

**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 2019**

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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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**Annotations**

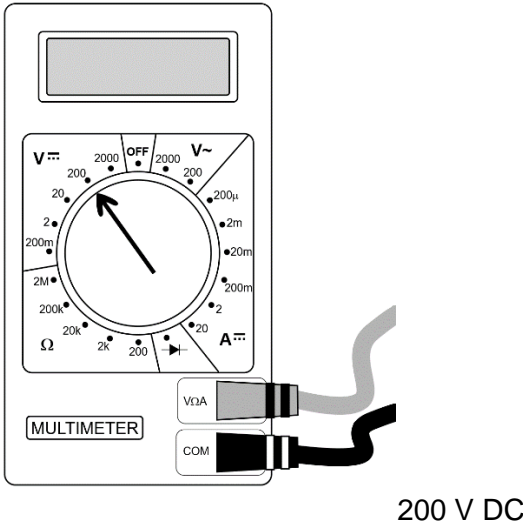
<b>Annotation</b>	<b>Meaning</b>
<b>tick</b>	<b>Correct response</b>
<b>cross</b>	<b>Incorrect response</b>
<b>Omission mark (carat)</b>	<b>Incomplete response</b>
<b>ECF</b>	<b>Error carried forward</b>
<b>BOD</b>	<b>Benefit of doubt</b>
<b>NBOD</b>	<b>No benefit of doubt</b>
<b>Wtte</b>	<b>Words to that effect</b>

**Subject-specific marking instructions**


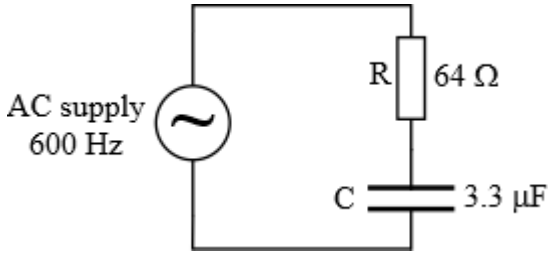
In all numerical calculation questions a correct response will gain all marks unless specified otherwise.

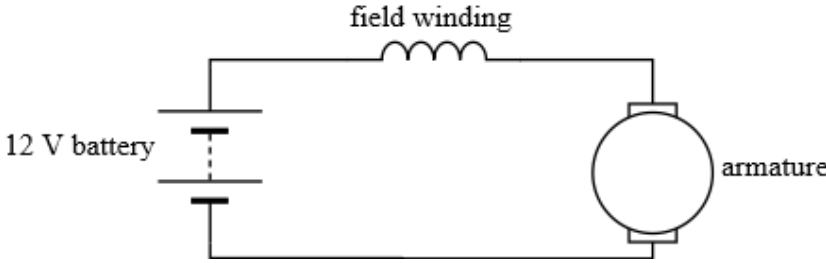
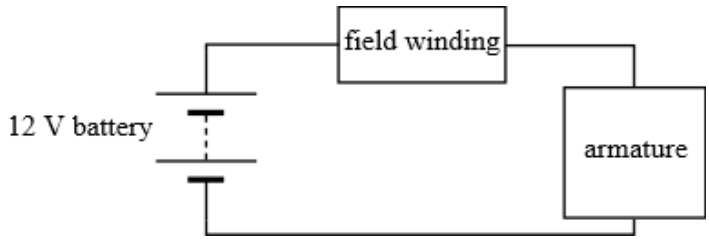
Rounding of answers should be to the same number of significant figures as the data in the question, or, otherwise, an answer will be correct provided it rounds to the correct answer.








Symbols used in circuit diagrams must identify relevant components uniquely and unambiguously.

Question			Answer	Marks	Guidance
1	(a)	(i)	$20\ \Omega + 40\ \Omega = 60\ \Omega$	1	Unit given in question
1	(a)	(ii)	$I = \frac{V}{R} = \frac{9}{60} = 0.15\ \text{A}$ Correct numerical answer (0.15) Correct units A	1 1	<i>For applying knowledge from Unit 2 LO3</i>  Accept A, mA or $\mu\text{A}$ etc. 150 mA for [2]
1	(a)	(iii)	$V = IR = 0.15 \times 40 = 6\ \text{V}$ ecf from (ii)	1	Unit given in question
1	(a)	(iv)	$P = IV = 0.15 \times 6 = 0.9\ \text{W}$ ecf from (ii) and (iii)	1	Unit given in question
1	(b)	(i)	 <p>200 V DC</p>	1	
1	(b)	(ii)	maximum number of decimal places (1) e.g.: Setting on 200 provides <u>maximum number of decimal places</u> (wtte) for accuracy of measurement without going over range.	1	Mark for understanding 'maximum number of decimal places'

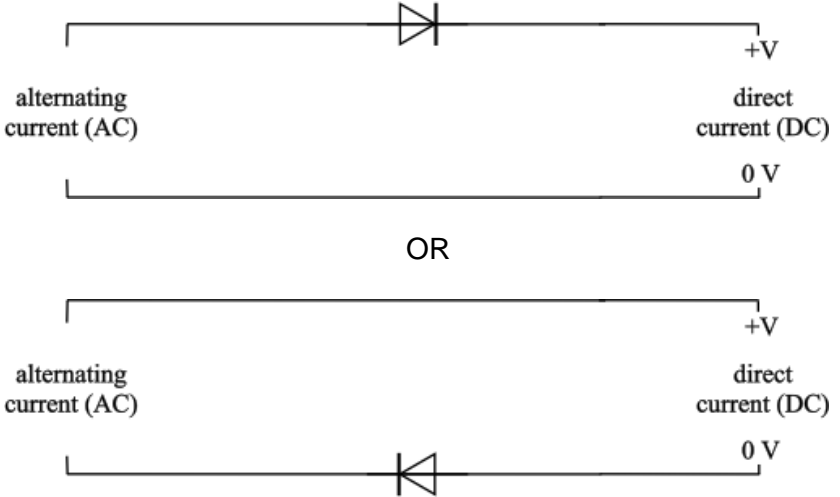
Question			Answer	Marks	Guidance
1	(c)	(i)	$6 - 1.8 = 4.2 \text{ V}$	1	
1	(c)	(ii)	0.8 mA	1	
1	(c)	(iii)	$0.8 - 0.6 = 0.2 \text{ mA}$	1	
1	(c)	(iv)	$R_1 = \frac{V_1}{I_1} = \frac{1.8}{0.0008} = 2250 \Omega$	1	2.25 k $\Omega$ Accept answer to 2sf: 2300 $\Omega$ Accept e.c.f. from 1(c)(ii) for $I_1$
1	(c)	(v)	$R_t = \frac{V}{I_2} = \frac{4.2}{0.0002} = 21000 \Omega$  $R_t = R_2 + 18000$  $\therefore R_2 = 21000 - 18000 = 3000 \Omega$	1	Full marks for any method that gives 3000 $\Omega$ or 3 k $\Omega$ Accept e.c.f. from 1(c)(iii) for $I_2$ and/or for V from 1(c)(i)
2	(a)	(i)	6 V	1	
2	(a)	(ii)	2 ms	1	
2	(a)	(iii)	12 V	1	<b>Not <math>\pm 6 \text{ V}</math></b>
2	(a)	(iv)	$T = 2 \text{ ms} = 2 \times 10^{-3} \text{ s}$  $f = \frac{1}{T} = \frac{1}{2 \times 10^{-3}} = 500 \text{ Hz}$	1  1  1	<i>For applying knowledge from Unit 2 LO3</i> Conversion of ms to s or use of kHz in answer  Use of $f=1/T$ to get answer ecf from conversion and 1(a)(ii)  Correct units in answer (Hz or kHz)

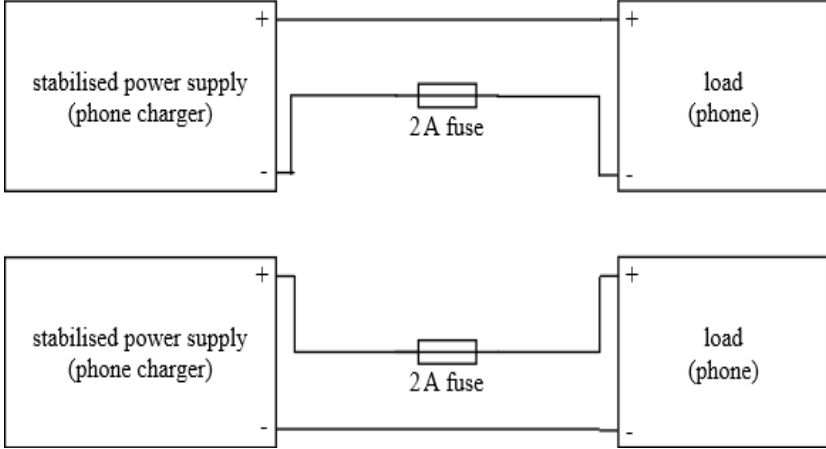
Question			Answer	Marks	Guidance
2	(b)	(i)	Correct symbols used for R and C. Series circuit of three elements with correct values	1 1	Accept US resistor symbol  Accept any symbols for this mark  
2	(b)	(ii)	$f = 600\text{Hz}$ $C = 3.3\mu\text{F} = 3.3 \times 10^{-6}\text{F}$ $X_C = \frac{1}{2\pi \times 600 \times 3.3 \times 10^{-6}} = 80\Omega$	1 1 1	<i>For applying knowledge from Unit 2 LO3</i> Conversion to F Successful calculation using correct values ecf from conversion to F Correct units
2	(b)	(iii)	$Z = \sqrt{R^2 + X_C^2} = \sqrt{64^2 + 80^2} = 102\Omega$ ecf from 2bii	1	Ignore units Accept answer to 2sf: 100Ω Accept answers 102.7 Ω or 103 Ω from using the precise answer to 2(b)ii of 80.38 Ω.

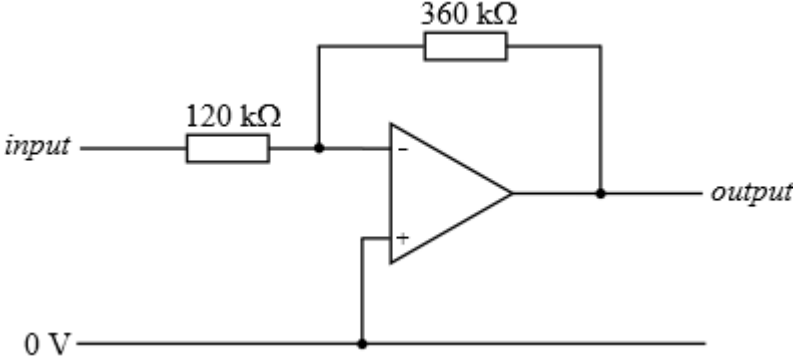
Question		Answer	Marks	Guidance
3	(a)	A series wound DC motor is used to start a car engine. When a voltage is first applied to the motor it is not turning and so the EMF generated by the motor is <b>zero</b> and the torque provided by the motor is <b>high</b> . After a short time the motor has reached high speed and so the EMF generated by the motor is <b>high</b> and the torque provided by the motor is <b>low</b> .	1 1 1 1	1 mark for each correct word:  zero high high low
3	(b)		1	Accept any labelled symbols for field winding and armature in series with the battery. 
3	(c) (i)	$R_t = 0.20 \Omega$	1	
3	(c) (ii)	Selection of correct formula $V = E + I_a R_t$ seen or implied $E = V - I_a R_t = 12 - (20 \times 0.2) = 8(V)$ Mark for correct units = V	1 1 1	Allow ecf for $R_t$ from 3(c)(i) Award mark for 8 regardless of units <i>For applying knowledge from Unit 2 LO3</i>

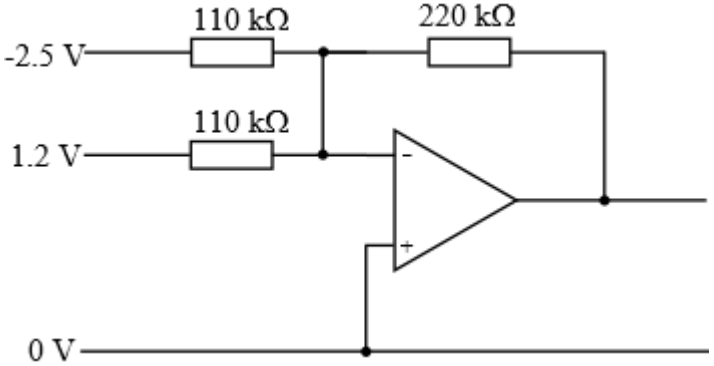
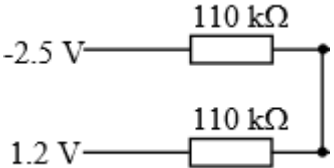
Question	Answer	Marks	Guidance
<p>4 (a)</p>	<p>1 mark for each correct link</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p><b>Block</b></p> <div style="border: 1px solid black; padding: 2px; width: 80px; margin: 5px;">rectifier</div> <div style="border: 1px solid black; padding: 2px; width: 80px; margin: 5px;">smoothing circuit</div> <div style="border: 1px solid black; padding: 2px; width: 80px; margin: 5px;">stabilising circuit (load regulator)</div> <div style="border: 1px solid black; padding: 2px; width: 80px; margin: 5px;">transformer</div> </div> <div style="text-align: center;"> <p><b>Function</b></p> <div style="border: 1px solid black; padding: 2px; width: 180px; margin: 5px;">produces a constant 5 V regardless of whether it is providing a large current for a flat phone battery or a small current to a fully charged phone</div> <div style="border: 1px solid black; padding: 2px; width: 180px; margin: 5px;">reduces the 230 V AC to a much lower AC voltage</div> <div style="border: 1px solid black; padding: 2px; width: 180px; margin: 5px;">converts alternating current to direct current</div> <div style="border: 1px solid black; padding: 2px; width: 180px; margin: 5px;">converts a sine wave to a square wave</div> <div style="border: 1px solid black; padding: 2px; width: 180px; margin: 5px;">keeps the DC voltage above a certain value by storing charge on a capacitor to provide electricity to the output when the supply voltage is low</div> <div style="border: 1px solid black; padding: 2px; width: 180px; margin: 5px;">converts electrical energy into mechanical energy</div> </div> </div>	<p>2</p>	<p>No marks for any block with links to more than one function.</p>
<p>4 (b)</p>	<p>Correct diode symbol  used anywhere in diagram</p> <p>Diode achieves rectification</p> <p>Rectifier produces correct polarity half-wave rectified dc with one diode</p>	<p>1</p> <p>1</p> <p>1</p>	<p>Accept alternative diode symbol</p> <div style="display: flex; justify-content: space-around; align-items: center;">    </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;">    </div> <p>Award this mark even if polarity of output is incorrect</p> <p>Must obtain rectification mark for this mark</p> <p>For a correct full-wave rectifier circuit that produces the</p>



Question	Answer	Marks	Guidance
	<p>Correct answers for 3 marks:</p>  <p>OR</p>		<p>required polarity award 2 marks.</p> <p>Accept other correct alternative solutions. Ignore load resistor <u>across</u> output or transformer across input</p>
<p>4 (c)</p>	<p>Direct current: only flows in one direction (owtte)</p> <p>Alternating current: changes direction periodically/moves one way then the other/keeps changing 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>

Question			Answer	Marks	Guidance
4	(d)	(i)	<p>Either of the below</p>  <p>The top diagram shows a box labeled 'stabilised power supply (phone charger)' with a '+' terminal at the top and a '-' terminal at the bottom. A wire connects the '+' terminal to the '+' terminal of a second box labeled 'load (phone)'. A wire connects the '-' terminal to the '-' terminal of the 'load (phone)'. A small rectangular component labeled '2 A fuse' is connected in series between the two positive terminals.</p> <p>The bottom diagram shows a similar setup, but the '2 A fuse' is connected in series between the two negative terminals.</p>	1	
4	(d)	(ii)	<p>When too much <u>current</u> flows</p> <p>the thin fuse wire melts</p> <p><u>disconnecting</u> the supply from the load so preventing and damage to the supply or the load.</p>	<p>1</p> <p>1</p> <p>1</p>	<p>Must mention current for this mark. Look for comment about a large current (2 A <u>or more</u>)</p> <p>Look for comment about fuse failing/blowing under adverse conditions</p> <p>Look for comment about disconnecting or preventing further flow of current</p>

Question			Answer	Marks	Guidance
5	(a)	(i)	inverting amplifier	1	
5	(a)	(ii)		1	<p>Must have both correctly labelled for one mark</p> <p>Allow labelling of output anywhere on output line</p> <p>Accept <math>V_{in}</math> and <math>V_{out}</math></p>
5	(a)	(iii)	$\text{Voltage Gain} = -\frac{R_f}{R_{in}} = -\frac{360000}{120000} = -3$ <p>magnitude sign</p>	<p>1</p> <p>1</p>	<p>Ignore any units</p> <p>1 mark for +3</p> <p>1 mark for a negative number</p>
5	(a)	(iv)	$V_{out} = G \times V_{in} = -3 \times 1.5 = -4.5 \text{ V}$	1	Unit given in question ecf Voltage Gain from 5a(iii)

Question	Answer	Marks	Guidance
5 (b) (i)	 <p data-bbox="353 734 1198 805">Op-amp with feedback resistor of 220 kΩ from output to inverting input and non-inverting input to 0 V</p> <p data-bbox="353 837 1153 901">Two input resistors of 110 kΩ each with inputs labelled -2.5 V and 1.2 V</p>	1  1	<p data-bbox="1370 837 2072 901">Accept any two correctly labelled resistors joined to a common point</p> 
5 (b) (ii)	$V_{\text{out}} = -\frac{R_f}{R_{\text{in}}}(V_1 + V_2) = -\frac{220000}{110000} \times (-2.5 + 1.2) = 2.6 \text{ V}$	1	<p data-bbox="1370 1133 1579 1165">Correct answer</p> <p data-bbox="1370 1197 1657 1236">Unit given in question</p>
6 (a)	AND gate	1	

Question		Answer	Marks	Guidance																																				
6	(b)	<table border="1"> <thead> <tr> <th>A</th> <th>D</th> <th>E</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>all combinations of A and D (any order) E correct</p>	A	D	E	0	0	0	0	1	0	1	0	0	1	1	1	2																						
A	D	E																																						
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6	(c)	$E = A \cdot D$	1																																					
6	(d)	<table border="1"> <thead> <tr> <th>D</th> <th>E</th> <th>F</th> <th>G</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	D	E	F	G	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	1	1	1	0	1	0	0	1	1	0	0	0	0	1 1 1 1	1 mark for each correct column allow ecf from D to E allow ecf from D to F allow ecf from E and F to G
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 **Cambridge  
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