Cambridge TECHNICALS

CAMBRIDGE TECHNICALS IN ENGINEERING

LEVEL 3 UNIT 4 – PRINCIPLES OF ELECTRICAL AND ELECTRONIC ENGINEERING

DELIVERY GUIDE

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OCR
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CONTENTS

INTRODUCTION

This Delivery Guide has been developed to provide practitioners with a variety of creative and practical ideas to support the delivery of this qualification. The Guide is a collection of lesson ideas with associated activities, which you may find helpful as you plan your lessons.

OCR has collaborated with current practitioners to ensure that the ideas put forward in this Delivery Guide are practical, realistic and dynamic. The Guide is structured by learning outcome so you can see how each activity helps you cover the requirements of this unit.

We appreciate that practitioners are knowledgeable in relation to what works for them and their learners. Therefore, the resources we have produced should not restrict or impact on practitioners' creativity to deliver excellent learning opportunities.

Whether you are an experienced practitioner or new to the sector, we hope you find something in this guide which will help you to deliver excellent learning opportunities.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

Unit aim

Electrical systems and electronic devices are present in almost every aspect of modern life – and it is electrical and electronic engineers who design, test and produce these systems and devices.

This unit will develop learners' knowledge and understanding of the fundamental principles that underpin electrical and electronic engineering.

By completing this unit learners will develop an understanding of:

- fundamental electrical principles
- alternating voltage and current
- electric motors and generators
- power supplies and power system protection
- analogue electronics
- digital electronics

Unit 4 Principles of electrical and electronic engineering	
LO1	Understand fundamental electrical principles
LO2	Understand alternating voltage and current
LO3	Understand electric motors and generators
LO4	Understand power supplies and power system protection
LO5	Understand analogue electronics
LO6	Understand digital electronics

Opportunities for English and maths skills development

We believe that being able to make good progress in English and maths is essential to learners in both of these contexts and on a range of learning programmes. To help you enable your learners to progress in these subjects, we have signposted opportunities for English and maths skills practice within this resource. These suggestions are for guidance only. They are not designed to replace your own subject knowledge and expertise in deciding what is most appropriate for your learners.

ABC English

123 Maths

Please note

The timings for the suggested activities in this Delivery Guide **DO NOT** relate to the Guided Learning Hours (GLHs) for each unit.

Assessment guidance can be found within the Unit document available from www.ocr.org.uk.

The latest version of this Delivery Guide can be downloaded from the OCR website.

RELATED ACTIVITIES

The Suggested Activities in this Delivery Guide listed below have also been related to other Cambridge Technicals in Engineering units/Learning Outcomes (LOs). This could help with delivery planning and enable learners to cover multiple parts of units.

This unit (Unit 4)	Title of suggested activity	Other units/LOs	
LO1	Units and defining equations	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO1 Understand applications of SI units and measurement
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO1	Measurements	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO1 Understand applications of SI units and measurement
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO1	Circuit theory: resistors in series and parallel	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO1	Kirchhoff's first law	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO1	Kirchhoff's second law	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO1	Maximum power transfer (Lesson Element provided)	Unit 1 Mathematics for engineering	LO2 Be able to use geometry and graphs in the context of engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO2	Phase shift and phase angle	Unit 1 Mathematics for engineering	LO4 Be able to use trigonometry in the context of engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO2	AC circuits and phasor diagrams for pure resistance, inductance and capacitance	Unit 1 Mathematics for engineering	LO4 Be able to use trigonometry in the context of engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO2	AC circuits with combinations of resistance, inductance and capacitance (Lesson Element provided)	Unit 1 Mathematics for engineering	LO4 Be able to use trigonometry in the context of engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO2	More AC circuit and phasor diagrams	Unit 1 Mathematics for engineering	LO4 Be able to use trigonometry in the context of engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO3	DC motors, generators and defining equations	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO3	Types of DC generator and their defining equations	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO4	AC and DC supplies	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
LO5	The non-inverting op-amp	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
LO5	The summing op-amp	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
LO6	Logic gates and their function	Unit 1 Mathematics for engineering	LO6 Be able to apply statistics and probability in the context of engineering problems
LO6	Truth tables	Unit 1 Mathematics for engineering	LO6 Be able to apply statistics and probability in the context of engineering problems
LO6	Simple combinational logic problems	Unit 1 Mathematics for engineering	LO6 Be able to apply statistics and probability in the context of engineering problems

KEY TERMS

UNIT 4 – PRINCIPLES OF ELECTRICAL AND ELECTRONIC ENGINEERING

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Resistance (electrical)	Electrical resistance is the opposition to the passage of an electric current in a circuit. The SI unit of electrical resistance is the ohm (Ω).
Power (electrical)	Electric power is the rate at which electric energy is transferred by an electric circuit. The SI unit of power is the watt (one joule per second).
Energy (electrical)	Electrical energy is the rate at which energy is transferred (or supplied) over a period of time. It is usually measured as kilowatt-hour (kWh). This is actually a measurement of average power consumption.
Series resistance	Series resistance refers to a resistor or combination of resistors connected in series. Total resistance is given by $R = R_1 + R_2 + R_3$
Parallel resistance	Parallel resistance refers to resistors connected in parallel. Total resistance is given by $1/R = 1/R_1 + 1/R_2. + 1/R_3$
Kirchhoff's first law	Kirchhoff's first law (the current law) states that at any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node.
Kirchhoff's second law	Kirchhoff's second law (the voltage law) states that the directed sum of the electrical potential differences (voltage) around any closed network is zero.
Maximum power transfer theorem	The maximum power transfer theorem states that the maximum amount of power will be dissipated by a load resistance when that load resistance is equal to the equivalent resistance of the network (or sometimes cell) supplying the power.
Motor (electric)	An electric motor is an electric machine that converts electrical energy into mechanical energy.
Generator (electric)	An electric generator is a device for converting mechanical energy into electrical energy by electromagnetic induction.
Amplitude, frequency and periodic time (AC waveforms)	Amplitude (A) is the magnitude or intensity of the signal waveform measured in volts or amps. Frequency, (f) is the number of times the waveform repeats itself within a one second time period. Frequency is the reciprocal of the time period, ($f = 1/T$) with the unit of frequency being the Hertz, (Hz). Period (T) is the length of time in seconds that the waveform takes to repeat itself from start to finish. This can also be called the Periodic Time of the waveform for sine waves.
Phase shift and phase angle	The angular shift between two alternating waveforms is referred to as the phase shift, with the angular difference termed the phase angle.
Phasor diagram	Phasor diagrams are used to represent a rotating vector, simply called a phasor, which is a scaled line whose length represents an AC quantity that has both magnitude (amplitude) and direction (phase) which is frozen at some point in time.

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Inductive reactance (XL)	Inductive reactance is the opposition to current flowing through a coil in an AC circuit. It is given by the formula $X_L = 2\pi fL$ with unit ohm.
Capacitve reactance (XC)	Capacitive reactance is the opposition to current flowing through a capacitor in an AC circuit. It is given by the formula $X_c = 1/2\pi fC$ with unit ohm.
DC motor equations	The defining equation for the DC motor is $V = E + I_aR_a$ where V is the supply voltage, E is the back emf produced by the motor, I_aR_a are the armature current and armature resistance.
DC generator equations	The defining equation for the DC generator is $V = E - I_aR_a$ where V is the generated voltage, E is the back emf produced by the generator, I_aR_a are the armature current and armature resistance.
Rectification (diode rectification)	Rectification is the process of converting an AC supply to a DC supply. It can be achieved using diodes connected in a half or full-wave bridge configuration.
Load regulation	Load regulation is the capability to maintain a constant voltage (or current) level on the output of a power supply despite changes in the supply load.
Circuit protection	Circuit protection can be defined as the intentional installation of a 'weak link' in an electrical circuit to bring about circuit protection. It is often achieved using fuses, circuit breakers or limiting resistors. Alternative forms of circuit protection (such as diodes) can protect against reverse polarity.
Analogue circuit	An analogue circuit is a circuit with a continuous, variable signal (that is, an analogue signal), as opposed to a digital circuit where a signal must be one of two discrete levels.
Operational amplifier (Op Amp)	An operational amplifier (Op-Amp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output.
Digital circuit	A digital circuit is a circuit where the signal must be one of two discrete levels. Each level is interpreted as one of two different states (for example, on/off, 0/1, true/false). Digital circuits often use transistors to create logic gates in order to perform Boolean logic.
Logic gate	A logic gate is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels.
Truth table	A truth table shows how a logic circuit's output responds to various combinations of the inputs, using logic 1 for true and logic 0 for false. All permutations of the inputs are listed on the left, and the output of the circuit is listed on the right.
Combinational logic	Combinational logic refers to a digital logic function made of primitive logic gates (AND, OR, NOT, etc.) in which all outputs of the function are directly related to the current combination of values on its inputs. Any changes to the signals being applied to the inputs will immediately propagate through the gates until their effects appear at the outputs.
Boolean expression	Boolean logic is a form of algebra in which all values are reduced to either TRUE or FALSE. As add, subtract, multiply and divide are the primary operations of arithmetic, AND, OR and NOT are the primary operations of Boolean logic. Boolean logic is turned into logic gates and the logic gates make up logic circuits that perform functions.
Flip Flop (bistable)	A flip-flop (often referred to as a bistable gate or latch) is a circuit that has two stable states and can be used to store information. It is often used in devices such as counters, memory chips and microprocessors.

MISCONCEPTIONS

Some common misconceptions and guidance on how they could be overcome		
What is the misconception?	**How can this be overcome?**	**Resources which could help**
Difference between power and energy	Reference might be made to domestic appliances (eg a hairdryer that consumes 2000 watts). This is the power consumed by the hairdryer. If the hairdryer is used for 1 hour, then it consumes 2000 watt-hours or 2kWh of energy. This could be related to domestic energy costs (tariff costs).	http://www.energylens.com/articles/kw-and-kwh
Application of Kirchhoff's Laws	Kirchhoff's laws could be explained using practical resistor circuits in which voltage and current are measured.	Practical circuit construction
Use of radian measure in AC circuit theory and waveforms ($\omega = 2 \times \pi \times f$)	Learners will need to appreciate that in electrical calculations involving sine waves that radians are used (ie 2π radians = 360^0). Teachers could explain that one cycle of a sine wave = 360^0 = 2π radians. Web-based resources might prove useful to illustrate this.	http://www.electronics-tutorials.ws/accircuits/phasors.html
Determining overall impedance and phase angle using phasor diagrams	An effective way of understanding phasor diagrams, and determining overall impedance (Z) and phase angle (ø) might be by drawing scale diagrams. Impedance and phase angle can be determined using Pythagoras' Theorem and the cosine rule respectively.	http://www.electronics-tutorials.ws/accircuits/phasors.html
Application of motor and generator defining equations (V = E + for motor, $V = E + I_aR_a$ for generator)	To understand the DC motor and generator defining equations learners will need to appreciate that the motor is also acting as a generator, generating a back-emf (E). The coils of wire in the armature also have a resistance (R_a) and so a volt drop also occurs across the armature (I_aR_a). Once this is understood then the equations might be simpler to apply.	http://www.electrical4u.com/types-of-dc-motor-separately-excited-shunt-series-compound-dc-motor/
Operation of an Operational Amplifier (op-Amp) circuit	Software simulation tools might be used to reinforce understanding of op-amp circuits and their operation. Building practical op-amp circuits could also prove useful.	https://www.circuitlab.com/circuit/me84mf/op-amp-non-inverting-amplifier/
Implementing Combinational Logic and Boolean Expressions	Software simulation tools might be used to reinforce understanding of combinational logic circuits and their operation. Boolean expressions might also be related back to practical examples.	http://www.neuroproductions.be/logic-lab/

SUGGESTED ACTIVITIES

LO No:	**1**		
LO Title:	**Understand fundamental electrical principles**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Units and defining equations	Teachers could begin this unit by reinforcing learners' understanding of electrical units and defining electrical equations. This might include presenting defining equations for resistance (Ohm's law), power and energy and also determination of total resistance for series and parallel combinations of resistors. Web based resources such as the following online book (http://www.vias.org/feee/index.html) might prove useful throughout this unit. Further web-based resources might prove useful in explaining electrical units http://www.engineeringtoolbox.com/electrical-units-d_454.html and resistor combinations: http://www.physicsclassroom.com/class/circuits/Lesson-4/Combination-Circuits. Teachers could develop practice questions in order that learners can practice applying electrical equations.	2 hours	Unit 1, LO1 Unit 2, LO1 Unit 2, LO3
Measurements	Teachers might extend learners' understanding of electrical units through their measurement in circuits. Web based resources – ie http://www.allaboutcircuits.com/vol_1/chpt_3/9.html might prove useful in demonstrating how measurements can be taken. If access to suitable equipment is available then the teacher might be able to demonstrate practically measurements being made, or practical learner-based activities could be developed. Learners could use a voltmeter, ammeter and ohmmeter (or a multimeter) to measure current, voltage and resistance.	1 hour	Unit 1, LO1 Unit 2, LO1 Unit 2, LO3
Circuit theory: resistors in series and parallel	Learners could build upon knowledge of series and parallel resistor circuits, and also Ohm's law to determine total resistance and current in circuits that are a combination of series and parallel resistors. Theory could be linked with practice, and learners might be able to determine by calculation resistance and current and then prove this through practically building and testing circuits. Online simulation software ie http://www.docircuits.com/ could prove useful in building and testing circuits. Practice at applying theory to many examples may reinforce learning.	1 hour	Unit 1, LO1 Unit 2, LO3
Kirchhoff's first law	The teacher might begin by introducing learners to Kirchhoff's first law (the current law) through the use of web-based resources http://www.electronics-tutorials.ws/dccircuits/dcp_4.html/. A practical demonstration could be used to show that the current entering a node in a circuit equals the current leaving the node. The teachers could develop suitable questions giving learners practice at applying Kirchhoff's first law in simple circuit configurations. Again, simulation software could be used to relate theoretical calculations to actual circuits.	2 hours	Unit 1, LO1 Unit 2, LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Kirchhoff's second law	Kirchhoff's second law (the voltage law) follows from the first law. Teachers could begin with a practical demonstration showing that the voltages in a closed circuit loop sum to zero. A simple circuit with a voltage source (battery) and resistors could be used to demonstrate this. Suitable practice questions could be used to reinforce learners' understanding of Kirchhoff's second law – and again practice at performing many calculations could prove useful. Simulation software could be used in order for learners to prove the result of manual calculations.	2 hours	Unit 1, LO1 Unit 2, LO3
Maximum power transfer [Lesson Element]	The maximum power transfer theorem states that maximum power is transferred from a source to a load when the value of load resistance is the same as the internal or equivalent resistance (of the cell or circuit). Understanding of this could be reinforced through a practical activity (an experiment) where the effect of varying load resistance is observed. Learners could plot load power over a given range of load resistance to prove that this is the case. Graphs could be plotted manually or using software tools, such as a spreadsheet, thereby giving learners the opportunity to develop their ICT skills.	2 hours	Unit 1, LO2 Unit 2, LO3

SUGGESTED ACTIVITIES

LO No:	2		
LO Title:	**Understand alternating voltage and current**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Generators, alternating current and voltage	Learners could be tasked to research how alternating current (AC) and direct current (DC) are generated, along with a comparison of both methods. Findings could be presented in the form of a poster. Web-based resources, such as http://www.allaboutcircuits.com/vol_2/chpt_1/1.html/ might prove useful. The teacher might then introduce learners to the mathematical theory of alternating waveforms, including the terms amplitude, frequency and periodic time. Web-based resources might again prove useful - http://www.electronics-tutorials.ws/accircuits/ac-waveform.html	1 hour	
Phase shift and phase angle	The angular shift between two alternating waveforms is referred to as the phase shift, with the angular difference termed the phase angle. Teachers might be able to demonstrate this phenomenon to learners practically using a suitable circuit and an oscilloscope. Web-based resources could also prove useful such as http://www.electronics-tutorials.ws/accircuits/phase-difference.html. Learners could practice determining phase shift and phase angle both graphically and using mathematical expressions for a number of waveforms.	1 hour	Unit 1, LO4 Unit 2, LO3
AC circuits and phasor diagrams for pure resistance, inductance and capacitance	AC waveforms can be represented by phasor diagrams. The teacher might use animated web resources to explain phasor diagrams to include circuits containing a single resistor, inductor and capacitor. The following web page includes animated phasor diagrams showing their relationship to sine waves of voltage and current - http://www.animations.physics.unsw.edu.au//jw/AC.html. Teachers could develop activities in order for learners to practice drawing scale phasor diagrams for single component circuits.	2 hours	Unit 1, LO4 Unit 2, LO3
AC circuits with combinations of resistance, inductance and capacitance [Lesson Element]	Once learners are confident with representing alternating circuit quantities as a phasor diagram for circuits containing a single resistor, inductor or capacitor, teachers might move onto circuits containing combinations of components. This might include series R_L and R_C circuits. Again, learners might begin by representing reactance phasors (ie R, X_L and X_C) on a scale drawing in order to determine circuit impedance (Z) and phase angle (ø) using Pythagoras' Theorem and phase angle using the cosine rule. Learners might then apply the defining equations to calculate overall circuit impedance and phase angle. The following printable web-based resource might prove useful - http://www.physics.ryerson.ca/sites/default/files/u11/guidelines/L5_RLC_Circuits.pdf	2 hours	Unit 1, LO4 Unit 2, LO3
More AC circuit and phasor diagrams	Learners could conclude by considering circuits with a combination of R, L and C in series. Total circuit impedance and phase angle could again be determined through drawing scale phasor diagrams, and through applying the defining equations. Practice with many examples will prove useful for embedding learning. The teacher might develop a worksheet with examples of single component, two component and three component circuits where learners have to determine overall circuit impedance and phase angle.	2 hours	Unit 1, LO4 Unit 2, LO3

SUGGESTED ACTIVITIES

LO No:	3		
LO Title:	**Understand electric motors and generators**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
DC motors, generators and defining equations	Learners could begin this learning outcome by researching the operation of DC motors and generators, including their defining equations. Web-based resources such as http://www.animations.physics.unsw.edu.au/jw/electricmotors.html which include animated diagrams might prove useful. This website also explains how to construct a simple DC motor/generator and learners could undertake this activity. The teacher might then introduce learners to the defining equations for the DC motor and generator with learners applying these to simple calculations.	1 hour	Unit 1, LO1 Unit 2, LO3
Types of DC motors and their defining equations	Learners could research the configuration and operation of different types of DC motor including: series wound DC motor and shunt wound DC motor. Teachers could introduce learners to the defining equations for both types of DC motor, and develop simple problems whereby learners can implement calculations. Web-based resources ie http://www.electrical4u.com/types-of-dc-motor-separately-excited-shunt-series-compound-dc-motor/ may prove useful.	2 hours	
Types of DC generator and their defining equations	Similarly learners could research the configuration and operation of different types of DC generator including the separately excited DC generator, series wound self excited DC generator and shunt wound self-excited DC generator. Learners could practice solving problems using the defining equation for each type of generator. Web-based resources could again prove useful – such as the following website which explains each types of DC generator in detail (http://www.electrical4u.com/types-of-dc-generators/)	2 hours	Unit 1, LO1 Unit 2, LO3
Motor and generator applications	Once learners are confident with the configuration and operation of different types of DC motor and DC generator, they could be tasked to research particular applications of each type. Learners could draw a table highlighting the applications, and reasons for using, each type of motor and generator (eg the shunt wound DC motor is commonly used in constant speed applications such as a lathe or industrial process line as it maintains a constant speed irrespective of load changes). This could alternatively be presented as a poster presentation.	2 hours	
Starting a DC motor	Teachers could explain the particular requirements for starting a DC motor (ie due to its high starting current) and how this high starting current is overcome using a motor starter. Web-based resources might prove useful in explaining this – with the following web pages explaining 3 and 4 point starters that include a 'no volt coil' and overload protection - http://www.electrical4u.com/starting-methods-to-limit-starting-current-torque-of-dc-motor/. Learners could practice explaining the reasons for using a DC motor starter and how a typical starter operates.	1 hour	
DC motor speed control	Learners could undertake a research activity to explain how the speed of a DC motor might be altered using both field and armature control. Learners should concentrate on the shunt wound DC motor and the series wound DC motor. Web-based resources such as http://www.electricaleasy.com/2014/01/speed-control-methods-of-dc-motor.html might prove a useful starting point. Learners could present their findings as a PowerPoint presentation.	2 hours	

SUGGESTED ACTIVITIES

LO No:	**4**		
LO Title:	**Understand power supplies and power system protection**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
AC and DC supplies	Teachers could begin with a brief introduction and recap of AC and DC power supplies, including a comparison of both. Learners might then focus on AC supplies including their generation and distribution methods in more detail. One possible approach to this could be a learner-produced poster highlighting the generation and distribution of AC power – from power station to commercial and domestic users. Learners could build their poster to include detail of single and three phase distributions systems.	1 hour	Unit 2, LO3
Single phase distribution systems	Learners could research single phase distributions systems ie single-phase 2-wire system and single-phase 3-wire system and compare the advantages and disadvantages of both techniques. Learners could illustrate the effects and advantages of adding a third 'neutral' wire in the 3-wire system. Web-based resources could again prove useful such as: http://www.allaboutcircuits.com/vol_2/chpt_10/1.html which explains single-phase systems.	2 hours	
Three phase distribution systems	Learners could continue their research of distribution systems by looking at 3-phase systems including 3-phase 3-wire Delta connected systems and 3-phase 4-wire Star connected systems. Web resources such as http://www.allaboutcircuits.com/vol_2/chpt_10/2.html/ could prove useful. This web resource also includes a number of worksheets. Learners should concentrate on the configuration and advantages of such systems and not in detail on their mathematical description (which might be too complex). The following web-link includes animated diagrams of both systems: http://en.wikipedia.org/wiki/Three-phase_electric_power#Generation_and_distribution	2 hours	
Diode rectification	Diode rectification is used to convert an AC supply into a DC supply and includes three basic types of rectification: half-wave using a single diode, full-wave using two diodes and full-wave using four diodes. The following website might be used to illustrate this - http://www.allaboutcircuits.com/vol_3/chpt_3/4.html If access to suitable resources is available, then the teacher might be able to demonstrate this practically, or learners might be able to undertake an experiment to show rectification taking place. This could prove useful to embedding understanding of how diode rectification works.	2 hours	
Stabilised power supplies	The following website provides a useful block diagram of a stabilised power supply showing AC input, rectification, filtering(using capacitors) voltage regulation and DC output - http://www.electronicsarea.com/voltage_regulators.asp. Learners could construct or simulate a stabilised power supply, and take voltage measurements at each stage of the circuit to see rectification, filtering and regulation taking place. Learners could produce a presentation to explain how a stabilised power supply works.	1 hour	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Load regulation	Load regulation is the capability of a power supply to maintain constant voltage or current regardless of changes in the supply load. Learners could be tasked to research the reasons why load regulation is important. The following PDF document gives a comprehensive description of operation of a regulated DC power supply, and includes useful mention of load regulation http://www.talkingelectronics.com/Download%20eBooks/Principles%20of%20electronics/CH-17.pdf Learners may be able to perform simple calculations involving load regulation as indicated in the PDF.	1 hour	
Circuit protection	Learners could complete this learning outcome by investigating different methods of circuit protection including fuses, circuit breakers, diodes and limiting resistors. Web-based resources will invariably prove useful, with the following looking at fuses and circuit breakers http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/electricity/mainselectrev3.shtml and diodes http://jeelabs.org/2011/01/09/easy-electrons-%E2%80%93-diodes/. If access to suitable resources is available then learners may be able to investigate the operation of protective devices practically. Learners could provide a tabulated explanation of each type of circuit protection along with what form of protection is being offered.	2 hours	

SUGGESTED ACTIVITIES

LO No:	5		
LO Title:	**Understand analogue electronics**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Analogue circuits	Teachers might being this learning outcome by giving a brief introduction to the differences between analogue and digital circuits, introducing learners to the concept of circuits that contain both analogue and digital electronics. Learners could be tasked to research the advantages, disadvantages and applications of both techniques. Web resources might prove useful ie https://learn.sparkfun.com/tutorials/analog-vs-digital/analog-and-digital-circuits.	1 hour	
Characteristics of operational amplifiers (op-amp)	The operational amplifier (op-amp) is a high gain amplifier commonly used in analogue circuit design. Learners might begin by finding out about the characteristics of the op-amp. Web-based resources, such as the following video tutorials may prove a useful starting point - http://www.allaboutcircuits.com/videos/73.html. Teachers might also direct learners to evaluate op-amp characteristics through the use of component data sheets. The following web site has links to many data sheets where learners might explore the popular '741' op-amp http://www.datasheetcatalog.com/.	1 hour	
The inverting op-amp	The inverting op-amp is one common way in which op-amps are configured to operate. Teachers might use web-based resources to explain this mode of operation, including how system gain and output voltage is determined and calculated (eg http://www.electronics-tutorials.ws/opamp/opamp_2.html). If access to suitable resources is available then learners may be able to evaluate op-amp operation and performance in inverting mode practically. An alternative approach may be to investigate op-amp performance using a simulation tool. The following are free online simulation resources - https://www.circuitlab.com/circuit/me84mf/op-amp-non-inverting-amplifier/ and http://www.ti.com/lsds/ti/analog/webench/amplifiers.page	2 hours	
The non-inverting op-amp	A continuation of the inverting op-amp configuration is the non-inverting op-amp. Teachers might similarly use web-based resources to explain how the non-inverting op-amp performs, including associated equations for gain and output voltage. Practical experimentation might be used to reinforce learning and understanding, and online simulation tools could be used where access to practical resources is limited.	2 hours	Unit 1, LO1
The summing op-amp	The summing op-amp is the final configuration for learners to investigate. The following web-based resource includes a complete explanation of the summing op-amp along with worked calculations - http://www.electronics-tutorials.ws/opamp/opamp_4.html. Again, if access to practical resources or simulations tools is available then this could prove a useful way in which to explain operation in this configuration.	2 hours	Unit 1, LO1

SUGGESTED ACTIVITIES

LO No:	**6**		
LO Title:	**Understand digital electronics**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Digital circuits and logic	Teachers might begin this learning outcome with an introduction to digital circuits and introduce learners to the concept of digital logic functions. The following web-based resources might prove a useful starting point to introduce the concept and history of digital logic - http://www.electronics-tutorials.ws/logic/logic_1.html Learners could be tasked to produce a presentation about digital logic, its history and its application.	1 hour	
Logic gates and their function	Learners could research the function and operation of a range of logic gates – including AND, NAND, OR, NOR, NOT and XOR gates. Web-based resources may prove useful such as the following which includes a series of tutorials on these logic functions http://www.electronics-tutorials.ws/logic/logic_1.html. Learners might evaluate a range of practical logic integrated circuits using datasheets available from http://www.datasheetcatalog.com/.	2 hours	Unit 1, LO6
Truth tables	Learners might develop their understanding of logic truth tables in conjunction with researching the function and operation of logic gates. Further web-based resources could prove useful – such as http://www.electronics-tutorials.ws/boolean/bool_7.html. Learners could produce a presentation outlining the function and application of a range of logic gates including associated logic truth tables.	2 hours	Unit 1, LO6
Simple combinational logic problems	Logic gates are often used in combination in order to produce a desired logic function (ie a desired set of output conditions for a given set of input conditions). Learners could develop their understanding of logic gates (both singly and in combination) by solving given simple logic problems provided by the teacher. Operation of combinational logic combinations (ie input to output truth tables) could be determined manually, or by simulation. The following web-based resource is an online logic simulation tool - http://www.neuroproductions.be/logic-lab/. If access to practical resources is available, then learners might be able to construct and test combinational logic circuits using a range of logic gates.	2 hours	Unit 1, LO6

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Boolean expressions	The starting point for many logic designs is with a truth table describing how the circuit should operate. Another way of representing and manipulating combinational logic functions is using Boolean expressions. Teachers might used web-based resources to explain how combinational logic functions can be represented by Boolean expressions – such as http://www.allaboutcircuits.com/vol_4/chpt_7/9.html. Learners could undertake simple logic problems in order to develop and recognise simple Boolean expressions.	2 hours	
D type bistable flip flop [Lesson Element]	Flip flops are devices that have two stable states and are often used to store data – ones and zeros. They are hence termed bistable. They are commonly made up internally of a combination of logic gates (combinational logic). Learners might begin be researching the function and operation of the flip flop - focusing first on the D type flip flop. Their research might include its circuit symbol – including inputs and outputs and its behaviour (when triggered with a rising edge). Web-based resources might prove a useful starting point – such as the following which introduces the D type flip flop http://www.electronics-tutorials.ws/sequential/seq_4.html. Learners could practice plotting input (trigger) and corresponding output waveforms. Simulation software might prove useful in understanding flip flop operation such as http://www.docircuits.com/public-circuit/457/d-flipflop. If access to practical resources is available then learners might construct and test flip flop circuits.	2 hours	
T type bistable flip flop	T type (or Toggle) flip flops are another type of flip flop. Learners could extend their learning of the D type flip flop to research the circuit symbol and function of the T type flip flop. Web-based resources ie http://www.brighthubengineering.com/diy-electronics-devices/46610-jk-and-t-flip-flops/#imgn_1 and simulation software might again prove useful. Learners could present a comparison of the function, features and operation of different types of flip flop (both D and T types).	2 hours	

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