Unit 307E: 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

Textbooks

* *BS 7671:2018* *Requirements for Electrical Installations, IET Wiring Regulations* (2018) 18th edition. London: Institution of Engineering and Technology. ISBN 978-1-7856-1170-4
* Scaddan, B. (2018) *Electrical installation Work*, 9th edition. London: Routledge Publishing. ISBN 978-0-3670-2334-8
* 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 978-1-5104-3224-6

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/)
* [Efixx | The Electricians’ Channel](https://www.efixx.co.uk/Apprentice%20Hub/downloads)
* [GCSE.com | Algebra](https://www.gcse.com/maths/algebra.htm)
* [JavaLab | DC Motor 2](https://javalab.org/en/dc_motor_2_en/)
* [JavaLab | Lorentzs Force (Electromagnetic swing)](https://javalab.org/en/lorentzs_force_3d_en/)
* [JavaLab | Faraday’s Law of Electromagnetic Induction](https://javalab.org/en/faradays_law_en/)
* [Learning Lounge | Basic Electricity](https://www.learninglounge.com/com/2035138912) (2009)

British Standards

* BS 7671:2018+A1:2020. *Requirements for Electrical Installations. IET Wiring Regulations*.

| **Learning outcomes** | **Criteria** | **Delivery guidance** |
| --- | --- | --- |
| 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 have an understanding of indices and square roots. * Learners to know how to transpose basic formulae. * Learners to understand fractions and percentages. * Learners to undertake the e-learning pages, solve simple algebra equations and take the tests from GCSE.com (see Suggested resources). * Learners to be shown simple algebra problems in electrical work such as Ohm’s Law and Kirchhoff’s current and voltage laws to solve unknown quantities in engineering situations. |
| 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 know how units are derived from the base units. * Learners to know the base units such as length, mass, temperature and time. * Learners to understand derived units such as area, volume, density and velocity. |
| * 1. The values of base and derived SI units which apply specifically to electrical quantities | * Learners to be familiar with the electrical SI units of measurement and commonly used multiples and sub-multiples in electrical installation work. * Learners to know the values of base and derived SI units such as: * resistance * resistivity * power * frequency * current. |
| * 1. The appropriate electrical instruments for the measurement of different electrical quantities | * Learners to understand the electrical instruments used to measure electrical units, such as ohm meters, watt meters, ammeters, voltmeters and kWh meters to measure resistance, power, current, voltage and energy respectively. |
| 1. Understand basic mechanics and the relationship between force, work, energy and power | * 1. What is meant by mass and weight | * Learners to know the difference between mass and weight and the SI units for each. * 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 understand that mass is the comparison of an amount of material measured against a known value. |
| * 1. The principles of basic mechanics as they apply to levers, gears and pulleys | * Learners to know about class 1, 2 and 3 levers. * Learners to understand gear ratios. * Learners to understand the term ‘mechanical advantage’ and to know how it is related to pulleys. |
| * 1. The main principles of mechanical principles and their inter-relationships | * Learners to understand: * the work required to move or raise a mass * kinetic and potential energy * power and efficiency. |
| * 1. Calculation of mechanical energy, power and efficiency | * Learners to refer to worked examples from Tanner, *Book 1* or similar textbooks. * Learners to refer to BBC Bitesize: Work, power and efficiency (see Suggested resources). |
| 1. Understand the fundamental relationship between resistance, resistivity, voltage, current and power | * 1. The basic principles of electron theory | * Learners to understand: * the structure of an atom, nucleus, protons, orbiting electrons, positive and negative charges * outer shell free electrons loosely or tightly bound * the electron structure of copper (29 protons). |
| * 1. Materials which are good conductors and insulators | * Learners to know: * the materials used in the electrical industry, such as copper, aluminium, etc. * types of cable insulation * about high-voltage glass insulators. |
| * 1. What is meant by resistance and resistivity in relation to electrical circuits | * 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 dependence on material. * Learners to be able to show examples of the relationship R = ρ l/A. |
| * 1. The relationship between current, voltage and resistance in parallel and series DC circuits | * Learners to know: * formulae relating to Ohm’s law * the laws of series direct current (DC) circuits * the laws of parallel DC circuits. |
| * 1. The values of current, voltage and resistance in parallel and series DC circuits | * Learners to understand simple DC circuits and the values of current, voltage and resistance. |
| * 1. The values of power in parallel and series DC circuits | * Learners to understand simple DC circuits and the three formulae for calculating power. |
| * 1. What is meant by the term ‘voltage drop’ in relation to electrical circuits | * 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. |
| * 1. The chemical and thermal effects of electric currents | * Learners to understand that when current flows through a wire a heating effect occurs, such as in electric heaters and other heating devices. * Learners to understand that when an electric current flows through an electrolyte a chemical reaction occurs, such as in batteries and electroplating. |
| 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 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 * the field plot when two fixed magnets are facing each other with like poles in the centre * 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 passing 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 understand: * how an electric current passing through a conductor or coil can produce a magnetic field * that a force can be exerted on a current carrying conductor when in a magnetic field * that electromagnetism is the phenomenon of the interaction of electric currents and magnetic fields including motors, generators, relays, solenoids and transformers * that electromotive force is the potential difference of the power source in an electrical circuit, measured in volts. * Learners to be shown interactive demonstrations of electromagnetism (see the three JavaLab websites in Suggested resources). |
| * 1. The basic principles of AC generation in terms of: * a single-loop generator * sine waves * frequency * EMF * magnetic flux * three-phase systems | * Learners to know how a sine wave is generated from a single loop rotated in a magnetic field. * Learners to understand that the number of cycles generated in one second is the frequency, measured in Hertz. * Learners to know that the electromagnetic field (EMF) induced is derived from the product of flux density, the length of the flux path and the velocity. * Learners to know how the principle of sine wave generation can be extended to a three-phase system. |
| * 1. The characteristics of sine waves | * Learners to understand: * sine waves * amplitude and peak-to-peak value * root mean square (RMS) value * average over half a cycle * periodic time * frequency * the relationship between frequency and time. |
| * 1. The features and characteristics of a generation, transmission and distribution system | * Learners to understand: * that generation relates to power stations and can burn fossil fuels or be powered by hydro or nuclear fuel * that transmission of the generated voltage is stepped up by transformers to the standard grid or super grid voltages * that distribution of the transmission voltages is stepped down via transformers to the required voltages to substations, either above or below ground * the voltages present for generation, transmission and distribution of a power network utilising a three-phase system. |