

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 2017

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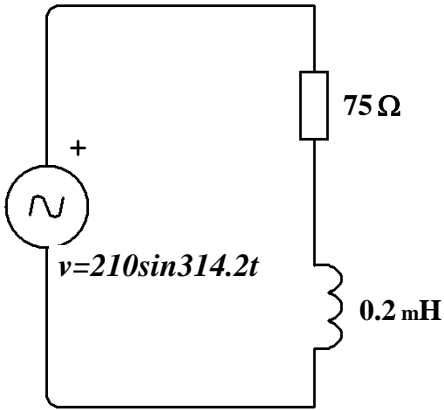
All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

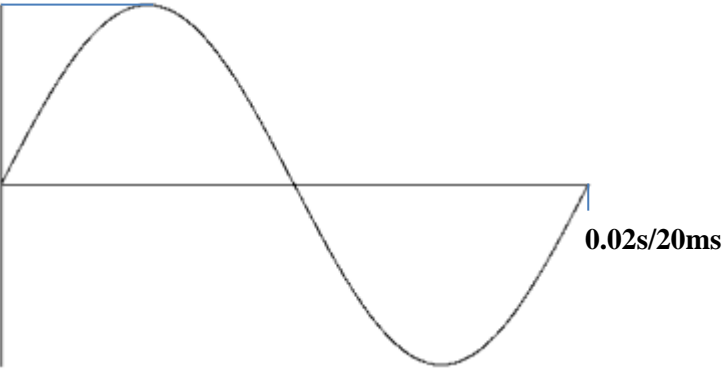
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

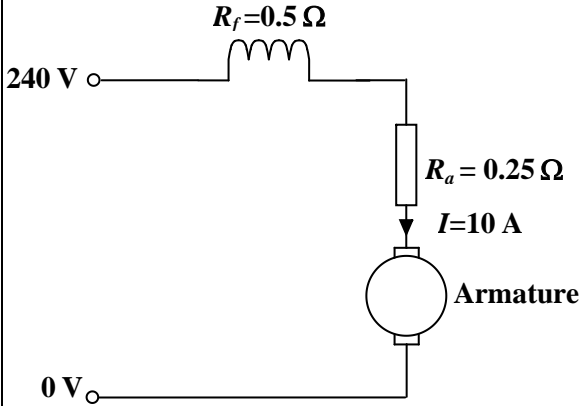
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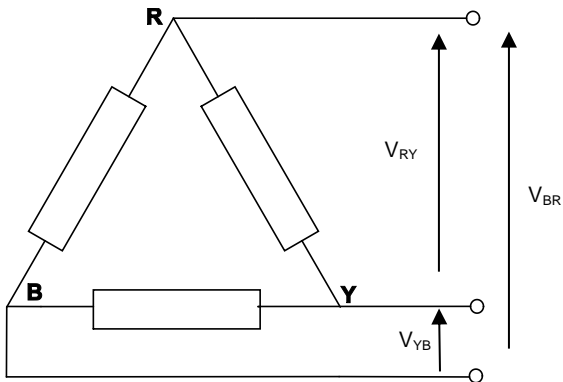
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Question			Answer	Marks	Guidance
1	(a)	(i)	$I = 24/150$ $= 0.16 \text{ (A)}$	1 1	(For applying knowledge from Unit 2, LO3)
		(ii)	$R = 150 + 25 = 175 \text{ } (\Omega)$ $I = 24/175 = 0.137 \text{ (A) or } 0.14 \text{ (A)}$	1 1	(For applying knowledge from Unit 2, LO3)
		(iii)	$P = I^2R = 0.137^2 \times 25$ $P = 0.469 \text{ or } 0.47 \text{ or } 0.49 \text{ (W)}$	1 1	(For applying knowledge from Unit 2, LO3)
	(b)	(i)	Connect one probe to V/ Ω mA and one probe to COM. Probe ends: one to point X, one to point Y (polarity not important).	1 1	Ignore reference to red/black or positive/negative.
		(ii)	Use $R_{total} = R_1 + R_2$ and $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$ $R = 1 \text{ k}\Omega + 1.5 \text{ k}\Omega = 2.5 \text{ k}\Omega$ $1/R = 1/2.5 \text{ k}\Omega + 1/3.3 \text{ k}\Omega$ $= 1422 \text{ } (\Omega) \text{ or } 1.422 \text{ k}(\Omega)$	1 1 1	(For applying knowledge from Unit 2, LO3) Max 2 marks for incorrect parallel resistor combinations, such as $R = 1 \text{ k}\Omega + 3.3 \text{ k}\Omega = 4.3 \text{ k}\Omega$ $1/R = 1/1.5 \text{ k}\Omega + 1/4.3 \text{ k}\Omega$ $= 1112 \text{ } (\Omega) \text{ or } 1.112 \text{ k}(\Omega)$
		(iii)	Answer must be consistent with answer to (ii), e.g. if answer to (ii) is $1422 \text{ } (\Omega)$ or $1.422 \text{ k}(\Omega)$ then $\Omega / 2000$	1	

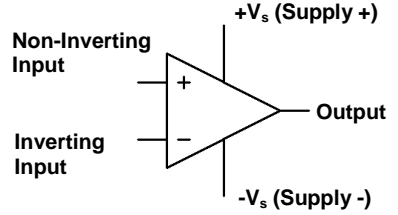
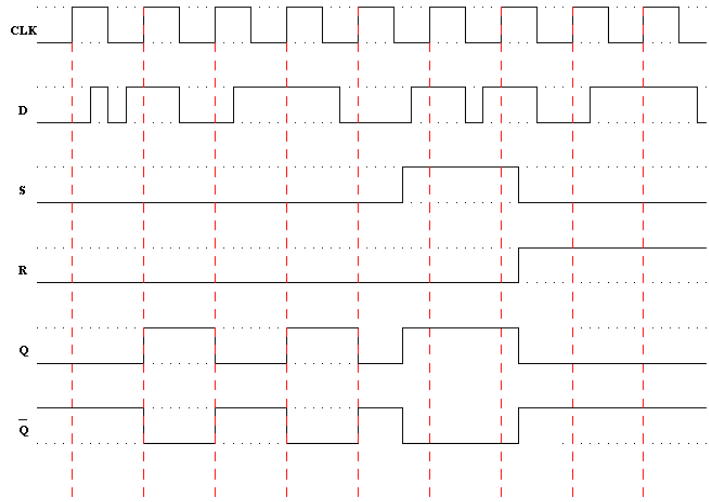
Question		Answer	Marks	Guidance
2	(a)	 <p>The diagram shows a rectangular circuit loop. On the left vertical branch, there is an AC voltage source represented by a circle with a tilde symbol (~) inside and a plus sign (+) above it. Below the source is the equation $v = 210 \sin 314.2t$. On the top horizontal branch, there is a resistor represented by a rectangle, with the value 75Ω to its right. On the right vertical branch, there is an inductor represented by a vertical coil, with the value 0.2 mH to its right. The bottom horizontal branch is a simple wire connecting the bottom terminals of the source, resistor, and inductor.</p>	3	<p>Award 1 mark for each correct symbol with value connected in series.</p> <p>Allow 2 marks if inductor symbol with both inductance and resistance indicated.</p> <p>Allow 210V 50 Hz ac supply.</p>

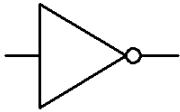
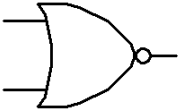
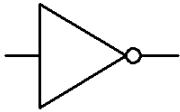
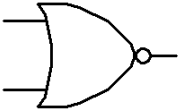
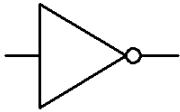
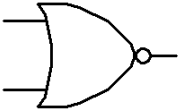
Question	Answer	Marks	Guidance
(b)	 <p data-bbox="353 670 638 774"> $2\pi f = 314.2$ $f = 314.2/2\pi = 50 \text{ Hz}$ $t = 1/f = 1/50 = 0.02 \text{ s}$ </p>	<p data-bbox="1272 231 1294 255">1</p> <p data-bbox="1272 300 1294 323">1</p> <p data-bbox="1272 707 1294 730">1</p> <p data-bbox="1272 738 1294 762">1</p>	<p data-bbox="1370 231 1926 295">Award 1 mark for sine wave as shown (For applying knowledge from Unit 1, LO4)</p> <p data-bbox="1370 331 2027 395">Award 1 mark for correct value of peak voltage on sketch.</p> <p data-bbox="1370 707 1960 738">Award 1 mark for calculation of periodic time.</p> <p data-bbox="1370 738 2027 802">Award 1 mark for correct value of periodic time on sketch.</p>

Question	Answer	Marks	Guidance
(c)	$2\pi f = 314.2$ $X_L = 2\pi fL = 0.2 \times 10^{-3} \times 314.2 = 0.06284(\Omega)$ $Z = \sqrt{R^2 + X_L^2}$ $Z = \sqrt{75^2 + 0.06284^2}$ $Z = 75(\Omega)$ $I = V/Z = 210(V)/75(\Omega)$ $I = 2.8 \text{ A}$	<p>1</p> <p>1</p> <p>1</p>	<p>Allow ECF. There must be evidence of calculation of impedance.</p> <p>Allow ECF. (For applying knowledge from Unit 2, LO3)</p>
(d)	$V_L = IX_L = 2.8 \times 0.06284$ $= 0.176 \text{ V}$	<p>1</p> <p>1</p>	<p>Allow ECF for current from part (c)</p>
3 (a)	 <p>The diagram shows a series circuit. On the left, there is a 240 V AC source. The circuit continues through a field coil labeled $R_f = 0.5 \Omega$. This is followed by an armature resistor labeled $R_a = 0.25 \Omega$. Below the resistor, a downward-pointing arrow indicates a current $I = 10 \text{ A}$. The circuit then passes through an armature, represented by a circle with a vertical line through its center, labeled "Armature". Finally, the circuit connects to a 0 V terminal at the bottom left.</p>	<p>3</p> <p>1</p> <p>1</p>	<p>1 mark for each of armature, armature resistance and field resistance connected in series.</p> <p>1 mark for values of voltage and current (with arrow).</p> <p>1 mark for resistor values correctly labelled.</p> <p>Allow marks if:</p> <ul style="list-style-type: none"> both resistor and inductor symbol used to represent field coil and/or armature symbol includes armature resistance.

Question	Answer	Marks	Guidance
(b)	$V = E + I(R_f + R_a)$ $V = E + 10(0.5 + 0.25)$ $E = 240 - 7.5 = 232.5 \text{ V}$	<p>1</p> <p>1</p> <p>1</p>	<p>Award 1 mark for identification of correct formula.</p> <p>For substitution and rearrangement</p> <p>Award 1 mark for correct numerical result with unit.</p> <p>Allow use of $E = V + IR_t$ <u>this series only</u> (as quoted incorrectly in version 2 of the formula booklet):</p> <p>$E = V + IR_t$ 1 mark id of formula</p> <p>$E = 240 + 10(0.5 + 0.25)$ 1 mark for substitution</p> <p>$E = 240 + 7.5 = 247.5 \text{ V}$ 1 mark with correct unit</p>
(c)	<p>Any suitable application e.g. trains, delivery vehicles, cranes and hoist.</p> <p>Series wound motors have high torque at start up therefore good for motors which are used for traction/require high initial torque.</p>	<p>1</p> <p>1</p>	<p>Accept any reasonable alternative examples</p>
4 (a)		<p>1</p> <p>1</p> <p>1</p>	<p>Resistors or AC power sources drawn in delta arrangement.</p> <p>Three wires drawn.</p> <p>Line voltages correctly labelled V_{BR}, V_{RY}, V_{YB}.</p>

Question		Answer	Marks	Guidance
	(b)	<p>Accept any one from:</p> <ul style="list-style-type: none"> • colour sequence; current UK colour sequence brown, black and grey. • 3-phase 4 wire star connected system. • 120° degrees phase shift (between incoming phases) or 0°, 120°, 240°. 	1	Allow benefit of doubt if red, yellow, blue seen
	(c)	<p>For a given amount of power transmission, three-phase networks require conductors with a smaller cross-sectional area, therefore cheaper as fewer resources needed.</p> <p>Two voltages are available on a three phase network.</p>	1 1	Also accept other suitable advantages

Question		Answer	Marks	Guidance
5	(a)		3	1 mark for every 2 correct points. i.e. correct labels and correctly drawn symbol. Allow $-V_s = 0$. Maximum 3 marks.
	(b) (i)	Gain = $-120\text{ k}\Omega / 10\text{ k}\Omega = -12$	1	Correct numerical value and sign, no units.
	(ii)	Gain = V_{out}/V_{in} $V_{out} = V_{in} \times \text{Gain}$ $V_{out} = 0.2 \times -12 = -2.4\text{ V}$	1 1	Award 1 mark for correct numerical result With correct unit, and sign. Allow ecf Gain from b(i)
	(iii)	Gain = V_{out}/V_{in} $V_{out} = V_{in} \times \text{Gain}$, $V_{out} = -1.5 \times -12$ $V_{out} = +18\text{ V}$	1 1	Award 1 mark for correct numerical result With correct unit, and sign. Allow ecf Gain from b(i)
6	(a)		4 1	Award 1 mark if Q correct for 2 rising edges. Maximum 4 marks. Allow ECF Award 1 mark if \bar{Q} inverse of Q.

Question	Answer	Marks	Guidance																																																															
(b)	<table border="1" data-bbox="483 236 1072 619"> <thead> <tr> <th data-bbox="483 236 772 272">Circuit Symbol</th> <th data-bbox="772 236 1072 272">Logic Gate Name</th> </tr> </thead> <tbody> <tr> <td data-bbox="483 272 772 448">  </td> <td data-bbox="772 272 1072 448">NOT</td> </tr> <tr> <td data-bbox="483 448 772 619">  </td> <td data-bbox="772 448 1072 619">NOR</td> </tr> </tbody> </table>	Circuit Symbol	Logic Gate Name		NOT		NOR	2	Award 1 mark/ correct logic gate name.																																																									
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(c)	<table border="1" data-bbox="432 683 1093 1002"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>A.B</th> <th>A.C</th> <th>A.B + A.C</th> <th>Q</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</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>1</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr> </tbody> </table>	A	B	C	A.B	A.C	A.B + A.C	Q	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	1	1	0	0	0	1	1	0	0	0	0	0	1	1	0	1	0	1	1	0	1	1	0	1	0	1	0	1	1	1	1	1	1	0	1 4	Award 1 mark for correct input combination (columns A, B and C correct) in order of binary count. Award 1 mark for every 2 correct rows, maximum 4 marks. Max 2 marks if $Q=A.B + A.C$ i.e. not inverted. Columns A, B, C and Q only ones required.
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