Delivery Unit

Level 3

Electrical Scientific Principles and Technologies

Unit Code: NETK3-08

115 GLH

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Unit Aim

This unit is designed to enable learners to understand the relationship between electrical scientific principles and the competencies required of a qualified electrical operative. Its content is the knowledge needed by a learner to underpin the application of skills in the installation and maintenance of electrical systems and equipment.

Summary of Learning Outcomes

The learner will:

1. Understand mathematical principles which are appropriate to electrical installation, maintenance and design work.
2. Understand standard units of measurement used in electrical installation, maintenance and design work.
3. Understand basic mechanics and the relationship between force, work, energy and power.
4. Understand the relationship between resistance, resistivity, voltage, current and power.
5. Understand the fundamental principles which underpin the relationship between magnetism and electricity.
6. Understand the types, applications and limitations of electronic components in electrical systems and equipment.
7. Understand electrical supply systems.
8. Understand how different electrical properties can affect electrical circuits, systems and equipment.
9. Understand the operating principles and applications of d.c. machines and a.c. motors.
10. Understand the operating principles of electrical components.
11. Understand the principles and applications of electrical lighting systems.
12. Understand the principles and applications of electrical heating.

Assessment

Two graded exams:

- Learning outcomes **1 - 6** are assessed by a graded on-screen exam. **It is graded on the first attempt only: Pass, Merit, Distinction; (or Fail). Any resitting will only be subject to a Pass grade maximum.**
- Learning outcomes **7 - 12** are assessed by a centre marked and graded written paper. **It is graded on the first attempt only: Pass 50% (39 Marks), Merit 65% (51 Marks), Distinction 80% (63 Marks) or Fail. Any resitting will only be subject to a Pass grade maximum.**

There is also a centre marked practical assessment covering transformers.

The purpose of the standalone grades is to indicate to an employer the learner's ability in electrical science and principles, which is useful if an employer wishes to develop the learner further; for example on higher level qualifications. The grades from the examinations will not contribute toward the overall apprenticeship grade.

Guidance

Delivery advice has been included adjacent to the assessment criteria. This also gives a range of items to be covered with some ideas to help the delivery.

The content covered in learning outcomes 1-6 will underpin learning outcomes 7-12.

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
1. Understand mathematical principles which are appropriate to electrical installation, maintenance and design work. ***(This outcome is assessed by a graded on-screen exam)***	**1.1 Identify and apply appropriate mathematical principles which are relevant to electrical work tasks.**	Mathematical principles: Fractions and percentages Algebra Statistics Transposition Triangles and trigonometry Indices.
2. Understand standard units of measurement used in electrical installation, maintenance and design work. ***(This outcome is assessed by a graded on-screen exam)***	**2.1 Identify and use internationally recognised base and derived (SI) units of measurement.**	(SI) Units of measurement for: • Length, Area, Volume, Mass; Density • Time, Temperature; Velocity.
	2.2 Identify and determine values of base and derived SI units which apply specifically to electrical quantities.	Electrical quantities (SI units): • Resistance, • Resistivity, • Power. • Frequency, • Current, • Voltage • Energy • Impedance • Inductance and inductive reactance • Capacitance and capacitive reactance • Power factor.

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
2. Understand standard units of measurement used in electrical installation, maintenance and design work (continued). ***(This outcome is assessed by a graded on-screen exam)***	**2.3 Identify appropriate electrical instruments for the measurement of different electrical quantities.**	Electrical quantities(measurement): • Resistance • Power • Current • Voltage • Energy.
3. Understand basic mechanics and the relationship between force, work, energy and power. ***(This outcome is assessed by a graded on-screen exam)***	**3.1 Specify what is meant by mass and weight.**	
	3.2 Explain the principles of basic mechanics as they apply to levers, gears and pulleys.	Cover Class I, Class II and Class III levers.
	3.3 Describe the main principles of the following and their inter-relationships: • **force** • **work** • **energy (kinetic and potential)** • **power** • **efficiency.**	
	3.4. Calculate values of mechanical energy, power and efficiency.	

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
4. Understand the relationship between resistance, resistivity, voltage, current and power. ***(This outcome is assessed by a graded on-screen exam)***	**4.1 Describe the basic principles of electron theory.**	
	4.2 Identify and distinguish between materials which are good conductors and insulators.	Relate to cables used in electrical installation work.
	4.3 Describe what is meant by resistance and resistivity in relation to electrical circuits.	
	4.4 Explain the relationship between current, voltage and resistance in parallel and series d.c. circuits.	Cover basic types of circuits.
	4.5 Calculate the values of current, voltage and resistance in parallel and series D.C. circuits.	
	4.6 Calculate values of power in parallel and series d.c. circuits.	
	4.7 State what is meant by the term voltage drop in relation to electrical circuits.	This can link to unit NETK3/04, in terms of cable selection and circuit design
	4.8 Describe the chemical and thermal effects of electric currents.	Such as: Chemical: primary and secondary cells, electroplating. Heating: Cookers, water heaters, soldering irons, electric fires etc. See if the learners can think of examples of each.

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
5. Understand the fundamental principles which underpin the relationship between magnetism and electricity. ***(This outcome is assessed by a graded on-screen exam)***	**5.1 Describe the effects of magnetism in terms of attraction and repulsion.**	Cover the fundamental laws of magnetism.
	5.2 State the difference between magnetic flux and flux density.	The SI unit of magnetic flux is the weber (Wb). The tesla (symbol T) is the SI derived unit of magnetic flux density, denoted as B. One tesla is equal to one weber per square metre. $T = Wb/m^2$. As a simple memory aid 'Magnetic flux densi**T**y is measured in **T**eslas. The amount of magnetic flux a magnet displays is a direct result of the material that makes up the magnet. The magnetic flux density is a product of the magnetic flux and the area that this flux is present within.
	5.3 Describe 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.**	Examples of magnetic effects can be seen in bells, motors, relays, transformers and generators. Cover: Maxwell's right hand grip rule and right handed screw rule. Cover fleming's left hand rule in relation to motors. As a memory aid ***motors*** drive on the left hand side (LHS). RHS is for generators - see below.
	5.4 Describe the basic principles of generating an a.c. supply in terms of: • **a single-loop generator** • **sine-wave** • **frequency** • **EMF** • **magnetic flux.**	You-tube has videos of generators to help explain the process. Also link topic to motors. A lesson could involve students using a simple hand wound generator connected to an oscilloscope. Learners can generate and a.c. and calculate RMS, average value, peak to peak value, periodic time, frequency and amplitude (see below). Can also construct simple generators out of magnets, cardboard and coils of wire. Cover Fleming's right hand rule in relation to generators.
	5.5 Identify the characteristics of sine-waves.	In terms of a.c. cover: Root mean square (RMS) value, average value, peak to peak value, periodic time, frequency and amplitude.

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
6. Understand the types, applications and limitations of electronic components in electrical systems and equipment. ***(This outcome is assessed by a graded on-screen exam)***	**6.1 Describe the function and application of electronic components that are used in electrical systems.**	Electronic components and devices: • Capacitors • Resistors • Rectifiers • Diodes: Zener, LED; photo • Thermistors • Diacs • Triacs • Transistors • Thyristors • Invertors. Electrical systems: • Security alarms • Telephones • Dimmer switches • Heating/boiler controls • Motor control • Wireless control systems.
	6.2 State the basic operating principles of electronic components and devices.	

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
7. Understand electrical supply systems. ***(This outcome is assessed by a graded written paper)***	**7.1 Describe how electricity is generated and transmitted for domestic and industrial/ commercial consumption.**	Cover: • Power Stations, fossil fuels, hydro; nuclear. • Super-grid and standard grid system, transformers, transmission voltages, distribution voltages, sub-stations, above and below ground distribution
	7.2 Specify the features and characteristics of a generation and transmission system.	
	7.3 State the basic operating principles of other sources of electricity.	Other sources: batteries, cells or UPS systems, solar power (thermal and photovoltaic), wind energy, wave energy, micro hydro, combined heat and power (CHP) including micro CHP.
	7.4 Describe the main characteristics of: • **single phase electrical supplies** • **three phase electrical supplies** • **three phase and neutral supplies** • **sub-station transformers.**	Link to criteria 8.8. Also cover PME and PEN conductors.
	7.5 Identify types of transformers.	Such as: auto, current, voltage, isolating etc.
	7.6 Describe the operating principles, applications and limitations of transformers.	Operating principles, applications and limitations: • Iron loss, copper loss • Relationship between current and voltage and primary and secondary windings • Step up and step down transformers.
	7.7 Determine by calculation and measurement: • **primary and secondary voltages** • **primary and secondary current** • **kVA rating of a transformer.**	Criteria 7.7 is assessed by a centre marked practical (Transformers).

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
8. Understand how different electrical properties can affect electrical circuits, systems and equipment. ***(This outcome is assessed by a graded written paper)***	**8.1 Explain the relationship between resistance, inductance, capacitance and impedance.**	Cover the relationship in simple RLC series; and parallel circuits. Cover the relevant phasor diagrams.
	8.2 Determine electrical quantities in alternating current circuits.	Electrical quantities: Resistance, inductance, Inductive reactance, capacitance, capacitive reactance; Impedance.
	8.3 Explain the relationship between kW, kVAr, kVA and power factor.	Cover the power triangle (and also the voltage and impedance triangle). Active/True Power (kW), Reactive Power kVAr); Apparent Power (kVA). (Further note: in electrical engineering Active power is denoted by P, Apparent power by S, and reactive power Q. For further study on this topic and also complex numbers - please see L3 Engineering VRQs offered by EAL).
	8.4 Calculate power factor.	R/Z
	8.5 Explain what is meant by power factor correction.	Bringing the power factor closer to unity by reducing the undesirable effects of reactive power.
	8.6 Specify methods of power factor correction.	Local correction at load using a single capacitor, bulk correction using capacitor banks. Use of a synchronous motor (e.g. driving a fan).
	8.7 Determine the neutral current in a three-phase and neutral supply and why systems should be balanced.	Phase current can be added phasorially.
	8.8 Calculate values of voltage and current in star and delta connected systems.	This can link back to 7.4. Cover: Line and phase voltage; and line and phase current.

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
9. Understand the operating principles and applications of d.c. machines and a.c. motors.	**9.1 State the basic types, applications and describe the operating principles of d.c. machines.**	A d.c. machine relates to motors and generators. Cover the following: • Series • Shunt • Compound. Cover basic types circuit diagrams. Cover commutation and the principles of these machines. Cover fundamental calculations.
(This outcome is assessed by a graded written paper)	**9.2 Describe the operating principles of a.c. motors.**	a.c. motors: • Single phase a.c. motors (split phase, induction, capacitor start-induction run, capacitor start and run, capacitor start - capacitor run) , universal, synchronous). • Three phase a.c. motors (induction, wound-rotor, synchronous).
	9.3 State the basic types, applications and limitations of a.c. motors.	
	9.4 Describe the basic operating principles, limitations and applications of motor control.	Cover the following methods: Direct-on-line, star-delta, rotor-resistance, soft-start, variable frequency.
10. Understand the operating principles of electrical components. ***(This outcome is assessed by a graded written paper)***	**10.1 Specify the main types and operating principles of electrical components.**	Cover: • Relays • Solenoids • Over-current protection devices: Fuses (HRC, cartridge and re-wireable), Circuit-breakers, RCBOs; RCDs, AFDDs.

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Learning Outcomes The learner will:	**Assessment Criteria** The learner can:	**Delivery Advice** (not exhaustive):
11. Understand the principles and applications of electrical lighting systems. ***(This outcome is assessed by a graded written paper)***	**11.1 Explain the basic principles of illumination and state the applications of:** • **inverse square law** • **cosine law** • **lumen method.**	Cover the relevant calculations. For luminaires cover: General Lighting Service (GLS): • Tungsten • Halogen. Discharge lighting: • Low and high pressure mercury vapour • Low and high pressure sodium vapour • Metal halide • Energy saving (such as compact fluorescent lamps) • LED.
	11.2 Explain the operating principles, types, limitations and applications of luminaires.	
12.1 Understand the principles and applications of electrical heating. ***(This outcome is assessed by a graded written paper)***	**12.1 Explain the basic principles of electrical space heating and electrical water heating.**	Electrical space and water heating appliances and components: • Convection cycle • Conduction • Radiation • Immersion heaters • Storage heaters • Convector heaters • Under floor heating • Controls, timers and programmers for heating systems.
	12.2 Explain the operating principles, types, limitations and applications of electrical space and water heating appliances and components.	