrical currents in terms of: * production of a magnetic field * force on a current-carrying conductor in a magnetic field * electromagnetism * electromotive force | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 5. * Learners to understand solenoids. * Learners to understand the grip rule. * Learners to know F = BIL. * Learners to know left hand rules for motors. * Learners to know right hand rules for generators. |
| * 1. The basic principles of A.C generation in terms of: * a single-loop generator * sinewave * frequency * EMF * magnetic flux * three-phase systems | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 5. * Learners to know how a sine wave is generated from a single loop rotated in a magnetic field. * Learners to show the voltage at various angles of rotation within the magnetic field over one cycle. * Learners to know how the principle of sine wave generation can be extended to a three-phase system. * Learners to know the voltages produced by 3 phase 4 wire L-L, L-N, and L-E and Star and Delta formations. |
| * 1. The characteristics of sinewaves | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch2, Section 5. * Learners to understand sine waves. * Learners to understand peak value. * Learners to understand root mean square (RMS) value. * Learners to understand average over half a cycle. * Learners to understand periodic time. * Learners to understand frequency. * Learners to understand the relationship between frequency and time. |
| * 1. The features and characteristics of a generation, transmission, and distribution system | * Learners to refer to *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, Ch3. * Learners to understand and be able to illustrate system diagrams showing: * the generation voltages (power station) * the transmission part of the grid and super grid network * the distribution part of the network * where users are connected * where step up is required * where step down is required. |