

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 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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Oxford Cambridge and RSA

Wednesday 21 May 2025 - Morning

LEVEL 3 CAMBRIDGE TECHNICAL IN ENGINEERING

Unit 4: Principles of electrical and electronic engineering

05822/05823/05824/05825/05873

MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 60

Post-standardisation

Version: **5.1** Last updated: **13/01/2025**

(FOR OFFICE USE ONLY)

This document consists of 16 pages

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. For answers marked by levels of response: Not applicable in F501

To determine the level – start at the highest level and work down until you reach the level that matches the answer

To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. 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

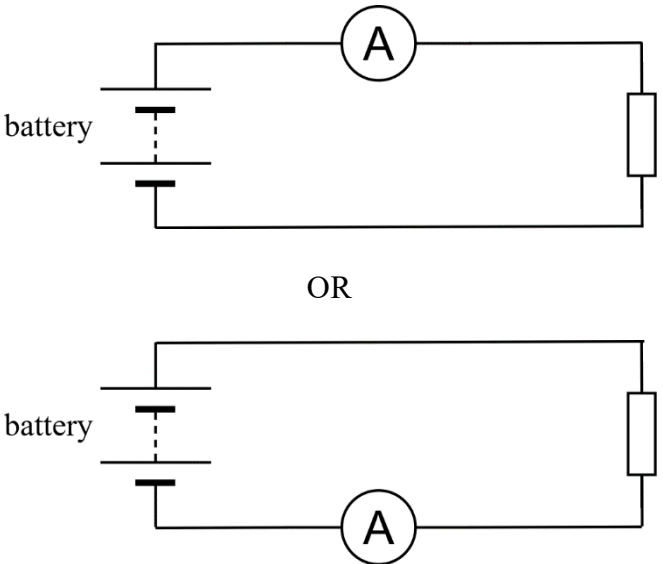
Mark scheme abbreviations:

Wtte: words to that effect

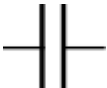
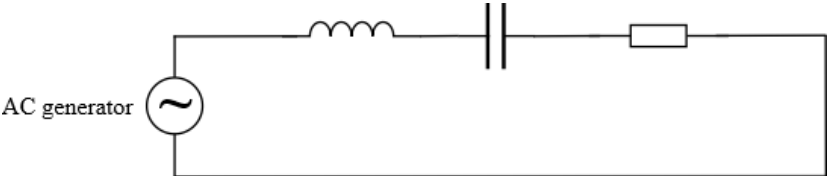
Ecf: error carried forward

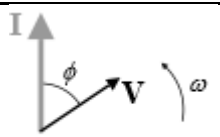
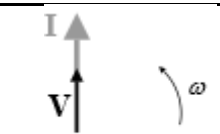
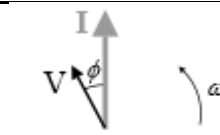
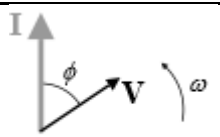
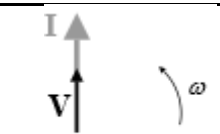
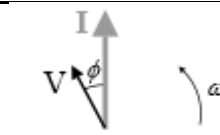
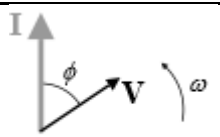
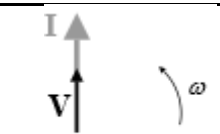
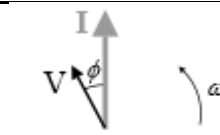
12. Subject-specific marking instructions

- 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.

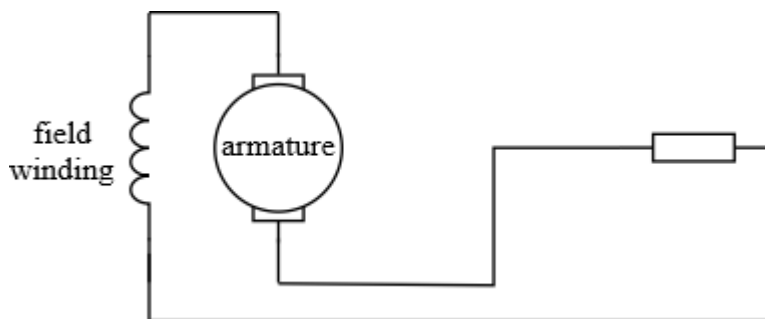
Question			Answer	Marks	Guidance
1	(a)		Battery provides current to resistor Correct ammeter symbol in series with resistor and battery  OR	1 1	
1	(b)	(i)	current = 34 mA = 0.034 A voltage across resistor = $I R = 0.034 \text{ A} \times 220 \Omega = 7.48 = \mathbf{7.5 \text{ V}}$	1 1	Evidence of converting mA to A or otherwise dealing correctly with mA Synoptic mark from unit 2: LO 1.1 Correct answer. Allow ecf from current conversion
1	(b)	(ii)	$P = I V = 0.034 \text{ A} \times 7.48 \text{ V} = \mathbf{0.25 \text{ W}}$ / $0.034 \text{ A} \times 7.5 \text{ V} = \mathbf{0.26}$ OR $P = I^2 R = (0.034 \text{ A})^2 \times 220 \Omega = \mathbf{0.25 \text{ W}}$	1	Allow any correct method Do not penalise error in converting from mA if already penalised in 1(b)(i) Ecf from voltage in 1bi

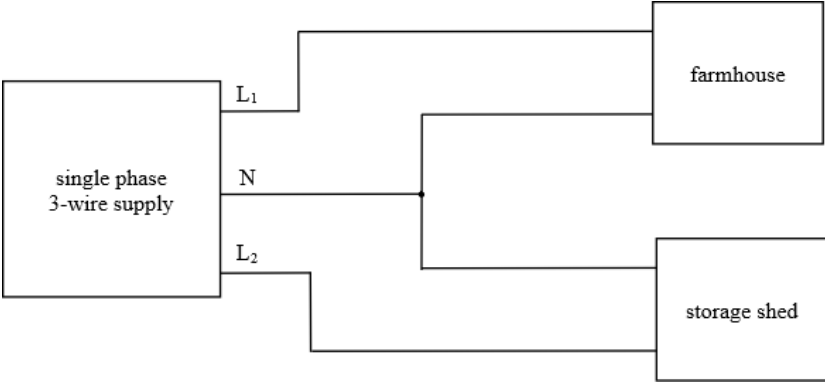
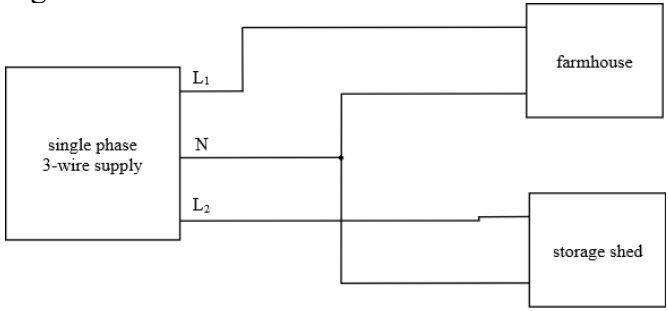
Question			Answer	Marks	Guidance																												
1	(c)	(i)	1 mark for each correct answer	3	current, $I = \frac{P}{V} = \frac{0.42 \text{ W}}{5.4 \text{ V}} = 0.078 \text{ A} = 78 \text{ mA}$ Or any other valid method e.g. $I = \frac{V}{R} = \frac{5.4 \text{ V}}{68 \text{ } \Omega} = 0.079 \text{ A} = 79 \text{ mA}$ voltage, $V = IR = 0.062 \text{ A} \times 100 \text{ } \Omega = 6.2 \text{ V}$ Or any other valid method e.g. $V = \sqrt{P \times R} = \sqrt{0.38 \text{ W} \times 100 \text{ } \Omega} = 6.2 \text{ V}$ power, $P = IV = 0.046 \text{ A} \times 6.9 \text{ V} = 0.32 \text{ W}$ Or any other valid method e.g. $P = \frac{V^2}{R} = \frac{(6.9 \text{ V})^2}{150 \text{ } \Omega} = 0.32 \text{ W}$																												
			<table><tr><th>resistor value / Ω</th><th>current / mA</th><th>voltage across resistor / V</th><th>power dissipated in resistor / W</th></tr><tr><td>22</td><td>132</td><td>2.9</td><td>0.39</td></tr><tr><td>33</td><td>114</td><td>3.8</td><td>0.43</td></tr><tr><td>47</td><td>97</td><td>4.5</td><td>0.44</td></tr><tr><td>68</td><td>78 or 79</td><td>5.4</td><td>0.42</td></tr><tr><td>100</td><td>62</td><td>6.1 or 6.2</td><td>0.38</td></tr><tr><td>150</td><td>46</td><td>6.9</td><td>0.32</td></tr></table>			resistor value / Ω	current / mA	voltage across resistor / V	power dissipated in resistor / W	22	132	2.9	0.39	33	114	3.8	0.43	47	97	4.5	0.44	68	78 or 79	5.4	0.42	100	62	6.1 or 6.2	0.38	150	46	6.9	0.32
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			150			46	6.9	0.32																									
1	(c)	(ii)	The <u>maximum power</u> occurs at a resistance of 47 Ω /that resistance	1	Statement about largest value of power shown in table Allow follow through																												
			Internal resistance equals load resistance (at maximum power)	1	Any clear statement of the maximum power theorem Accept a correct calculation of internal resistance using values from the table and comparing answer to 47 Ω given																												

2	(a)	Correct symbol for an inductor  Correct symbol for a capacitor  Correct symbol for a resistor  All components in series with AC supply 	1 1 1 1	Accept alternative inductor symbol Accept US resistor symbol  Order of components unimportant
2	(b)	Converts μH to H $220 \mu\text{H} = 220 \div 1000000 = 0.00022$ Calculates X_L $X_L = 2 \pi f L = 2 \times \pi \times 350 \times 0.00022 = \mathbf{0.48 \Omega}$	1 1	

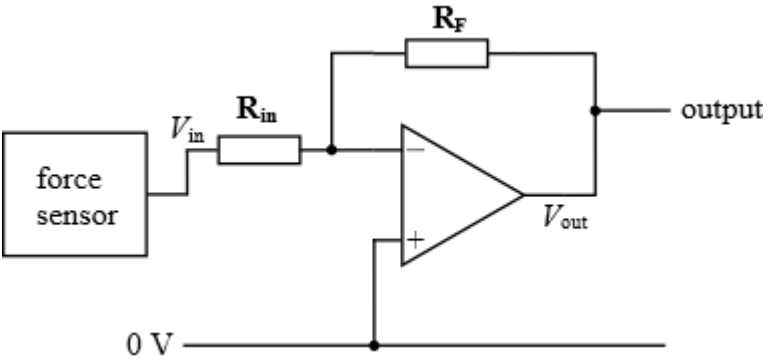
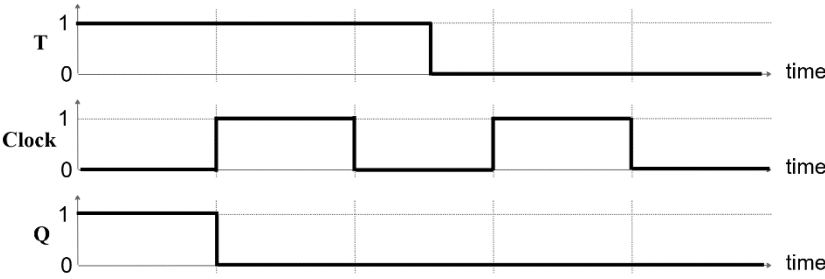
2	(c)	<table><tr><th>f/Hz</th><th>X_L/Ω</th><th>X_C/Ω</th><th>Z/Ω</th><th>ϕ</th><th>phasor diagram</th></tr><tr><td>100</td><td>0.14</td><td>5.0</td><td>5.9</td><td>56°</td><td></td></tr><tr><td>600</td><td>0.83</td><td>0.83</td><td>3.3</td><td>0°</td><td></td></tr><tr><td>1450</td><td>2.0</td><td>0.34</td><td>3.7</td><td>27°</td><td></td></tr></table> 1 mark each correct answer	f/Hz	X_L/Ω	X_C/Ω	Z/Ω	ϕ	phasor diagram	100	0.14	5.0	5.9	56°		600	0.83	0.83	3.3	0°		1450	2.0	0.34	3.7	27°		4	$\phi = \cos^{-1}\left(\frac{R}{Z}\right) = \cos^{-1}\left(\frac{3.3\Omega}{5.9\Omega}\right) = 56^\circ$ Ignore any minus sign OR any other valid method e.g. $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = -56^\circ$ N.B. $\phi = 0.98$ rad if calculation in radians Synoptic mark from unit 1: LO 4.5 $Z = R = 3.3\Omega$ OR $Z = \sqrt{R^2 + (X_L - X_C)^2}$ $= \sqrt{(3.3\Omega)^2 + (0.83\Omega - 0.83\Omega)^2} = 3.3\Omega$ OR any other valid method $X_C = \frac{1}{2\pi f C}$ $= \frac{1}{2\pi \times 1450\text{ Hz} \times 3.2 \times 10^{-4}\text{ F}}$ $= 0.34\Omega$ OR $X_C = X_L - \sqrt{Z^2 - R^2}$ $= 2.0\Omega - \sqrt{(3.7\Omega)^2 - (3.3\Omega)^2}$ $= 0.33\Omega$ (difference due to rounding) OR any other valid method $\phi = \cos^{-1}\left(\frac{R}{Z}\right) = \cos^{-1}\left(\frac{3.3\Omega}{3.7\Omega}\right) = 27^\circ$ Ignore any minus sign N.B. $\phi = 0.47$ rad if calculation in radians
f/Hz	X_L/Ω	X_C/Ω	Z/Ω	ϕ	phasor diagram																							
100	0.14	5.0	5.9	56°																								
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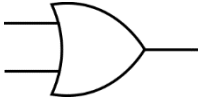
3	(a)	$R_t = R_a + R_f = 6.0 \, \Omega + 0.5 \, \Omega = 6.5 \, \Omega$ $I_a = \frac{E - V}{R_t}$ $I_a = \frac{24 \, \text{V} - 19 \, \text{V}}{6.5 \, \Omega} = \mathbf{0.77 \, A}$	1 1 1	Evidence of finding total resistance of motor Evidence of correctly rearranging formula Synoptic mark from unit 1: LO 1.4 Correct calculation ecf from total resistance Award 3 marks for correct answer of 0.77A
3	(b)	Maximum of two from the following points: - When there is no load on a series-wound DC motor the speed gets faster and faster/goes fast - Motor damaged by high speed - High starting torque - As the speed increases the EMF in the armature increases/reducing pd across the field coil/reducing field current/reducing magnetic field/increasing speed.	2	Motor speed increases uncontrollably (speed runaway) Motor burnt out Some explanation for why speed runaway occurs
3	(c)	(i) Motors convert electrical energy into mechanical energy. Generators convert mechanical energy into electrical energy.	1 1	Allow kinetic/movement for mechanical Do not allow electricity for electrical energy

3	(c)	(ii)	All three parts in series  The diagram shows a rectangular circuit loop. On the left vertical wire is a coil labeled 'field winding'. At the top of the loop is a circle labeled 'armature'. On the right vertical wire is a rectangular resistor. The circuit is closed at the bottom.	1	Arrangement unimportant provided all components in series
3	(c)	(iii)	One mark for each correct word Connecting the resistor to the generator causes a large current to flow through the field winding, which increases the EMF generated in the armature and the voltage from the generator causing heating of the resistor. This increases the torque required to turn the generator and decreases the speed of the scooter.	2	

4	(a)	 L1 and L2 to different buildings N to both buildings	1	Connection order unimportant e.g.  unimportant which building connects to which live unimportant whether N connects to top or bottom connection
4	(b)	Accept any of: • 180° • π (radians)	1	
4	(c)	When too much current flows/fault/short-circuit (wtte) the circuit is disconnected from the supply/current stops flowing/there is a gap in the circuit (wtte)	1	Allow power Do not allow electricity or voltage
4	(d)	 1 mark for each correctly placed label	5	Accept the circuit breaker trips The circuit breaker breaks the circuit is neutral

5	(a)	$V_{in} = 160 \text{ mV} = 0.16 \text{ V}$ $V_{out} = \text{Voltage Gain} \times V_{in} = -20 \times 0.16 \text{ V} = -3.2 \text{ V}$	1 1 1	Evidence of converting mV to V Synoptic mark from unit 2: LO 1.1 Answer correct magnitude Negative sign in answer Ecf from mV conversion
5	(b)	$R_F = 100 \text{ k}\Omega = 100000 \text{ }\Omega$ $R_{in} = \frac{-R_F}{\text{Voltage Gain}} = \frac{-100000 \text{ }\Omega}{-20} = 5000 \text{ }\Omega$	1 1	Evidence of converting k Ω to Ω Synoptic mark from unit 2: LO 1.1 Allow ecf if candidate relies on value from 5(a) in calculation Do not allow negative values for resistance

5	(c)	Non-inverting input (+) connected to 0 V only V_{out} connected to output Resistor from force sensor to inverting input (-) only Resistor from inverting input (-) to V_{out} R_{in} and R_F correctly labelled 	1 1 1 1 1	Do not allow a connection to 0V Can only be given if mark points 3 and 4 awarded V_{in} and V_{out} labels not required
6	(a)	Q changes from high to low at the first rising edge of Clock Q does not change after the first rising edge of Clock 	1 1	

6	(b)	(i)	Correct symbol 	1																
6	(b)	(ii)	<table border="1"><thead><tr><th>A</th><th>B</th><th>Q</th></tr></thead><tbody><tr><td>0</td><td>0</td><td>0</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>1</td></tr></tbody></table> All combinations of A and B Q correct	A	B	Q	0	0	0	1	0	1	0	1	1	1	1	1	1 1	Order unimportant Must have all combinations of A & B for Q mark
A	B	Q																		
0	0	0																		
1	0	1																		
0	1	1																		
1	1	1																		
6	(b)	(iii)	Q = A + B	1																

6	(c)		<table><tr><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>J</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr></table>	C	D	E	F	G	H	J	0	0	0	1	1	0	1	0	0	1	0	1	0	1	0	1	0	1	1	1	0	0	1	1	0	1	0	1	1	0	0	1	1	0	1	1	0	1	0	1	0	1	1	1	0	1	0	1	1	1	1	1	0	0	0	0		
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		1	1	1	0	0	0	0																																																												
	One mark for each correct column F, G, H, J	4	Allow ecf for H & J																																																																	

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