Unit 6: Electrical and Electronic Principles

Unit code: J/600/0255

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners an understanding of the underlying physical principles on which electrical and electronic devices and circuits depend. It will also develop skills in the application of circuit theory.

Unit introduction

The modern world relies on electrical and electronic devices – from mobile telephones to jet aeroplanes, these devices have had an enormous impact on the way we live today. Without early engineers such as Faraday and Lenz, who studied the then new concept of electricity, many of the inventions we now take for granted would not have been developed.

The unit starts by developing and extending learners' understanding of fundamental electrical and electronic principles through analysis of simple direct current (DC) circuits. Learners are then taken through the various properties and parameters associated with capacitance and inductance, before finally considering the application of single-phase alternating current (AC) theory. The unit will encourage learners to take an investigative approach through practical construction, measurement and testing of circuits and, where applicable, the use of computer-based circuit analysis and simulation.

For learners wishing to follow an electrical/electronic programme this unit is an essential building block that will provide the underpinning knowledge required for further study of electrical and electronic applications.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use circuit theory to determine voltage, current and resistance in direct current (DC) circuits

2 Understand the concepts of capacitance and determine capacitance values in DC circuits

3 Know the principles and properties of magnetism

4 Be able to use single-phase alternating current (AC) theory.

Unit content

1 Be able to use circuit theory to determine voltage, current and resistance in direct current (DC) circuits

DC circuit theory: voltage eg potential difference, electromotive force (emf); resistance eg conductors and insulators, resistivity, temperature coefficient, internal resistance of a DC source; circuit components (power source eg cell, battery, stabilised power supply; resistors eg function, types, values, colour coding; diodes eg types, characteristics, forward and reverse bias modes); circuit layout (DC power source, resistors in series, resistors in parallel, series and parallel combinations); Ohm's law, power and energy formulae eg $V = IR$, $P = IV$, $W = Pt$, application of Kirchhoff's voltage and current laws

DC networks: networks with one DC power source and at least five components eg DC power source with two series resistor and three parallel resistors connected in a series parallel arrangement; diode resistor circuit with DC power source, series resistors and diodes

Measurements in DC circuits: safe use of a multimeter eg setting, handling, health and safety; measurements (circuit current, voltage, resistance, internal resistance of a DC power source, testing a diode's forward and reverse bias)

2 Understand the concepts of capacitance and determine capacitance values in DC circuits

Capacitors: types (electrolytic, mica, plastic, paper, ceramic, fixed and variable capacitors); typical capacitance values and construction (plates, dielectric materials and strength, flux density, permittivity); function eg energy stored, circuits (series, parallel, combination); working voltage

Charging and discharging of a capacitor: measurement of voltage, current and time; tabulation of data and graphical representation of results; time constants

DC network that includes a capacitor: eg DC power source with two/three capacitors connected in series, DC power source

3 Know the principles and properties of magnetism

Magnetic field: magnetic field patterns eg flux, flux density (B), magnetomotive force (mmf) and field strength (H), permeability, B/H curves and loops; ferromagnetic materials; reluctance; magnetic screening; hysteresis

Electromagnetic induction: principles eg induced electromotive force (emf), eddy currents, self and mutual inductance; applications (electric motor/generator eg series and shunt motor/generator; transformer eg primary and secondary current and voltage ratios); application of Faraday's and Lenz's laws

4 Be able to use single-phase alternating current (AC) theory

Single phase AC circuit theory: waveform characteristics eg sinusoidal and non-sinusoidal waveforms, amplitude, period time, frequency, instantaneous, peak/peak-to-peak, root mean square (rms), average values, form factor; determination of values using phasor and algebraic representation of alternating quantities eg graphical and phasor addition of two sinusoidal voltages, reactance and impedance of pure R, L and C components

AC circuit measurements: safe use of an oscilloscope eg setting, handling, health and safety; measurements (periodic time, frequency, amplitude, peak/peak-to-peak, rms and average values); circuits eg half and full wave rectifiers

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:		To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:	
P1	use DC circuit theory to calculate current, voltage and resistance in DC networks	**M1**	use Kirchhoff's laws to determine the current in various parts of a network having four nodes and the power dissipated in a load resistor containing two voltage sources	**M1**	analyse the operation and the effects of varying component parameters of a power supply circuit that includes a transformer, diodes and capacitors
P2	use a multimeter to carry out circuit measurements in a DC network	**M2**	evaluate capacitance, charge, voltage and energy in a network containing a series-parallel combination of three capacitors	**D2**	evaluate the performance of a motor and a generator by reference to electrical theory.
P3	compare the forward and reverse characteristics of two different types of semi-conductor diode [IE4]	**M3**	compare the results of adding and subtracting two sinusoidal AC waveforms graphically and by phasor diagram.		
P4	describe the function of different types of capacitors				
P5	carry out an experiment to determine the relationship between the voltage and current for a charging and discharging capacitor [IE3]				
P6	calculate the charge, voltage and energy values in a DC network for both three capacitors in series and three capacitors in parallel				
P7	describe the characteristics of a magnetic field				
P8	describe the relationship between flux density (B) and field strength (H)				

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P9 describe the principles and applications of electromagnetic induction		
P10 use single phase AC circuit theory to determine the characteristics of a sinusoidal AC waveform [IE3]		
P11 use an oscilloscope to measure and determine the inputs and outputs of a single phase AC circuit [SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Unit 4: Mathematics for Engineering Technicians has strong links with this unit and it is recommended that both units are delivered concurrently to give learners the necessary mathematical skills. Some level of computer skills may also be necessary to use the computer-based software.

The four learning outcomes are linked and the delivery strategy should ensure that these links are maintained. Learning outcome 1 is the most likely starting point for delivery, as it will establish much of the underpinning knowledge and skills required for the remaining learning outcomes. The unit could be delivered through a combination of theory lessons and demonstrations, reinforced through practical work in an electrical science laboratory/workshop. It is important that learners have a thorough understanding of circuit theory if they are to be able to recognise, handle and select relevant components (for example power sources, resistors, diodes).

Initially, delivery could use paper-based or computer-based exercises (for example calculate the required value of a second resistance in a series circuit to give a current flow of 2A with a 6V power source). However, even at this stage it may be beneficial to introduce learners to real circuit components. The learners' ability to lay out circuits is an important part of this learning outcome and will support the other outcomes of the unit. Most centres will probably start with paper-based methods of drawing simple circuits (for example power source and series/parallel combination of resistors such as voltage and current divider circuits). It is likely that centres will move on to computer simulation and the use of real circuits/components, using either 'bread boarding' techniques or soldered circuits.

Learners should be given the opportunity to practise using the formulae identified in the unit content but are not required to memorise them. However, they should be expected to select the most appropriate formulae to determine the required circuit values of current, voltage or resistance. In addition, learners should have the confidence to transpose equations to meet their needs (for example use Ohm's law $V = IR$ and the power equation $P = IV$ to arrive at $P = I2R$, use $R = R1+R2$ to arrive at $R1 = R – R2$). Clearly, the ability to transpose formulae is a mathematical skill and tutors will need to ensure that appropriate support is provided during both the delivery of this learning outcome and the unit as a whole.

Wherever possible, centres should enable learners to experience a range of multimeters that reflect typical and current industry usage. It would not be appropriate to only use computer-based simulation packages. Tutors should ensure the safe use of multimeters and an awareness of their use in a laboratory/workshop and industrial setting.

The use of computer-based software packages for analysis and simulation of electrical circuits together with practical laboratory work will help to corroborate theoretical results.

Centres should consider whether it is necessary to deliver the section on diode theory with or without recourse to semi-conductor theory. It should be noted that Unit 35: Principles and Applications of Electronic Devices and Circuits does not specify the delivery of semi-conductor theory as a precursor to diode theory. If semi-conductor theory is delivered within this unit it should be focused towards enabling learners to achieve criterion P3.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, scheme of work and method of assessment • explain the terminology used to describe the parameters of direct current circuit theory and their associated symbols and units • demonstration of simple circuit layouts using components or computer simulation, together with representation of components using circuit symbols and explanation of resistor colour coding.
Whole-class teaching: • explain the application of Ohm's law in the calculation of resistance, current and voltage in direct current circuits. The use of formulae to evaluate power and energy • explain the application of Kirchhoff's voltage and current laws together with a demonstration of potential and current division using circuit simulation software. *Individual learner activities*: • tutor-led exercises on solution of problems involving direct current circuit theory *Whole-class teaching*: • explain the technique involved in the solution of problems involving combinations of series and parallel resistances and sources of emf followed by a demonstration of the characteristics of series and parallel circuits using circuit simulation software. *Individual learner activities*: • tutor-led solution of problems on series/parallel combinations.
Preparation for and carrying out **Assignment 1: DC Circuit Theory/Resistor Networks and Kirchhoff's Laws** (P1, M1).
Whole-class teaching: • practical activity to introduce and demonstrate the safe use of a multimeter, setting the various ranges and using them to measure the internal resistance of a DC voltage source • explain the characteristics of diodes followed by a demonstration to show how they operate in forward and reverse bias modes, and the function of resistors and diodes in a diode resistor circuit with a DC power source.
Preparation for and carrying out **Assignment 2: DC Circuit Theory/Measurement and Diodes** (P2, P3).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • consider the basic construction of a capacitor, discussion of the different types followed by an explanation of the effect of increasing the number of plates • explain the terminology associated with capacitors such as dielectric materials, dielectric strength, flux density and permittivity. *Group practical activity*: • to consider construction of various types of capacitor and the effect of increasing the number of plates. *Whole-class teaching*: • explain and discuss the use of capacitors as an energy store and introduce the formula for calculation of energy stored • demonstrate the effect of connecting capacitors in series, parallel and combination followed by solution of problems • explain the changes of current and voltage that occur during the charging and discharging of a capacitor together with the effect of circuit resistance and the concept of time constant • explain the evaluation of DC networks containing DC power source and various capacitor combinations followed by a demonstration using circuit simulation software. *Individual learner activities*: • tutor-led exercises on series and parallel capacitor combinations • tutor-led solution of problems involving the charging and discharging of capacitors • tutor-led solution of problems on DC networks to find charge, voltage and energy values in circuits with DC power source and capacitors in series/parallel.
Preparation for and carrying out **Assignment 3: Capacitors** (P4, P5, P6, M2).
Whole-class teaching: • describe and discuss the idea of magnetic fields generated by permanent magnets, together with the concept of magnetic flux and the laws of attraction and repulsion. Introduce and explain the relationship between flux density, magnetic flux and cross-sectional area followed by a demonstration of the flux density meter • explain and discuss the concepts of magneto-motive force, field strength and reluctance. *Individual learner activities*: • tutor-led solution of problems on flux density • tutor-led solution of problems on magneto-motive force, field strength and reluctance.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain and demonstrate the concept of electro-magnetic induction, explain the occurrence of eddy currents and how to minimise them followed by a discussion and explanation of self and mutual inductance • explain and discuss the magnetic field produced by a current • tutor demonstration showing the force acting on a current carrying conductor in a magnetic field and the associated formula ($F = BI\ell$) followed by a demonstration of Fleming's rules • tutor introduction to the concept of induced emf due to motion ($e = B\ell v$). *Individual learner activities*: • tutor-led solution of simple problems on self and mutual inductance • tutor-led solution of problems on force on a conductor and induced emf due to motion. *Whole-class teaching*: • describe the construction and operation of DC motors and generators with particular reference to the previous week's work • explain and discuss the transformer principle, the idea of an ideal transformer and the transformation ratios. Individual learner activities: • tutor-led solution of problems on DC motors and generators • tutor-led solution of simple problems involving the transformation ratios.
Preparation for and carrying out **Assignment 4: Magnetism, Transformers and Motor/Generators** (P7, P8, P9, D2).
Whole-class teaching: • describe and discuss the generation of a sinusoidal waveform and define the terms amplitude, periodic time, frequency, instantaneous, peak/peak to peak, root mean square (rms) and average values for an alternative current/voltage. Characteristics of non-sinusoidal waveforms and form-factor • solve problems involving waveform characteristics • explain and discuss phasor and algebraic representation of alternating quantities followed by a tutor-led demonstration of the methods of phasor addition. *Individual learner activities*: • tutor-led solution of problems on phasor addition. *Whole-class teaching*: • explain and discuss the calculation of capacitive and inductive reactance, and the calculation of impedance from circuits containing pure R, L and C • tutor demonstration to explain the safe use and setting up of an oscilloscope to measure the characteristics of sinusoidal waveforms • practical work to measure the characteristics of sinusoidal waveforms and complete worksheets • tutor demonstration of the use of an oscilloscope and multimeter to investigate half and full wave rectification. *Individual learner activities*: • tutor-led exercises on solution of problems involving circuit reactance and impedance.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • group practical work to compare measured and theoretical results • tutor demonstration to investigate primary and secondary current and voltage ratios. *Individual learner activities*: • record results and findings comparing measured and theoretical • tutor demonstration on the operation of a simple power supply and the function of the individual components.
Preparation for and carrying out **Assignment 5: Single Phase AC** (P9, P10, M3, D1).
Feedback on all assessment tasks, guidance on remedial action if necessary. Unit evaluation and close.

Assessment

Much of the evidence for the pass criteria can be achieved by practical experimentation with real components and circuits and computer-based software packages, where appropriate.

It is likely that at least five assessment instruments will be required for this unit. If practical work and tests are also used then the total number of pieces of assessed work could be even more than this. This should be carefully considered so that it does not place an unduly high assessment burden on learners or the tutor.

Wherever possible, practical work should lead to a final product that can be handed in for assessment at the end of the session without further need for report writing. This will help control authenticity of evidence and also keep the assessment activities short, sharp and relevant.

Clearly, the ability to safely use a multimeter (P2) will require process evidence, ie, it will need to be observed by the tutor during relevant practical activities. Tutors could capture this evidence by using an appropriate record of observation and oral questioning of each learner during the practical activities used for delivery.

The assessment of the use of circuit theory to calculate current, voltage and resistance in DC networks (P1) could be achieved by using a paper-based or computer-based method. However, it is essential that centres combine any testing of this sort with practical hands-on experience of real circuits and components. This could be achieved by prototyping circuits using simulation software to establish theoretical circuit values, followed by learners building the circuit and physically checking theory against actual results by measurement. Whichever method is used, centres need to ensure that sufficient product evidence is available of the circuit being used/developed and the formulae selected/used to determine the required current, voltage or resistance values. This is particularly important where computer software is used that does not have a facility to print results or where print-outs do not show sufficient detail to meet the criteria.

The comparison of the forward and reverse characteristics of two types of semi-conductor diode (P3) will require the use of a multimeter, power supply, ammeter with shunt, and a switch resistor box.

For P4, learners will need to describe the full range of types of capacitors (electrolytic, mica, plastic, paper, ceramic, fixed and variable) including typical capacitance values, construction (plates, dielectric materials and strength, flux density, permittivity), their function and working voltages.

P5 requires learners to carry out a laboratory experiment to investigate the charging and discharging of a capacitor through a resistor. A simple but effective way of doing this is to use a power supply unit, a 500μF electrolytic capacitor, a stopwatch or clock and an AVO type multimeter, using the internal resistance of the meter as the resistor. Learners could then be asked to plot the graph of the growth of capacitor voltage against time and evaluate the time constant by comparing the results with standard theory.

P6 involves the calculation of charge, voltage and energy values for DC networks that include a DC power source with two/three capacitors connected in series and a DC power source with two/three capacitors connected in parallel.

The characteristics of magnetic fields for P7 could be demonstrated on an OHP by using magnets and iron filings. Learners could sketch the results and then make appropriate comparisons with expected theoretical results. For P8, learners need to explain the relationship between flux density (B) and field strength (H) with particular emphasis on BH curves and the use of different materials such as silicon iron and mild steel.

The evidence for P9 will be descriptive and requires learners to provide basic explanations of the principles and concepts of electromagnetic induction such as the movement of a conductor within a magnetic field.

P10 and P11 could link AC theory and practice with learners observing and measuring some of the fundamental characteristics of a single wave AC circuit. This will require the use of a multimeter and an oscilloscope to make appropriate comparisons of frequency, maximum and rms values.

M1 relates to the use of Kirchhoff's laws and here again learners should be encouraged to check their results by using a computer software package and/or practical experiment. This criterion naturally follows on from the work on resistors in series and parallel in DC circuits and, as such, could perhaps be incorporated into an assignment covering P1, P2 and M1.

For M2, learners need to evaluate capacitance, charge, voltage and energy for specific capacitors in a series parallel combination. This extends the understanding from the pass grade criterion and could naturally form a next step in an assignment/assessment activity devised for P6.

M3 is intended as an exercise in the graphical addition of two sinusoidal voltages or currents, checking the values theoretically by calculation and also by practical means. This criterion could be linked to *Unit 4: Mathematics for Engineering Technicians* and, once learners had been taught the sine and cosine rules, could be used to provide evidence for both units.

For D1, a basic power supply could be simulated to allow all the respective properties to be investigated without the hazards of high voltages or currents present. This could be achieved using a function generator as a source of sinusoidal alternating voltage, along with a small isolating transformer, diode rectifiers (half wave and bridge) smoothing capacitors and load resistors.

D2 requires learners to predict the performance of motors and generators by reference to electrical theory. This can be achieved practically using appropriate experimental rigs that allow learners to compare their results with known characteristics for specific machines.

As suggested earlier, and illustrated in the assignment grid, it would be appropriate to use a five-assessment model to assess this unit.

The first is a theoretical assignment under controlled conditions and could assess P1 and M1.

A second practical assignment could be used to assess P2 and P3, again possibly under controlled conditions.

Assignment 3 is to assess P4, P5, P6 and M2 and could be a mixed assignment, preferably not done under controlled conditions.

The fourth assignment could again be a mixed assignment to assess P7, P8, P9 and D2.

Finally, assignment 5 is to assess P10, P11, M3 and D1 and could be of a practical nature carried out under controlled conditions.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	DC Circuit Theory/ Resistor Networks and Kirchhoff's Laws	An activity requiring learners to complete two tasks, one for each criterion. Task 1 involves learners evaluating current, voltage and resistance in a DC network and task 2 using Kirchhoff's laws to determine the current and power dissipated in a load resistor.	A report containing the results of calculations to evaluate current, voltage, resistance and power for a DC network using DC circuit theory and Kirchhoff's laws. Carried out under controlled conditions.
P2, P3	DC Circuit Theory/ Measurement and Diodes	A practical activity requiring learners to complete measurements using a multimeter in a DC network for task 1 and compare the forward and reverse characteristics of two different types of semi-conductor diode for task 2.	For both tasks learners will be required to complete pre-prepared response sheets with their measurements and make required responses together with a brief conclusion. Carried out under controlled conditions.
P4, P5, P6, M2	Capacitors	A mixed activity comprising of four tasks. The first being of a descriptive nature to describe the types and function of capacitors. Second, an experiment to determine the relationship between voltage and current for a charging and discharging capacitor. The third and fourth involve the learner carrying out calculations to evaluate capacitance, charge voltage and energy in DC networks.	A written report containing written responses to the descriptive task, tabulated results and graphs for the practical, together with calculations for the DC networks.
P7, P8, P9, D2	Magnetism, Transformers and Motor/Generators	A mixed activity comprising four tasks. The first three are to describe the characteristics of a magnetic field, explain the relationship between flux density and field strength, and describe the principles and applications of electromagnetic induction. The final task is to evaluate the performance of a motor and generator.	A written report containing labelled diagrams illustrating magnetic fields, graphical plots of BH curves and diagrams with descriptions to illustrate principles and applications of electromagnetic induction. For the distinction criteria it would be envisaged that comprehensive answers to pre-prepared response sheets together with diagrams, graphs and calculations need to be submitted.

Criteria covered	Assignment title	Scenario	Assessment method
P10, P11, M3, D1	Single Phase AC	A practical activity requiring learners to complete four tasks. First, use single-phase AC theory to consider the characteristics of a sinusoidal AC waveform and second, use an oscilloscope to evaluate the inputs and outputs of a single phase AC circuit. Third, to compare the results of the addition and subtraction of two sinusoidal AC waveforms. Fourth, to analyse the operation of a power supply.	A written report using pre-prepared response sheets and graph paper carried out under controlled conditions.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Applied Electrical and Mechanical Science for Technicians	Mathematics for Engineering Technicians

This unit also covers some of the knowledge and understanding associated with the SEMTA Level 3 NVQ in Electrical and Electronic Engineering, particularly:

- Unit 15: Checking the Compliance of Electronic Components Against the Specification
- Unit 17: Assembling and Wiring Electronic Equipment and Systems
- Unit 18: Testing Post-Production electronic components and Circuits
- Unit 24: Assembling Transformers and Inductors
- Unit 25: Fitting Small Transformer and Inductor Cores
- Unit 26: Assembling Rotor and Armature Windings
- Unit 27: Assembling Stator Windings
- Unit 28: Assembling and Fitting Commutators
- Unit 30: Assembling and Fitting Electrical Rotating Equipment
- Unit 31: Mounting Electrical Components in Enclosures
- Unit 32: Wiring Electrical Components and Equipment in Enclosures
- Unit 33: Selecting and Preparing Materials and Components for Electrical Assembly.

Essential resources

It is essential that learners have access to a well-equipped electrical and electronics laboratory with up-to-date electrical/electronic instruments such as digital and analogue multimeters, function generators and oscilloscopes. Centres will also need to provide appropriate circuit components, as identified in the unit content, together with the means to physically construct circuits.

With the increased use of computer-based methods for circuit design and simulation, centres are strongly advised to consider the provision of suitable hardware and software.

Employer engagement and vocational contexts

Centres are encouraged to relate theory to real engineering applications wherever possible. Industrial visits or work experience could be used to support learning and provide learners with an appreciation of the industrial applications of electrical and electronic principles.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CE, University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Student Book* (Pearson, 2010) ISBN 9781846907241

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907265

Bird J O – *Electrical and Electronic Principles and Technology* (Newnes, 2004) ISBN 0750665505

Bird J O – *Electrical Circuit Theory and Technology* (Newnes, 2004) ISBN 0750657847

Robertson C R – *Fundamental Electrical and Electronic Principles* (Butterworth-Heinemann, 2001) ISBN 0750651458

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information when comparing different types of semi-conductor diode exploring issues and problems relating to electrical principles
Self-managers	organising their time and resources and prioritising actions when using measuring equipment.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Creative thinkers	trying out alternatives or new solutions to electrical principles' problems
Reflective learners	reviewing progress when solving problems during the learner's activities and acting on the outcomes to make corrections to understanding solutions
Team workers	collaborating with other learners when working on practical and investigative group work to achieve a valid solution.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using circuit simulation software to evaluate data when solving electrical principles' problems
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine electrical principles' problems set within electrical engineering contexts and situations
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant parameters and formulae to be applied to given electrical engineering situations
Select and apply a range of skills to find solutions	selecting and applying formulae to solve electrical engineering problems
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to electrical principles' problems to evaluate their effectiveness and reality at each stage of the calculation
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and tutors to establish an understanding of electrical principles' concepts and ideas
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate electrical principles' information data sources to solve problems and carry out practical work
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	taking notes and solving electrical principles' problems to communicate accurate solutions effectively.