Cambridge Technicals
Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for January 2022

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

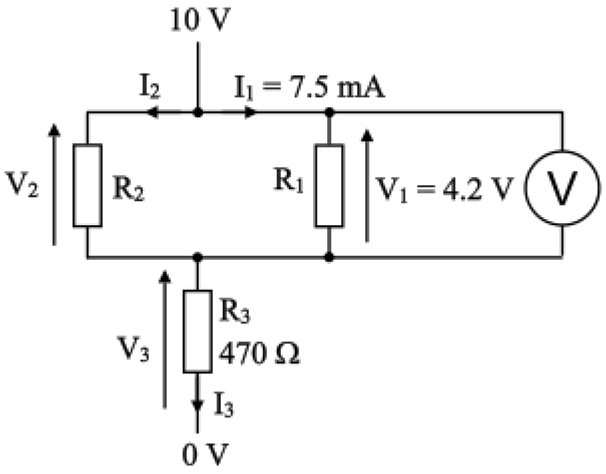
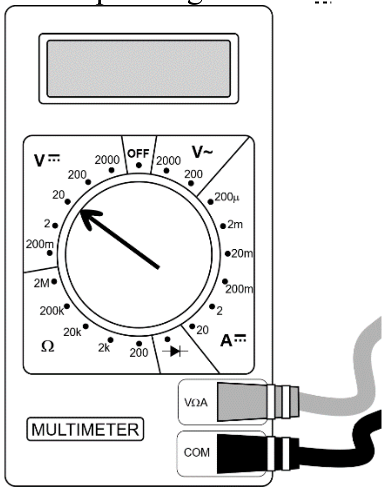
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

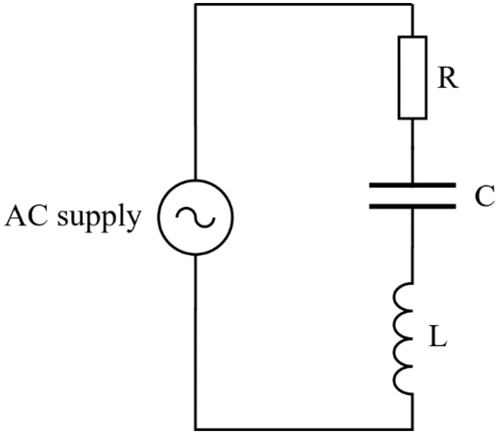
Annotation	***Meaning***
tick	Correct response
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
RE	Rounding error

Subject-specific marking instructions

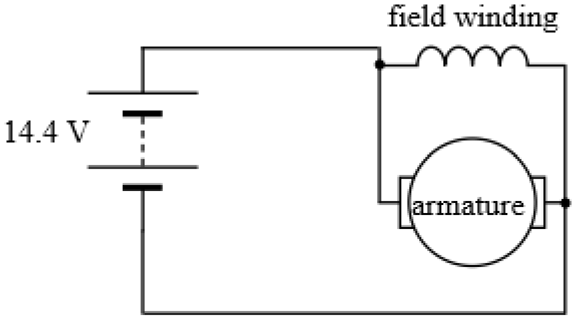
- In all numerical calculation questions a correct response will gain all marks unless specified otherwise.
- Rounding of answers should be to the same number of significant figures as the data in the question, or, otherwise, an answer will be correct provided it rounds to the correct answer.
- Symbols used in circuit diagrams must identify relevant components uniquely and unambiguously.

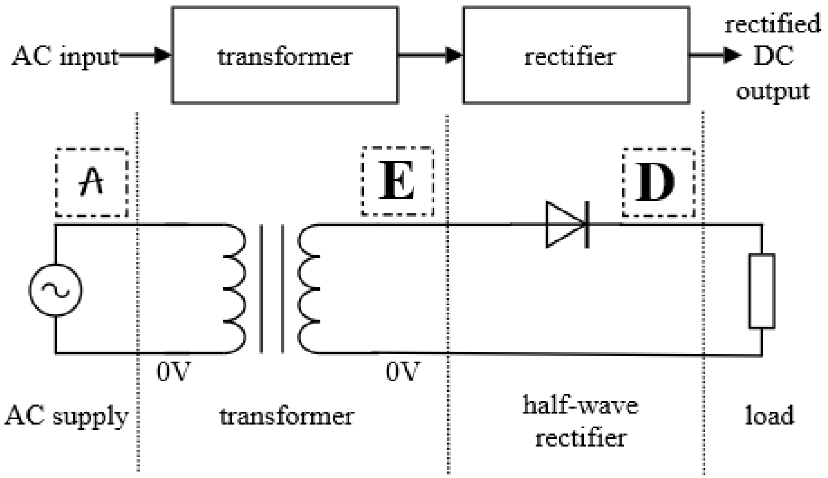
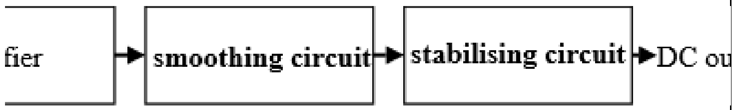
Question			Answer	Marks	Guidance
1	(a)	(i)	Voltmeter symbol connected across R_1  	1	Any unambiguous symbol for voltmeter
1	(a)	(ii)	Arrow pointing to 20 V ⎓  	1	
1	(b)		$R_1 = 4.2/0.0075 = 560\ \Omega$	1	

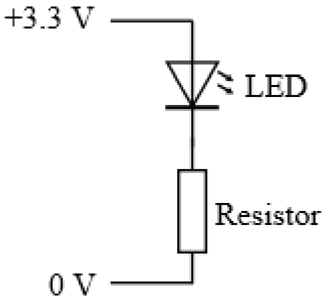
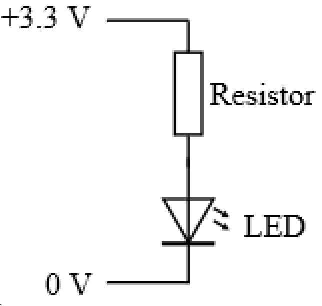
Question			Answer	Marks	Guidance
1	(c)		$V_3 = 10 - 4.2 = 5.8$ V	1	
1	(d)		$I_3 = V_3/R_3 = 5.8^*/470 = 0.0123$ A	1	*Allow ecf from 1c for their V_3
1	(e)		$I_2 = I_3 - I_1 = 0.0123^* - 0.0075 = 0.0048$ A $V_2 = V_1 = 4.2$ V Evidence of correct use of Kirchoff's laws $R_2 = 4.2 / 0.0048 = 875\ \Omega$	1 1	*Allow ecf from1d for their I_3 Correct answer awarded full marks. Allow 868Ω (no rounding on I_3)
1	(f)		Calculation of R_1 and R_2 in parallel (*ecf R_1 , R_2) $R_{1\&2} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{560 \times 875}{560 + 875} = 341\,\Omega$ OR $\frac{1}{R_{1\&2}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{560} + \frac{1}{875} = 0.00293\ \Omega^{-1} \left(\frac{41}{14000}\ \Omega^{-1} \right)$ $\therefore R_{1\&2} = \frac{1}{0.00293} = 341\,\Omega$ Calculation of total resistance (ecf $R_{1\&2}$): $R_T = R_{1\&2} + R_3 = 341 + 470 = 811\ \Omega$	1 1	*Allow ecf from 1(b) for their R_1 and 1(e) for their R_2 providing working out shown Accept any other method that gives the correct answer. e.g. $R_T = \frac{V_T}{I_3} = \frac{10}{0.0123} = 813\ \Omega$ Synoptic mark from Unit 2: 3.7

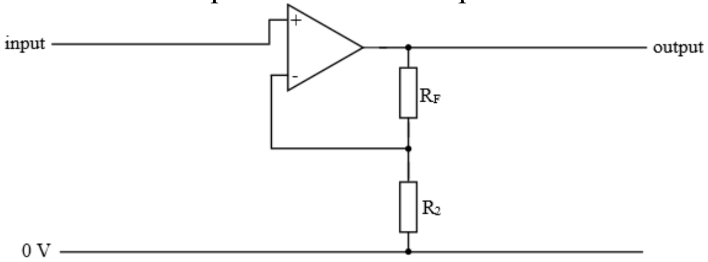
Question			Answer	Marks	Guidance
2	**(a)**	**(i)**	Four components in series correctly labelled Correct symbol for resistor, capacitor and inductor 	1 1	Accept AC or supply for the AC supply but not frequency alone. Order of components unimportant
2	**(a)**	**(ii)**	f = 455 kHz = 455000 Hz Correct conversion to Hz L = 240 µH = 2.4 x 10^{-4} H Correct conversion to H $X_L = 2\pi fL = 2\pi$ x 455000 x 2.4 x 10^{-4} = 686 Ω	1 1 1	Synoptic mark from Unit 2: 1.1 (only penalise incorrect conversion of kHz to Hz once in question 2) Correct numerical answer (ecf for f and L)

Question			**Answer**	**Marks**	**Guidance**
2	**(a)**	**(iii)**	$C = \frac{1}{2\pi \times 455000 \times 910} = 3.84 \times 10^{-10}$ $C = \frac{1}{2\pi f X_C}$ C = 3.84 x 10^{-10} F	1 1 1	Correct substitution (only penalise incorrect conversion of kHz to Hz once in question 2 ie ecf for frequency) Evidence of correctly rearranging the formula Synoptic mark from Unit 1: 1.3 Correct answer (with ecf) with consistent unit Synoptic mark from Unit 2: 3.15 Accept alternative units C = 384 pF = 0.384 nF = 0.000384 μF = 0.000000000384 F Max 2 marks if incorrect or no unit given.
2	**(a)**	**(iv)**	$Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{330^2 + (910 - 686)^2}$ Correct values in correct equation Z = 398.8 Ω	1 1	Allow ecf from 2(a)(ii) for their X_L (only penalise incorrect conversion of kHz to Hz once in question 2)
2	**(a)**	**(v)**	*I = V/Z* = 15 / 398.8 = 0.0376A	1	Allow ecf from 2(a)(iv) for their Z

Question			Answer	Marks	Guidance
3	(a)			1 1	Both circuit symbols drawn correctly Field winding and armature in parallel with power supply. Ignore any additional resistor symbols.
3	(b)		**reduced** **increased** **constant**	1 1 1	A shunt-wound DC motor maintains a fairly constant speed regardless of load. When the motor is running with no load it spins at high speed. When a load is applied to the motor the speed reduces and the EMF generated in the armature is ***reduced***, this means that the current in the armature is increased and so the torque is ***increased***. The current in the field winding is ***constant***. All of this keeps the load speed of the motor close to its no-load speed.
3	(c)	(i)	$I_f = \frac{V}{R_f} = \frac{14.4}{48} = 0.30(\text{A})$	1	
3	(c)	(ii)	$I_a = \frac{V-E}{R_a}$ evidence of correctly rearranging formula $I_a = \frac{14.4-12.2}{18} = 0.122\ (A)$ correct substituting and calculating	1 1	Synoptic mark from Unit 1: 1.3 Synoptic mark from Unit 1: 1.3
3	(c)	(iii)	$I_t = I_a + I_f = 0.122 + 0.300 = 0.422$ A	1	Allow ecf from i and ii

Question			Answer	Marks	Guidance
4	(a)			2	1 mark for each correct letter (E and D) in the correct boxes.
4	(b)	(i)	Box 3: smoothing circuit (accept: smoother, capacitor or condenser) Box 4 stabilising circuit (accept: stabiliser, [voltage/current/load] regulator)	1 1	
4	(b)	(ii)	Maintains constant [or little change in] voltage [or current] (wtte) Regardless of the load on the output (wtte)	1 1	Accept 'regardless of current drawn' if constant or little change in voltage

Question			Answer	Marks	Guidance
4	(c)	(i)	Any 3 from • Correct symbols for LED and resistor (do not allow variable resistor or thermistor etc) – 1 mark • Resistor and LED labelled – 1 mark • Components in series with power supply – 1 mark • Correct polarity for LED (for any symbol recognizable as a diode) – 1 mark	3	 OR 
4	(c)	(ii)	To stop too much current flowing through the LED (wtte) To prevent the LED from overheating (wtte)	1 1	Clear that it is **LED** current that is being limited Accept: preventing damage/blowing/melting of LED Alternative explanation considering the role of the current limiting resistor in prevention of damage to other components in the circuit can be awarded a maximum of 1 mark

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td></td><td>One mark for each correct answer
<table><tr><th>input voltage</th><th>output voltage</th><th>voltage gain</th></tr><tr><td>3.0</td><td>1.5</td><td>0.5</td></tr><tr><td>-2.5</td><td>-7.5</td><td>3</td></tr><tr><td>-4</td><td>6</td><td>-1.5</td></tr></table></td><td>3</td><td></td></tr>
<tr><td>5</td><td>(b)</td><td></td><td>2 resistor values in correct ratio $R_F:R_2 = 1:2$</td><td>2</td><td>If resistor values incorrect award 1 mark for evidence of correct formula used: Voltage Gain = $1 + R_F/R_2$</td></tr>
<tr><td>5</td><td>(c)</td><td></td><td>input connected to non-inverting input only (ignore any input resistor)
output connected to op-amp output
feedback resistor from output to inverting input only
resistor from inverting input to 0V only
R_F and R_2 correctly labelled</td><td>1
1
1
1
1</td><td>Allow V_{in} for input and V_{out} for output
 </td></tr>
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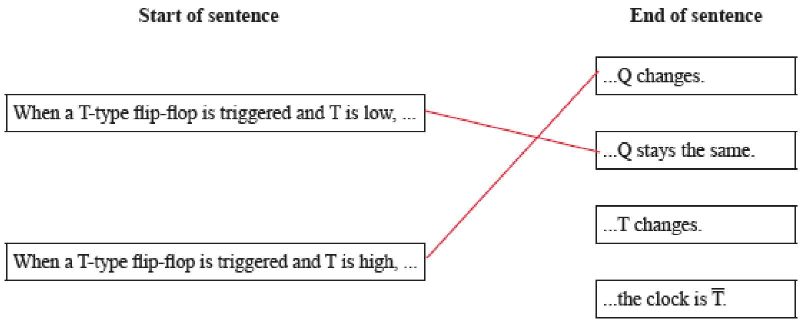
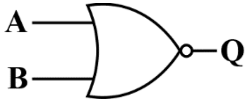
<tr><td>6</td><td>(a)</td><td></td><td>
</td><td>2</td><td>1 mark for each correct line</td></tr>
<tr><td>6</td><td>(b)</td><td>(i)</td><td><table>
<tr><th>A</th><th>B</th><th>Q</th></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table></td><td>1</td><td>All combinations of A and B (any order)</td></tr>
<tr><td>6</td><td>(b)</td><td>(ii)</td><td>NOR [gate]</td><td>1</td><td></td></tr>
<tr><td>6</td><td>(b)</td><td>(iii)</td><td>
</td><td>1</td><td></td></tr>
<tr><td>6</td><td>(b)</td><td>(iv)</td><td>$Q = \overline{A + B}$</td><td>1</td><td></td></tr>
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<tr><td>6</td><td>(c)</td><td></td><td>
<table>
<tr><th>G</th><th>H</th><th>J</th><th>K</th></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td></tr>
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<tr><td>0</td><td>0</td><td>1</td><td>0</td></tr>
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</td><td>1
1
1
1</td><td>1 mark for each correct column
allow ecf from **G** to **H**
allow ecf from **G** to **J**
allow ecf from **H** and **J** to **K**</td></tr>
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