

Cambridge Technicals

Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical in Engineering

05822 - 05825 & 05873

Mark Scheme for January 2025

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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.

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

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, email or via the RM Assessor messaging system.
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 objects 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 the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 10.

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 any way 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 is not 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.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths 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
	Transcription error
	Seen
	Blank page

Mark scheme abbreviations:

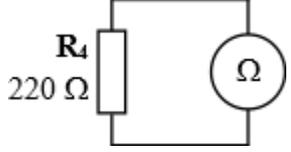
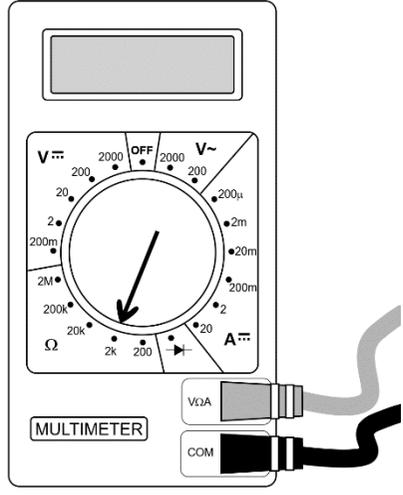
Wtte: words to that effect

Ecf: error carried forward

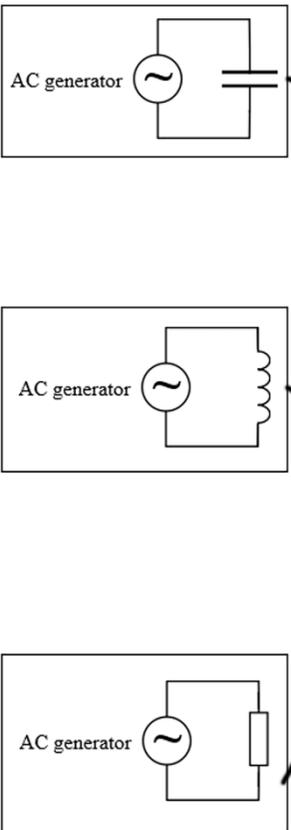
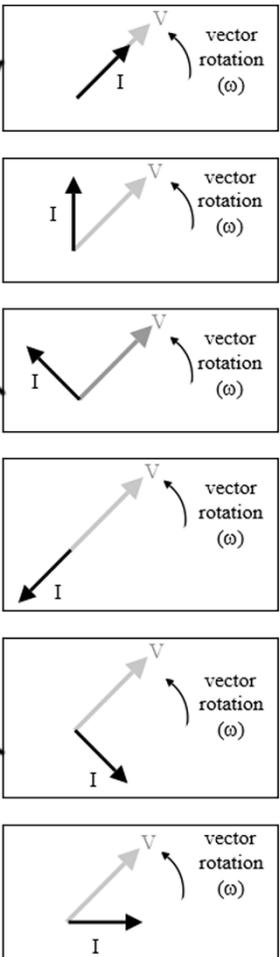
11. Subject-specific marking instructions

- 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)	$I_2 = \frac{V}{R_2} = \frac{3.0 \text{ V}}{220 \Omega} = 0.0136 \text{ A} = 0.014 \text{ A}$	1	
1	(b)	$R_3 + R_4 = 110 \Omega + 220 \Omega = 330 \Omega$	1	
1	(c)	$I_3 = \frac{V}{(R_3 + R_4)} = \frac{3.0 \text{ V}}{330 \Omega} = 0.00909 \text{ A} = 0.0091 \text{ A}$	1	Ecf from 1(b)
1	(d)	Answer expressing the idea that the only route for the current through R_3 is to go through R_4 / current in series is the same OR Answer expressing the idea that current/charge is conserved	1	Accept a statement naming Kirchoff's first (current) law
1	(e)	$V_2 = 3.0 \text{ V}$	1	Allow ecf from 1(a) ie calculation of $220 \times 1(a)$
1	(f)	$I_1 = I_2 + I_3 = 0.0136 + 0.00909 \text{ A} = 0.0227 \text{ A}$ $= 0.023 \text{ A to 2sf}$	1	Evidence of correctly calculating I_1 Allow ecf from 1(a) and 1(c)
1	(g)	(i) Any one of: <ul style="list-style-type: none"> To avoid measuring other resistor in the circuit To stop the power in the circuit from interfering with ohmmeter reading To prevent the power supply from damaging the ohmmeter 	1	Accept answer expressing the idea that the measuring in circuit will entail measuring other components as well as R_4 Accept answers that identify that current from the circuit will affect the reading on an ohmmeter. Accept answers identifying that there is a power supply in the circuit that may damage the meter.

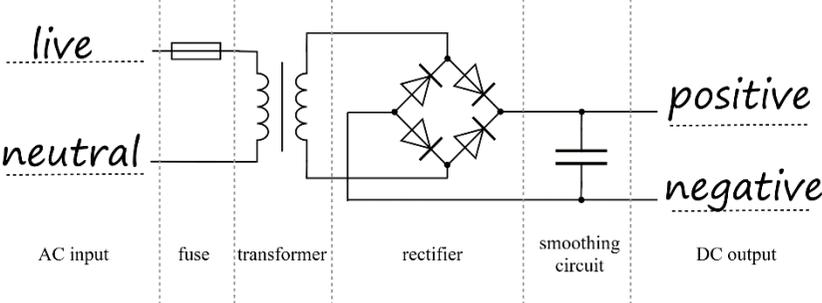
Question			Answer	Marks	Guidance	
1	(g)	(ii)		1		
1	(g)	(iii)		Arrow pointing to 2kΩ	1	

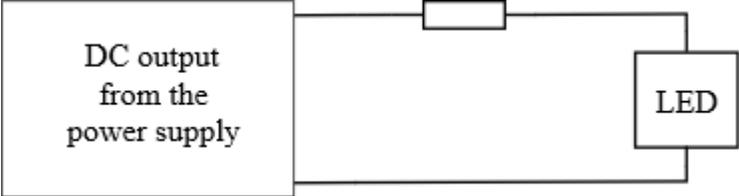
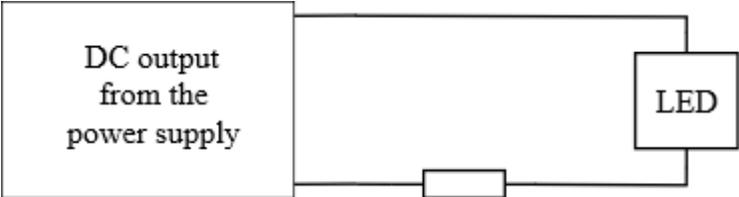
Question		Answer	Marks	Guidance
2	(a)	$T = \frac{1}{f} = \frac{1}{440 \text{ Hz}} = 0.0023 \text{ s}$	1	
2	(b)	$\omega = 2\pi f = 2\pi \times 440 \text{ Hz} = 2765 \text{ rad s}^{-1}$ $= 2800 \text{ rad s}^{-1}$ to 2 s. f.	1	2765 rad s ⁻¹ rounded to 2 or more significant figures Allow 880π
2	(c)	$t = 2 \text{ ms} = 2 \times 10^{-3} \text{ s}$ $v = V \sin(\omega t) = 8 \text{ V} \times \sin(2765 \text{ rad s}^{-1} \times (2 \times 10^{-3}) \text{ s})$ = answer between -5.05 and -5.48 V (dependant upon value used for ω)	1 1 1	Evidence of converting ms to s Synoptic mark from unit 2: LO 1.1 Evidence of substituting correct physical quantities into equation. Allow ecf for t and/or ω Evidence of correct calculation using radians for sin function. Allow ecf for t and/or ω Synoptic mark from unit 1: LO 4.1 Award 3 marks for numerically correct answer Award 2 marks if incorrect value of 0.77 V given from correct values substituted in but sine calculated in degrees
2	(d)	$X_C = \frac{1}{2\pi f C}$ $C = 22 \text{ nF} = 22 \times 10^{-9} \text{ F}$ $X_C = \frac{1}{2\pi \times 440 \text{ Hz} \times 22 \times 10^{-9} \text{ F}} = 16441 \Omega = 16000 \Omega$	1 1 1	Evidence of selecting correct formula Evidence of correctly converting nF to F Synoptic mark from unit 2: LO 1.1 ecf for nF conversion Award 3 marks for numerically correct answer

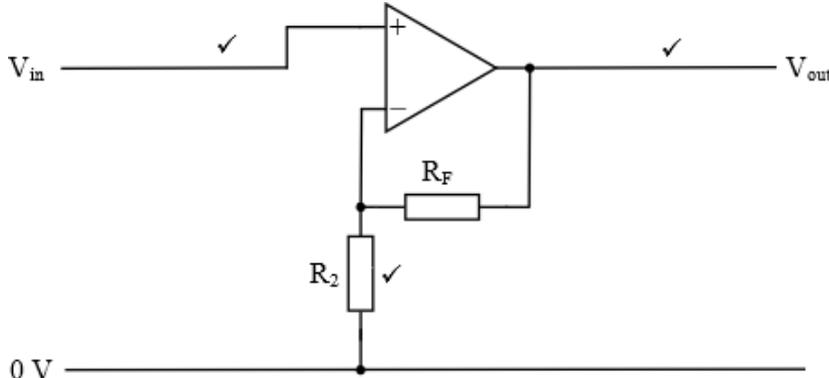
Question		Answer	Marks	Guidance
2	(e)	<p>1 mark for each correct line</p> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="text-align: center;"> <p><u>Circuit diagram</u></p>  </div> <div style="text-align: center;"> <p><u>Phasor diagram</u></p>  </div> </div>	<p>3</p>	

Question		Answer	Marks	Guidance
3	(a)	Separately excited DC generator	1	Based on a Lincoln SA200 welding generator
3	(b)	$I_f = \frac{V_f}{R_f}$ $= \frac{115 \text{ V}}{46 \Omega} = 2.5 \text{ A}$	1 1	Evidence of selecting the correct equation Correct answer Award 2 marks for numerically correct answer
3	(c)	$P = IV = 2.5 \text{ A} \times 115 \text{ V} = 287.5 \text{ W} = 290 \text{ W to 2 s.f.}$ <p style="text-align: center;">OR</p> $P = I^2R = (2.5 \text{ A})^2 \times 46 \Omega = 287.5 \text{ W} = 290 \text{ W to 2 s.f.}$	1	1 mark for correct answer. Accept answers to 2 s.f. or more Ecf for current. (Synoptic mark from unit 2: 3.8)
3	(d)	... produce a strong magnetic field in the generator.	1	
3	(e) (i)	$E = V + I_a R_a$ $E = 40 + 180 \text{ A} \times 0.02 \Omega$ $= 43.6 \text{ V} = 44 \text{ V to 2 s.f.}$	1 1 1	Evidence of selecting the correct equation Correct values substituted and calculation correct (Award first 2 marks for numerically correct answer) Correct units of V
3	(e) (ii)	One of: <ul style="list-style-type: none"> • So that the generator can supply a large current/180 A • So that the armature does not get too hot • To prevent too much power being wasted/dissipated in the armature • So that the output voltage is not too much smaller than the EMF/Not too many volts lost in the armature 	1	

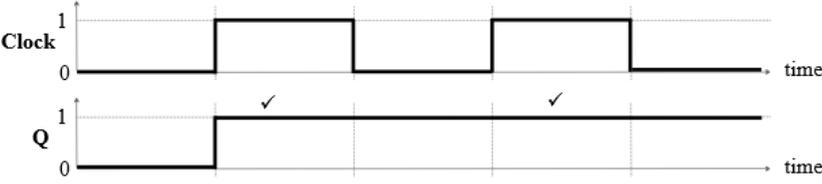
Question			Answer	Marks	Guidance
3	(e)	(iii)	$P = I^2R = (180 \text{ A})^2 \times 0.02 \Omega = 648 \text{ W} = 650 \text{ W to 2 s.f}$ <p style="text-align: center;">OR</p> $P = IV = 180 \text{ A} \times (43.6 \text{ V} - 40 \text{ V}) = 648 \text{ W}$ $= 650 \text{ W to 2 s.f}$	1	<p>(Synoptic mark from unit 2: 3.8)</p> <p>1 mark for correct answer. Accept answers to 2 s.f. or more.</p> <p>Ecf from 3(e)(i) if P=IV is used, beware of rounding errors from $180 \text{ A} \times (44 \text{ V} - 40 \text{ V}) = 720 \text{ W}$</p>
3	(f)		<p>A resistor is placed in series with the field winding and the 115 V DC supply. When the values of the resistor is increased, the current in the field winding decreases and therefore the EMF induced in the armature decreases.</p>	1 1	One mark for each correct term. No ecf.

Question	Answer	Marks	Guidance
<p>4 (a)</p>	 <p>1 mark: one label in the correct place 2 marks: two (or three) labels in the correct place 3 marks: all labels correct</p>	<p>3</p>	
<p>4 (b)</p>	<p>Alternating current changes direction periodically/moves one way then the other/keeps changing direction (owtte)</p> <p>Direct current only flows in one direction (owtte)</p>	<p>1</p> <p>1</p>	<p>Do not accept 'flows in both directions'. Answer must express the idea that the change in direction of current flow changes with time.</p>
<p>4 (c) (i)</p>	<p>Between the smoothing circuit and the DC output</p>	<p>1</p>	

Question		Answer	Marks	Guidance
4	(c) (ii)	<p>The output voltage { remains (near) constant changes very little</p> <p>when the { load changes output current changes</p> <p>[up to a maximum load/current]</p> <p>Allow similar argument for constant current source (second marking point must be consistent with first for 2 marks) i.e.</p> <p>When the { load changes output voltage changes</p> <p>the output current { remains (near) constant changes very little</p>	<p>1</p> <p>1</p>	<p>Idea that load regulation is to do with maintaining a (near) constant voltage/current</p> <p>for a changing load</p>
4	(d)	<p>Resistor connected in series with LED to DC output from the power supply</p> <p>E.g.</p>  <p>OR</p> 	1	<p>Accept old US NEMA resistor symbol </p>

Question		Answer	Marks	Guidance
5	(a)	$V_{in} = 200 \text{ mV} = 0.2 \text{ V}$	1	Evidence of converting mV to V Synoptic mark from unit 2: LO 1.1
		$V_{out} = \text{Voltage Gain} \times V_{in} = 12 \times 0.2 \text{ V} = 2.4 \text{ V}$	1	Ecf from mV conversion Award 2 marks for numerically correct answer
5	(b)	<p>V_{in} connected only to non-inverting input of op-amp (terminal labelled +) Output of op-amp connected to V_{out} Resistor connected from 0 V to inverting input of op-amp (terminal labelled -)</p> 	<p>1</p> <p>1</p> <p>1</p>	Resistor R_2 label not require mark
5	(c)	zero output impedance	1	

Question		Answer	Marks	Guidance															
5	(d)	R _F & R ₂ both have values greater than 1 kΩ	1	Both values must greater than 1 kΩ for first mark.															
		Value of R _F is 11 times the value of R ₂ $\frac{R_F}{R_2} = Voltage\ Gain - 1 = 12 - 1 = 11$ e.g. R _F = 330 kΩ and R ₂ = 30 kΩ or any other values in the correct ratio.	1																
6	(a)	NAND	1																
6	(b)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>P</th> <th>L</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table> <p>All combinations of P and L C correct</p>	P	L	C	0	0	1	1	0	1	0	1	1	1	1	0	1 1	Order unimportant Must have all combinations of P & L for C mark
P	L	C																	
0	0	1																	
1	0	1																	
0	1	1																	
1	1	0																	
6	(c)	The pressure sensor is <u>pressed</u> <u>and</u> the light sensor is <u>bright</u> .	1	Allow pressure sensor is 1/high and light sensor is 1/high															

Question	Answer	Marks	Guidance
<p>6 (d)</p>	<p>Q stays low until first rising edge of Clock and then goes suddenly high (vertical by eye) and then stays high until next rising edge of Clock</p> <p>Q is high from second rising edge of Clock until end of timing diagram</p> 	<p>1</p> <p>1</p>	
<p>6 (e)</p>	<p>So that the bell <u>stays on</u> once it has been triggered even after the C goes low/until it is reset</p>	<p>1</p>	<p>Any statement that expresses the idea that the alarm continues to make a noise after the triggering event is over.</p> <p>Accept appropriate use of the word ‘latches’.</p> <p>Accept a correct answer that refers to the logic state of the Q remaining high even when the clock returns to logic low.</p>

Question		Answer							Marks	Guidance
6	(f)	A	B	C	W	X	Y	Z	4	
		0	0	0	1	0	0	0		
		0	0	1	1	0	1	1		
		0	1	0	1	0	1	1		
		0	1	1	1	0	0	0		
		1	0	0	1	0	0	0		
		1	0	1	1	0	1	1		
		1	1	0	0	1	1	1		
		1	1	1	0	1	0	1		
		One mark for each correct column W , X , Y & Z								

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