Cambridge Technicals
Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825 & 05873

Mark Scheme for June 2023

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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.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

   YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or by email.

5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.
Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. (The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional lined pages if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add an annotation to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in anyway relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question

   Note: Award 0 marks - for an attempt that earns no credit (including copying out the question)

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses.
Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. Assistant Examiners will email a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking period. Your report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

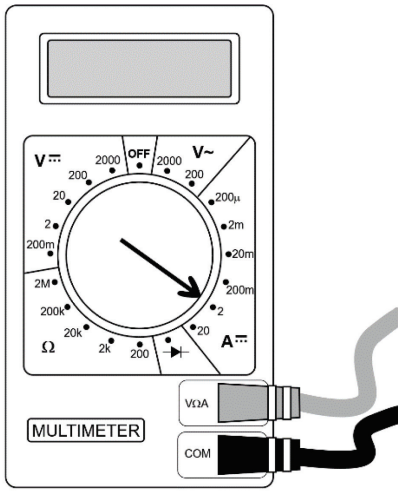
10. **Annotations**

Annotation	Meaning
	Correct response worthy of a mark. Number of ticks = number of marks awarded.
	Incorrect response
	Missing something/incomplete response
	Error carried forward
	Benefit of doubt
	No benefit of the doubt
	Rounding error

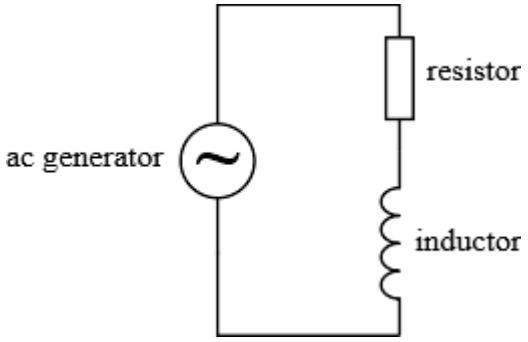
Mark scheme abbreviations:
Wtte: words to that effect
Ecf: error carried forward

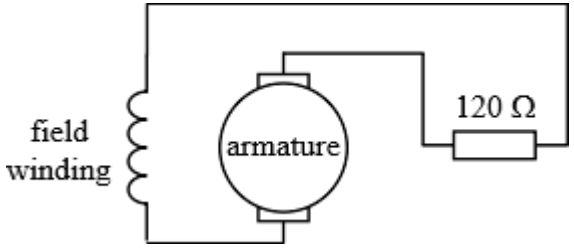
11. **Subject-specific marking instructions**

- 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.

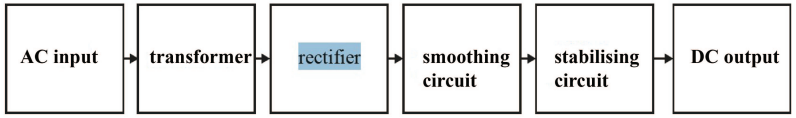
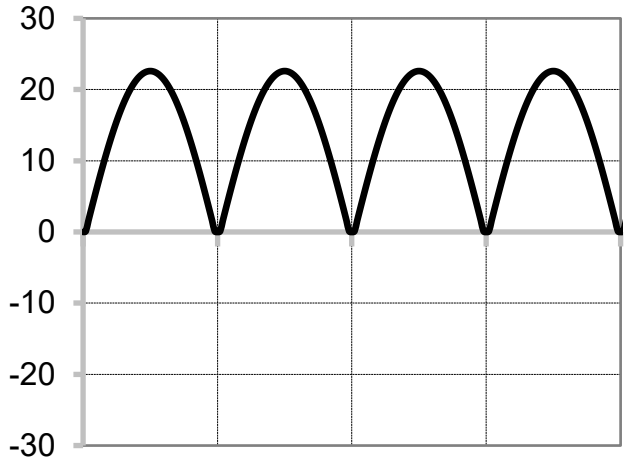
Question			Answer	Marks	Guidance
1	(a)		 **Arrow pointing to 2 A dc**	1	Synoptic mark from unit 2: LO 1.1
1	(b)	(i)	P = 0.6 W t = 5 mins = 5 × 60 s = 300 s W = Pt = 0.6 × 300 = **180** (J)	1 1	Correctly converts to minutes to seconds [1] Synoptic mark from unit 2: LO 1.1 Correctly multiplies power by time [1] ECF from seconds conversion Award 1 mark only for an answer of 3J (not converting time to seconds)
1	(b)	(ii)	V= 6 V P_1 = 0.6 W $I_1 = \frac{P_1}{V} = \frac{0.6}{6} = \mathbf{0.1}\ (A)$	1	

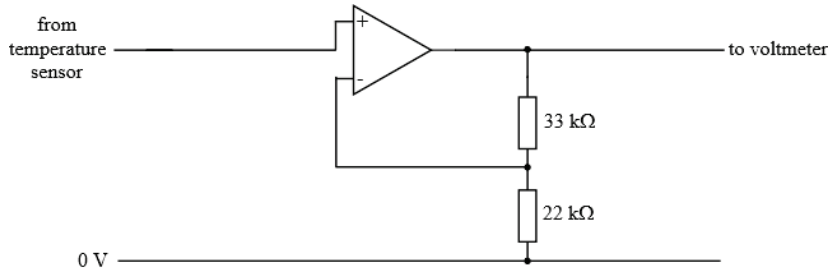
Question			Answer	Marks	Guidance
1	(b)	(iii)	$R_1 = \frac{V}{I_1} = \frac{6}{0.1} = \mathbf{60}\ (\Omega)$ OR $R_1 = \frac{V^2}{P_1} = \frac{6^2}{0.6} = \mathbf{60}\ (\Omega)$	1	Allow ecf for I_1 from 1(b)(ii)
1	(c)		$I = 500\ mA = 0.5\ A$ $I_2 = I - I_1 = 0.5 - 0.1 = 0.4\ A$ $R_2 = \frac{V}{I_2} = \frac{6}{0.4} = \mathbf{15}\ (\Omega)$	1 1	Correctly calculates current through L_2 [1] allow ecf (mark for application of Kirchoff's 1st law)
1	(d)		$P_2 = I_2 V = 0.4 \times 6 = \mathbf{2.4}$ (W) OR $P_2 = I_2^2 R_2 = 0.4^2 \times 15 = \mathbf{2.4}$ (W) OR $P_2 = V_2^2 / R_2 = 6^2 / 15 = \mathbf{2.4}$ (W)	1	Or any other valid method [1] Allow ecf from 1c for R_2 and I_2

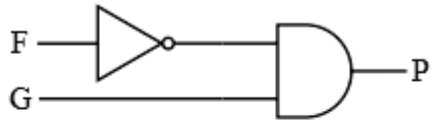
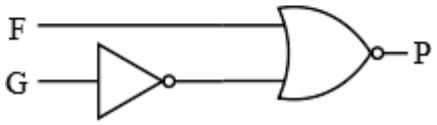
Question			Answer	Marks	Guidance
2	(a)		Direction of current flow changes Periodically with time. e.g. Current changes direction periodically OR Current keeps changing direction	1 1	Do not accept ‘flows in both directions’ or ‘flows both ways’.
2	(b)		Correct symbols for inductor and resistor Correct symbol for AC supply, all three components labelled and in series  	1 1	
2	(c)	(i)	**40** (V)	1	
2	(c)	(ii)	**500** (μs)	1	

Question			Answer	Marks	Guidance
2	(c)	(iii)	$T = 500\ \mu s = 5 \times 10^{-4}$ s $f = 1/T = 1/5 \times 10^{-4} =$ **2000** (Hz)	1 1	Synoptic mark from unit 2: LO 1.1 Ecf on unit conversion/their T from 2cii Accept f = 2 kHz with prefix added to unit (or f = 0.002 MHz) Correct answer 2 marks
2	(c)	(iv)	$\Delta t = 125\ \mu s$ [$\pm 10\ \mu s$] OR 375 μs [$\pm 10\ \mu s$] $\phi = 360° \times \Delta t/T = 360 \times 125/500 = \pm 90°$ [$\pm 7°$] OR $\pm 270°$ [$\pm 7°$]	1 1	Evidence of finding time difference (including as proportion of period). Converting time (or fraction of period) to angle. Correct answer by any other method [2]
2	(c)	(v)	$\phi \times 2\pi/360 = 90 \times 2\pi/360 = \pi/2$ rad = 1.57 rad [± 0.13 rad] OR $\phi \times 2\pi/360 = 270 \times 2\pi/360 = 3\pi/2$ rad = 4.71 rad [± 0.13 rad]	1	Accept $\pi/2$ rad or $\frac{1}{2}\pi$ rad Accept their 2civ converted to radians Synoptic mark from unit 1: LO 4.1
3	(a)		Labelled armature and field winding providing power to 120Ω resistor Armature and field winding connected in series with 120Ω resistor e.g.  	1 1	Accept unlabelled armature/field winding where symbols are clearly drawn Any arrangement that puts all parts in series regardless of order Allow additional series resistor

Question			Answer	Marks	Guidance
3	(b)	(i)	$I = \frac{V}{R} = \frac{8.2}{120} = \mathbf{0.068}\ (A)$	1	Synoptic mark from unit 2: LO 3.6
3	(b)	(ii)	$V = E - I_aR_t$ where $R_t = R_a + R_f$ $E = V + I(R_a + R_f) = 8.2 + 0.068(\mathbf{25 + 18})$ $= \mathbf{11.14}$ **V**	1 1 1	Evidence of selecting the correct equations Correct value (ecf from 3bi) Correct units Synoptic mark from unit 2: LO 1.1
3	(c)	(i)	A motor converts electrical energy to kinetic (or mechanical) energy/motion (wtte) A generator converts kinetic (or mechanical) energy/motion to electrical energy/electricity (wtte)	1 1	
3	(c)	(ii)	$V = E + I_aR_t$ where $R_t = R_a + R_f$ $I_a = \frac{V - E}{R_a + R_f} = \frac{24 - 17}{25 + 18}$ $= \mathbf{0.16}$ (A)	1 1	Evidence of selecting the correct equations Correct answer
3	(c)	(iii)	Shunt-wound (self-excited) DC motor Any one of: • Because the speed of a shunt-wound motor is not strongly dependent on load (wtte) • Because the speed of a series-wound motor is much higher when the load is reduced (wtte)	1 1	Accept suitable motors not on specification with valid explanations (e.g. permanent magnet dc motor, brushless dc motor, separately excited dc motor) for 2 marks

Question			Answer	Marks	Guidance
4	(a)			5	1 mark for each correctly placed label in blocks 1 and 2 and 3,4 and 5 Block 3 rectifier is given in the question
4	(b)		Convert AC to DC (wtte)	1	
4	(c)	(i)	… input is 24 V, **B and D** diodes … … input is 0 V, **no** diodes … … input is −24 V, **A and C** diodes …	1 1 1	Accept 0
4	(c)	(ii)	All positive Full wave rectified, same period 	1 1	Regardless of polarity

Question			Answer	Marks	Guidance
5	(a)	(i)	voltage gain $= \frac{V_{out}}{V_{in}} = \frac{5.5}{2.2} = \mathbf{2.5}$	1	
5	(a)	(ii)	Resistor from output to – Resistor from – to 0 V Temperature sensor to + Output to voltmeter e.g.  Using Gain = 1 + R_f / R_2, ratio R_f:R_2 = 3:2	1 1 1 1 1	Disregard any resistor from temperature sensor to 0 V or + input Accept any values for resistors in the correct ratio. ECF from 5(a)(i) for gain.
5	(b)		[very] high **input** impedance/resistance (wtte)	1	Accept infinite **input** impedance

Question			Answer	Marks	Guidance
5	(c)		**−5.9 V** Evidence of adding two voltages together (5.5 V + 6.3 V) Answer of correct magnitude |5.9| Negative value – $V_{out} = -\frac{R_f}{R_{in}}(V_1 + V_2)$ $= -\frac{15000}{30000} \times (5.5 + 6.3)$ $= \mathbf{-5.9}$ (V)	1 1 1	
6	(a)		Can have only one of two possible values High or low voltage Binary signals 0 or 1	1	
6	(b)		One input inverted, one input not inverted into 2-input logic gate Correct logic function  OR  	1 1	Accept any circuit that achieves the function regardless of complexity
6	(c)	(i)	EOR / XOR / ExOR / Exclusive-OR	1	
6	(c)	(ii)	**R = J ⊕ K**	1	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(c)</td><td>(iii)</td><td>All possible combinations of J, K and L
Column R correct
Column S correct
<table>
<tr><th>J</th><th>K</th><th>L</th><th>R</th><th>S</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
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</table></td><td>1
1
1</td><td>If not all possible combinations of input given allow max 1 mark for 4 fully correct rows</td></tr>
</table>

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