2016 Suite

OCR
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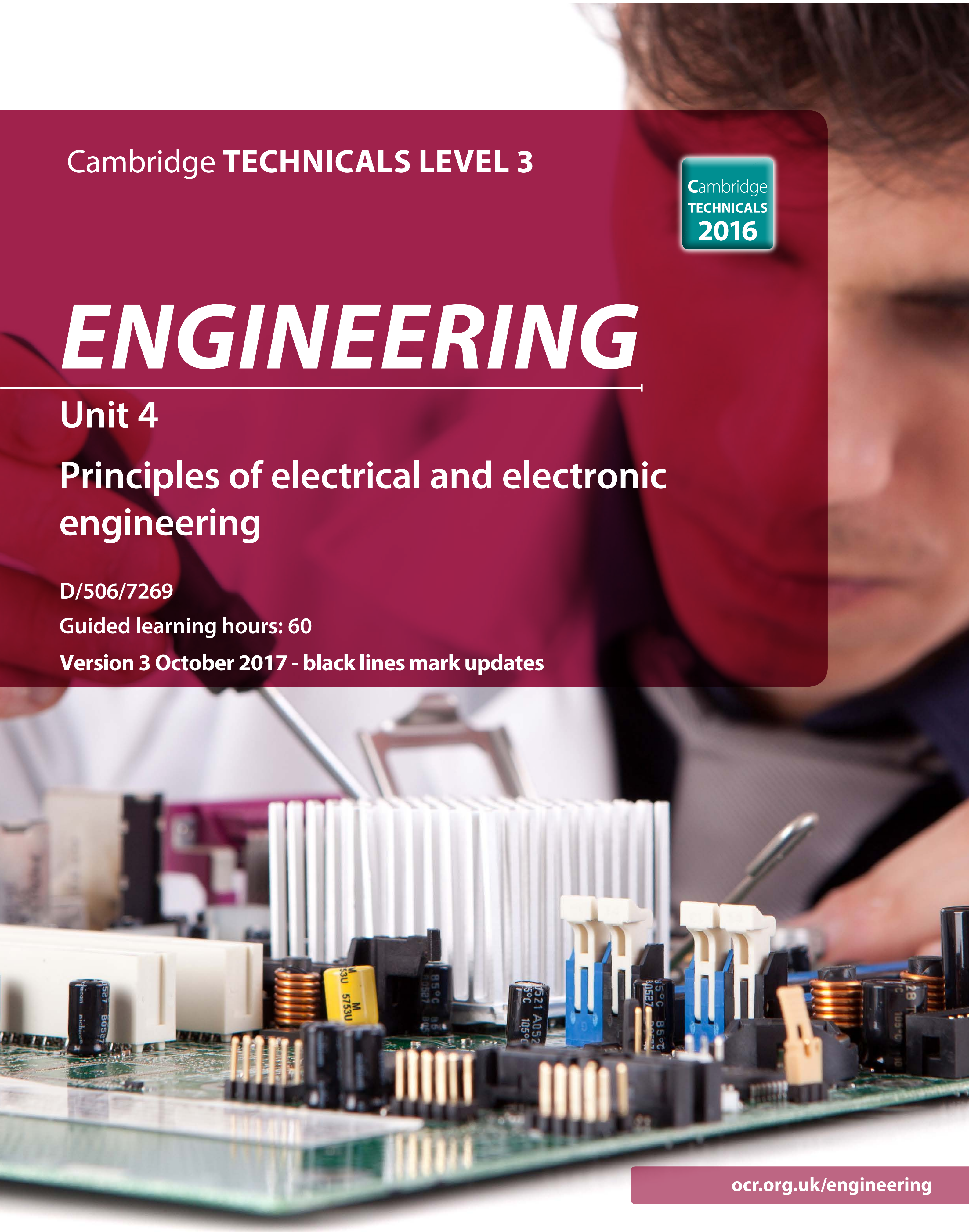

Cambridge **TECHNICALS LEVEL 3**

Cambridge TECHNICALS 2016

ENGINEERING

Unit 4

Principles of electrical and electronic engineering

D/506/7269

Guided learning hours: 60

Version 3 October 2017 - black lines mark updates

ocr.org.uk/engineering

LEVEL 3

UNIT 4: Principles of electrical and electronic engineering

D/506/7269

Guided learning hours: 60

Essential resources required for this unit: Formula Booklet for Level 3 Cambridge Technicals in Engineering, scientific calculator and a ruler (cm/mm)

This unit is externally assessed by an OCR set and marked examination.

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

TEACHING CONTENT

The teaching content in every unit states what has to be taught to ensure that learners are able to access the highest grades.
Anything which follows an i.e. details what must be taught as part of that area of content. Anything which follows an e.g. is illustrative.

For externally assessed units, where the teaching content column contains i.e. and e.g. under specific areas of content, the following rules will be adhered to when we set questions for an exam:

- a direct question may be asked about unit content which follows an i.e.
- where unit content is shown as an e.g. a direct question will not be asked about that example.

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
1. Understand fundamental electrical principles	1.1	application of the defining equations for: • resistance • power • energy • resistors connected in series • resistors connected in parallel	1.1	Use the equations below for DC circuit analysis: Ohms law: $R = V/I \quad V = IR \quad I = V/R$ $W = Pt$ $P = VI$ $R = R_1 + R_2 + R_3 + \ldots$ $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$
	1.2	measurement of voltage, current and resistance in a circuit using a: • voltmeter • ammeter • ohmmeter • multimeter	1.2	Considerations could include: • Appropriate connection of meters to circuits to measure voltage, current and resistance • Correct range selection • Internal meter resistance requirements when measuring voltage, current or resistance

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	1.3	circuit theory, i.e. • calculation of the total resistance and total current for a circuit that is a combination of resistors connected in series and parallel • Kirchhoff's first law and its application • Kirchhoff's second law and its application • the maximum power transfer theorem	1.3	Define and apply appropriate laws and circuit theorem. Use circuit theory to analyse resistor networks supplied by a single DC voltage source Considerations could include calculation of current, potential difference and/or power consumed for individual components of a circuit.
2. Understand alternating voltage and current	2.1	what is meant by a simple generator	2.1	Function: to generate an AC supply, to convert mechanical into electrical energy The principle of how a simple generator works
	2.2	what is meant by an alternating current (AC) and generated electromotive force (e.m.f.)	2.2	
	2.3	diagrammatic representations of a sine wave	2.3	Amplitude: peak(maximum) and peak-to-peak Frequency Periodic time
	2.4	to determine frequency and amplitude of a sine wave	2.4	
	2.5	to state and apply the formulae: $v = V \sin\theta$, $i = I \sin\theta$ $v = V \sin\omega t$, $i = I \sin\omega t$ $f = \frac{1}{T}$, $\omega = 2\pi f$	2.5	
	2.6	to determine the phase difference and phase angle in alternating quantities	2.6	Interpreting and sketching graphs of AC waveforms. Quantifying phase in degrees or radians. One cycle is 360° or 2π radians.

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	2.7	circuit diagrams and phasor diagrams for: • a pure resistance being supplied by an alternating current • a pure inductance being supplied by an alternating current • a pure capacitance being supplied by an alternating current • a pure resistance and inductance in series • a pure resistance and capacitance in series	2.7, 2.8 and 2.9	
	2.8	application of the defining equation for reactance (X) and impedance (Z) for: • pure resistance • pure inductance • pure capacitance		When $X = 0$, $Z = R$ and $\phi = 0$ When $X_L = 2\pi fL$, $Z = X_L$ and $\phi = 90^o$ When $X_C = \dfrac{1}{2\pi fC}$, $Z = X_C$ and $\phi = -90^o$
	2.9	application of the defining equation for impedance for: • pure resistance and inductance in series • pure resistance and capacitance in series		$Z = \sqrt{(R^2 + X_L{}^2)}$ and $\cos\phi = R/Z$ $Z = \sqrt{(R^2 + X_C{}^2)}$ and $\cos\phi = R/Z$ $I = V/Z$

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	2.10	circuit diagrams and phasor diagrams where a pure resistance, inductance and capacitance is in series with an AC supply when: • X_L is greater than X_C • X_C is greater than X_L • X_L is equal to X_C	2.10 and 2.11	
	2.11	application of the defining equation for impedance for: • RLC series circuit when X_L is greater than X_C • RLC series circuit when X_C is greater than X_L • RLC series circuit when X_L is equal to X_C		When $X_L > X_C$ $Z = \sqrt{[R^2 + (X_L - X_C)^2]}$ and cos ø = R/Z When $X_C > X_L$ $Z = \sqrt{[R^2 + (X_C - X_L)^2]}$ and cos ø = R/Z When $X_L = X_C$ $Z = R$ $I = V/Z$

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
3. Understand electric motors and generators	3.1	the difference between motors and generators	3.1	Motors convert electrical energy into mechanical energy. Generators convert mechanical energy into electrical energy.
	3.2	application of the defining equation for: • motor • generator	3.2	motor: $V = E + I_a R_a$ generator: $V = E - I_a R_a$
	3.3	the type of field winding and action of a: • separately excited DC generator • series-wound self-excited DC generator • shunt-wound self-excited DC generator • series-wound DC motor • shunt-wound DC motor	3.3	Using circuit diagrams The differences between series and shunt wound motors • configuration • performance characteristics (e.g.torque vs speed) The differences between series and shunt wound generators • configuration • performance characteristics (e.g.current vs load)
	3.4	application of the defining equations for a: • separately excited DC generator • series-wound self-excited DC generator • shunt-wound self-excited DC generator • series-wound DC motor • shunt-wound DC motor	3.4	

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	3.5	applications for a: • separately excited DC generator • series wound self-excited DC generator • shunt-wound self-excited DC generator • series-wound DC motor • shunt-wound DC motor	3.5	• Typical applications • Suitability for application
	3.6	DC motor starters to include a no-volt trip coil and an overload current trip coil	3.6	• Using diagrams • Operation
	3.7	how the speed of a DC shunt motor and a series DC motor can be changed	3.7	$V = E + I_aR_a$ $n = (V - I_aR_a)/(k\Phi)$
4. Understand power supplies and power system protection	4.1	the meaning of: • an alternating current supply • a direct current supply	4.1	
	4.2	the distribution of electrical energy using: • single-phase 2-wire system • single phase 3-wire system • three phase 3- wire Delta connected system • three phase 4-wire Star connected system how: • an alternating current can be rectified to a half wave direct current using a single diode • full wave rectification can be obtained by using two diodes • full wave rectification can be obtained by using four diodes in a bridge configuration	4.2	Distribution system topologies indicating line and phase voltages (values not required) Advantages and disadvantages of single-phase and three-phase systems; including phase sequence and phase difference for three-phase systems Circuit diagrams and operation of single phase rectifier circuits

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	4.3	the capability of load regulation to maintain a constant voltage or current level on the output of a power supply regardless of changes in the supply load	4.3	
	4.4	how to draw a labelled block diagram of a stabilised power supply showing: • AC input • transformer • rectifier • smoothing circuit • stabilising circuit • DC output	4.4	
	4.5	power-system protection	4.5	Current and voltage transformers to provide convenient levels for protective relays Protective relays to sense faults and initiate tripping Circuit breakers to open/close system based on protective relay command Communications to detect voltage and current at remote terminals and remotely control tripping Backup power supplies to provide power to protection systems in case of main supply loss
	4.6	how to explain, with the aid of labelled diagrams, how power supplies and electrical components can be protected by: • current limiting resistors • diodes • fuses • circuit breakers		

Learning outcomes The Learner will:		Teaching content Learners must be taught:		Exemplification
5. Understand analogue electronics	5.1	the definition of an analogue circuit	5.1	An analogue electronic circuit is one that operates with currents and voltages that vary continuously with time.
	5.2	how to explain with the aid of a labelled diagram the characteristics of an operational amplifier (op-amp)	5.2	An operational amplifier (op-amp) has the following characteristics: • DC-coupled voltage amplifier • very high open loop gain • differential inputs • single-ended output • high input impedance • low output impedance
	5.3	how to draw a labelled diagram of an op-amp	5.3	Circuit symbol indicating two inputs, output and the supply voltages
	5.4	characteristic properties of an ideal op-amp	5.4	An ideal op-amp has the following characteristics: • infinite open-loop gain • infinite input impedance • zero output impedance • zero input offset voltage
	5.5	how to draw a labelled diagram and explain the function of: • an inverting amplifier • a non-inverting amplifier • a summing amplifier	5.5	Use of feedback and input resistors to make an op-amp into an inverting amplifier with a known voltage gain. Use of feedback and pulldown resistors to make an op-amp into a non-inverting amplifier with a known voltage gain. Use of feedback and input resistors to allow an op-amp to combine two or more different signals.

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	5.6	application of the defining equation for gain in: • an inverting amplifier • a non-inverting amplifier	5.6	Inverting op amp: $Voltage\ Gain = \frac{V_{out}}{V_{in}} = -\frac{R_F}{R_{in}}$ Non-inverting op amp: $Voltage\ Gain = \frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_2}$
	5.7	state and apply the formula for a summing amplifier V_{out}	5.7	$V_{out} = -\frac{R_F}{R_{in}}(V_1 + V_2 + V_3 \ldots)$ Formula will need to be recalled
6. Understand digital electronics	6.1	the definition of a digital electronic circuit	6.1	A digital electronic circuit is one that accepts and processes binary data (on/off) according to the rules of Boolean logic (AND, OR, NOT, etc.)
	6.2	how to draw a labelled diagram (symbol) and explain the function of the logic gates: • AND • NAND • OR • NOR • NOT • XOR	6.2	For two inputs (maximum)

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	6.3	how to construct truth tables for: • AND • NAND • OR • NOR • NOT • XOR	6.3	For two inputs (maximum)
	6.4	how to solve simple combinational logic problems	6.4	Construct truth tables for combinational logic circuits of: • up to 3 inputs (8 input logic combinations) • up to 5 logic gates Use Boolean expressions (up to 3 terms) to draw combinational logic diagrams Use truth tables to draw combinational logic diagrams: • up to 3 inputs (8 input logic combinations) • up to 5 logic gates Solving simple combinational logic problems requires application of the teaching content in 6.2, 6.3, 6.4 and 6.5
	6.5	how to recognise simple Boolean expressions	6.5	$Q = A.B$ $Q = \overline{A.B}$ $Q = A + B$ $Q = \overline{A + B}$ $Q = \overline{A}$ $Q = A \oplus B = \overline{A}.B + A.\overline{B}$

Learning outcomes		Teaching content		Exemplification
The Learner will:		**Learners must be taught:**		
	6.6	how to explain with the aid of a circuit symbol the function of: • T type bi-stable flip-flop • D type bi-stable flip-flop	6.6 and 6.7	Including timing diagrams and truth tables
	6.7	to explain the behaviour of a rising-edge triggered D flip-flop		

ASSESSMENT GUIDANCE

All Learning Outcomes are assessed through externally set written examination papers, worth a maximum of 60 marks and 1 hour and 30 minutes in duration. Learners should study the design requirements, influences and user needs within the taught content in the context of a range of real engineered products. Exam papers for this unit will use engineered products as the focus for some questions, however it is not a requirement of this unit for learners to have any detailed prior knowledge or understanding of particular products used. Questions will provide sufficient product information to be used, applied and interpreted in relation to the taught content. During the external assessment, learners will be expected to demonstrate their understanding through questions that require the skills of analysis and evaluation in particular contexts.

LEARNING OUTCOME WEIGHTINGS

Each learning outcome in this unit has been given a percentage weighting. This reflects the size and demand of the content you need to cover and its contribution to the overall understanding of this unit. See table below:

LO1	10-20%
LO2	10-20%
LO3	10-20%
LO4	10-20%
LO5	10-20%
LO6	10-20%

*SYNOPTIC ASSESSMENT AND LINKS BETWEEN UNITS

Ten per cent of the marks in each examination for this unit will be allocated to synoptic application of knowledge. There'll be questions that draw on knowledge and understanding from Unit 1 Mathematics for engineering and/or Unit 2 Science for engineering that then has to be applied in the context of this unit.

To find out more
ocr.org.uk/engineering
or call our Customer Contact Centre on **02476 851509**
Alternatively, you can email us on **vocational.qualifications@ocr.org.uk**

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