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 2024

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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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 50% Batch 1 and 100% Batch 2 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, *RM Assessor* messaging 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. Award No Response (NR) if:
   - there is nothing written in the answer space

   Award Zero '0' if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

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.

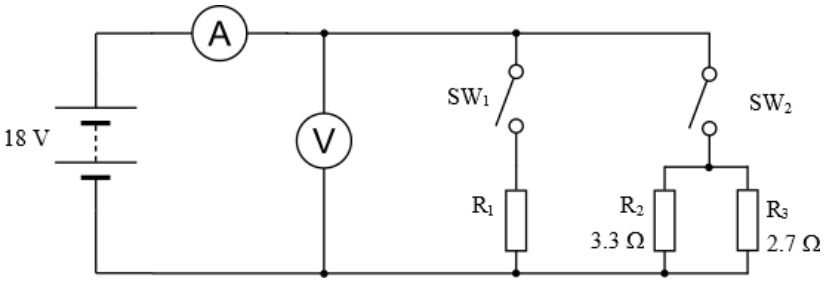
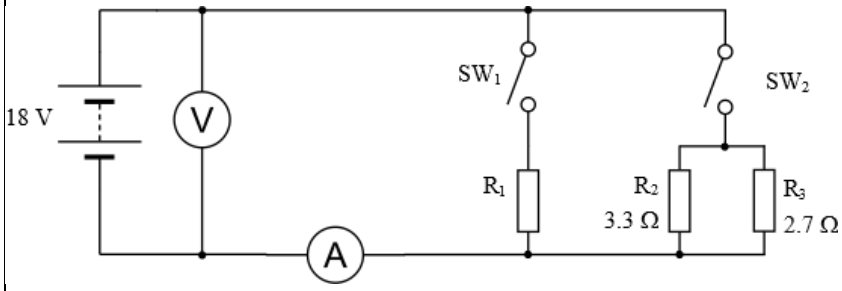
10. **Annotations**

Annotation	***Meaning***
	Correct response
	Incorrect response
	Incomplete response
	Error carried forward
	Benefit of doubt
	No benefit of doubt
	Rounding error
	Seen
	Blank page

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

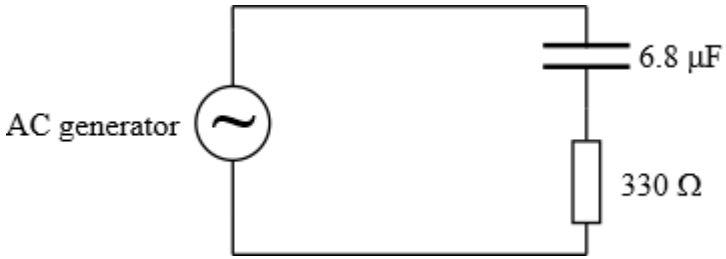
11. **Subject-specific marking instructions**

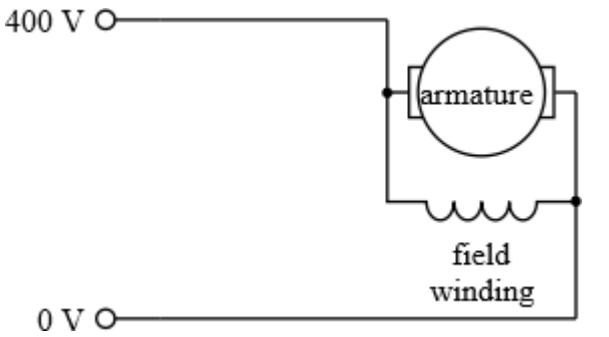
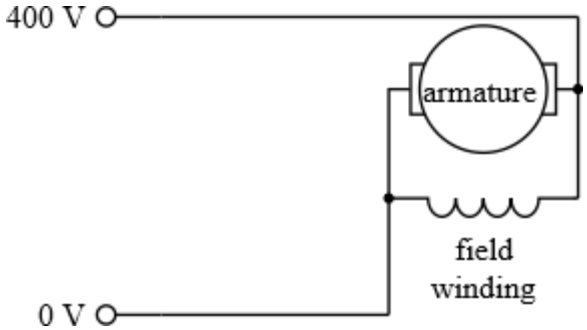
- In all numerical calculation questions a correct response will gain all marks unless specified otherwise.
- Rounding of answers should be to the same number of significant figures as the data in the question, or, otherwise, an answer will be correct provided it rounds to the correct answer.
- Symbols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

Question			Answer	Marks	Guidance
1	(a)		Voltmeter in parallel with battery [or heater circuit] Ammeter in series with battery and heater circuit e.g.  OR  Or any other arrangement providing correct ammeter and voltmeter readings (with unambiguous symbols)	1 1	Ignore ammeter for this mark Ignore voltmeter for this mark
1	(b)		Current through $R_2 = I_2 = \frac{V}{R_2} = \frac{18\ \text{V}}{3.3\ \Omega} = 5.45\ \text{A}$	1	

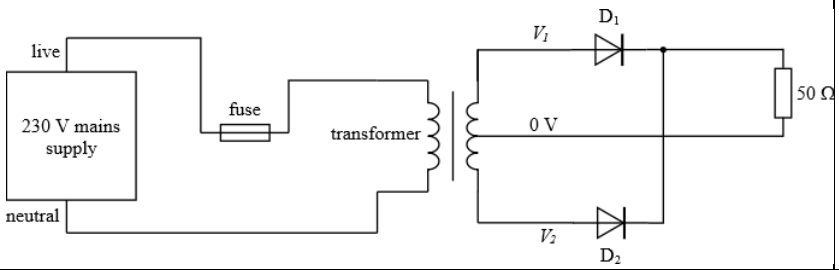
Question			Answer	Marks	Guidance
1	(c)		$P = IV = 5.45\ \text{A} \times 18\ \text{V} = 98\ [\pm 2]\ \text{W}$ ecf from 1(b)	1	Accept any other valid method e.g. $P = \frac{V^2}{R_2} = \frac{(18\ \text{V})^2}{3.3\ \Omega} = 98\ \text{W}$
1	(d)		$\frac{1}{R} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{3.3\ \Omega} + \frac{1}{2.7\ \Omega} = 0.673\ \Omega^{-1}$ $\therefore\ R = \frac{1}{0.673\ \Omega^{-1}} = 1.5\ \Omega$	1 1	Correct equation and values used Calculation correct (accept answers with a greater number of sig figs) (Synoptic mark from unit 1: LO1.3) Accept any other valid method e.g. $R = \frac{R_2 \times R_3}{R_2 + R_3} = \frac{3.3\ \Omega \times 2.7\ \Omega}{3.3\ \Omega\ +\ 2.7\ \Omega} = 1.5\ \Omega$
1	(e)	(i)	P = 1.1 kW = 1100 W $P = IV \quad \therefore I = \frac{P}{V} = \frac{1100\ \text{W}}{18\ \text{V}} = 61.1\ \text{A}$ $R_1 = \frac{V}{I} = \frac{18\ \text{V}}{61.1\ \text{A}} = 0.29\ \Omega$	1 1	Correct method Correct value for R_1 Allow 0.3 Ω with appropriate working out Accept any other valid method e.g. $P = \frac{V^2}{R_1} \qquad \therefore R_1 = \frac{V^2}{P} = \frac{(18\ \text{V})^2}{1100\ \text{W}} = 0.29\ \Omega$

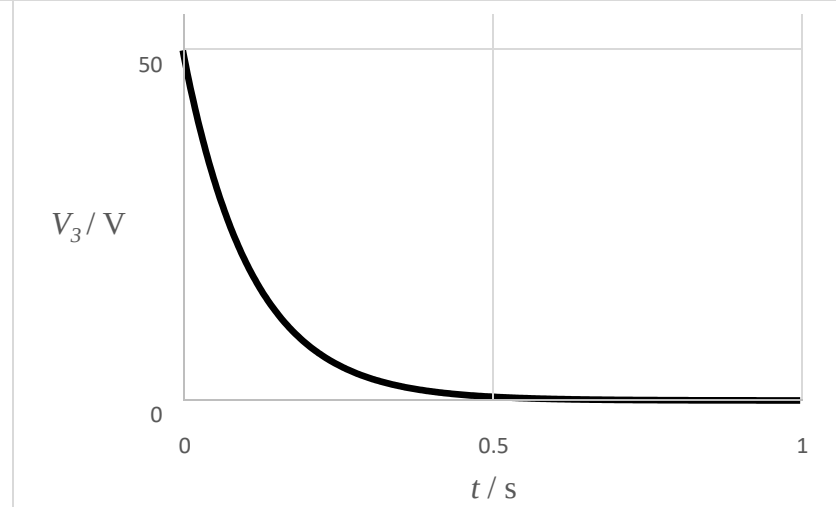
Question			Answer	Marks	Guidance
1	(e)	(ii)	Convert time to seconds time, t = 8 minute = 8 × 60 = 480 s Use of $W = Pt$ to calculate correct value for energy (ecf from first mark) W = 1100 W × 480 s = 528000 J OR W = 1.1 kW × 480 s = 528 kJ = 528kWs OR W = 0.147 kWh Units of energy given	1 1 1	(Synoptic mark from unit 2: LO1.1) Accept other valid units of energy, e.g. W s or kW s or kW h Accept any correct answer consistent with the units given for full marks.
2	(a)		One of: • A device to generate/produce an alternating current • A device that converts mechanical/kinetic/movement energy to electrical energy • A device with a rotating magnetic field that induces/produces an emf/current/electricity (in a coil/wire/its windings)	1	Or words to the same effect description is clearly of a generator not a motor

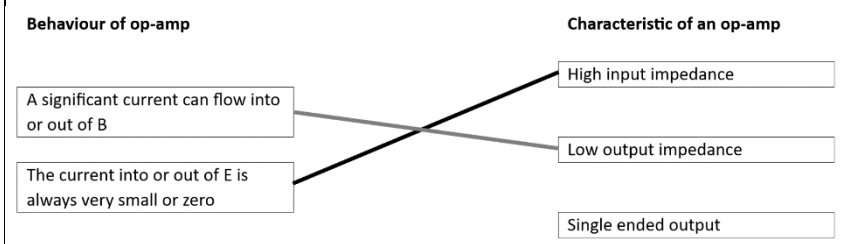
Question			Answer	Marks	Guidance
2	(b)		Correct symbols for resistor and capacitor AC generator, labelled capacitor and labelled resistor all in series circuit  	1 1	Award second mark regardless of symbols provided the three components are in series and the values are labelled on the two drawn components. Order and arrangement of components unimportant
2	(c)	(i)	$C = 6.8\ \mu\text{F} = 6.8 \times 10^{-6}\ \text{F}$ $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 120\ \text{Hz} \times 6.8 \times 10^{-6}\ \text{F}} = 195\ [\pm 2]\ \Omega$	1 1	Evidence of correctly dealing with μF Correct calculation (ecf from converting from μF)
2	(c)	(ii)	0 Ω	1	
2	(c)	(iii)	Correct equation Correct calculation with correct values used (ecf from (c)(i)) $Z = \sqrt{R^2 + {X_C}^2} = \sqrt{(330\ \Omega)^2 + (195\ \Omega)^2} = 383\ [\pm 5]\ \Omega$	1 1	

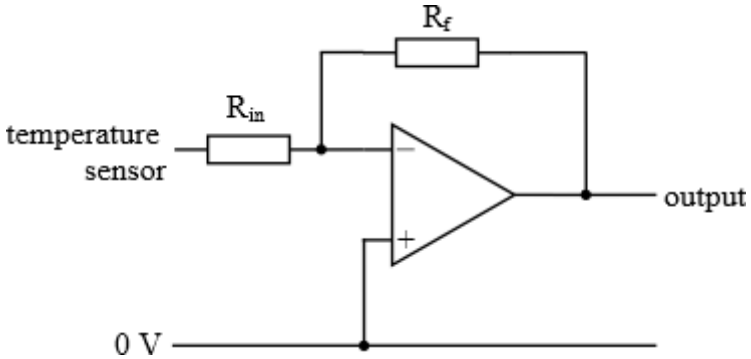
Question			Answer	Marks	Guidance
2	(c)	(iv)	Formula correctly rearranged $\cos\phi = \frac{R}{Z} \qquad \therefore \phi = \cos^{-1}(\frac{R}{Z})$ Correct answer with consistent units $\phi = \cos^{-1}\left(\frac{330}{383}\right) = 30.5° = 0.54\,rad$ ecf from 2(c)(iii)	1 1	Accept any correct answer consistent with given units (synoptic mark from unit 1 LO3.2)
3	(a)	(i)	Field winding in parallel with armature and power supply  OR 	1	

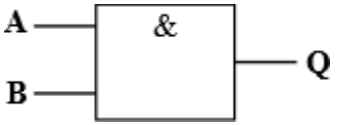
Question			Answer	Marks	Guidance
3	(a)	(ii)	[Conveyor belt needs to run a steady speed] Shunt wound motor speed does not change much with load/ Shunt wound motor speed (fairly) constant Series wound motor speed changes greatly with load/Series motor speed varies greatly/Series motor speed can become unstable at low loads	 1 1	 Valid comment about shunt wound motor speed and/or load characteristics Valid comment about series wound motor speed and/orload characteristics
3	(a)	(iii)	$I_f = \frac{V}{R_f} = \frac{400\ \text{V}}{10000\ \Omega} = 0.04\ \text{A}$	1	
3	(a)	(iv)	$V = E + I_a R_a$ $\therefore E = V - I_a R_a$ Evidence of using correct equation rearranged to find E $E = 400\ \text{V} - (2.0\ \text{A} \times 12\ \Omega) = 376\ \text{V}$ Correct numerical value Correct units	 1 1 1	
3	(b)		When the start switch is pressed, the motor starts turning. After theswitch is released, the motor is **turning**. The motor is turning when the power supply fails and provides no power to the motor for 15 minutes. After the power supply is restored, the motor will be **stopped**.	1 1	

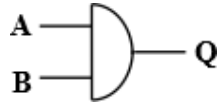
Question			Answer	Marks	Guidance
4	(a)	(i)	Mains supply, fuse and transformer in series circuit Fuse connected from live connection to transformer 	1 1	Award 1 mark for complete series circuit with fuse between neutral and transformer.
4	(a)	(ii)	Maximum of two marks from the following points: • If <u>too much **current** flows</u> through the fuse • The fuse gets very hot and the wire in the <u>fuse melts/blows</u> • This <u>disconnects the circuit</u>	2	Look for clear expressions of underlined ideas.
4	(a)	(iii)	One clear advantage. Words to the effect of: • Circuit breakers can be reset after fault has been rectified • Circuit breakers do not have to be replaced after a fault occurs • Do not need to keep a stock of spare fuses	1	Ignore answers referring to the response time of circuit breakers
4	(b)	(i)	To convert AC to DC (wtte)	1	

Question			Answer	Marks	Guidance
4	(b)	(ii)	D_1 is conducting but D_2 is not conducting. ✓	1	
4	(c)	(i)	$\tau = RC = 50\ \Omega \times 2200 \times 10^{-6}\ \text{F} = 0.11\ \text{s}$	1	(Synoptic mark from unit 2: LO3.18)
4	(c)	(ii)	Line starting at (0 s, 50 V) and V_3 falling as t increases Gradient gets less steep as t increases V_3 close to or at 0 V from around t = 0.5 s (parallel to the t-axis) 	1 1	(Synoptic marks from unit 2: LO3.17)

Question			Answer	Marks	Guidance
5	(a)		Input connections: **D** & **E** Output connection: **B** Supply voltage connections: **A** & **C** One line correct All other lines correct	 1 1	2 marks if all correct 1 mark if only one line correct
5	(b)		 1 mark for each correct line	2	
5	(c)	(i)	$V_{out} = -12 \times 0.3\ \text{V} = -3.6\ \text{V}$	1	Allow -4

Question			Answer	Marks	Guidance
5	(c)	(ii)	Op-amp with feedback resistor from op-amp output and output label to – (inverting input) Resistor from temperature sensor label to − (inverting input) 0 V to + (non-inverting input) $R_f > R_{in}$ Magnitude of resistor values in ratio 12:1  	1 1 1 1 1	For resistor values - allow incorrect placement of Rin/ feedback loop connected to + (non-inverting input)
6	(a)	(i)	One from: Signals can have only one of two state/are binary. Signals are processed by a logic gate Signals are processed according to the rules of Boolean logic	1	wtte
6	(a)	(ii)	One from: Signals at safety guard, switch and motor controller are 0 or 1 Signals are up/down, on/off or run/stop. Signals are processed by an AND gate (which is a logic gate)	1	Accept any one valid example from Fig. 2

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(b)</td><td></td><td>Correct symbol (labels unimportant)
 
</td><td>1</td><td>Accept correct IEC or DIN symbol
 

OR
 
</td></tr>
<tr><td>6</td><td>(c)</td><td></td><td><table><tr><th>A</th><th>B</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>0</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>1</td></tr></table>
All combinations of A & B correct labelled

Q correct and labelled</td><td>

1

1</td><td>

Order unimportant

Only award if all combinations of A & B are present</td></tr>
<tr><td>6</td><td>(d)</td><td></td><td>The safety guard must be down/1, and the switch must be on/1
OR
Both inputs/inputs A and B must be 1</td><td>1</td><td>wtte</td></tr>
</table>

Question			Answer	Marks	Guidance
6	(e)				

C	D	E	F	G	H	M
0	0	0	*1*	*0*	*1*	*0*
0	0	1	*1*	*0*	*1*	*1*
0	1	0	*0*	*0*	*0*	*0*
0	1	1	*0*	*0*	*0*	*0*
1	0	0	*0*	*0*	*0*	*0*
1	0	1	*0*	*0*	*0*	*0*
1	1	0	*0*	*1*	*1*	*0*
1	1	1	*0*	*1*	*1*	*1*

	F correct	1
	G correct	1
	H correct (ecf from F&G)	1
	M correct (ecf from H)	1

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