OCR
Oxford Cambridge and RSA

Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 4: Principles of electrical and electronic engineering

Date – Morning/Afternoon
Time allowed: 1 hour 30 minutes

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering
- a ruler (cm/mm)
- a scientific calculator

First Name						Last Name				
Centre Number						Candidate Number				
Date of Birth	D	D	M	M	Y	Y	Y	Y		

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working.
- Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **12** pages.

Answer **all** questions in the spaces provided.

1 (a) An electric heating element has a resistance of 60 ohms and is to operate on a 240 volt supply for two hours.

(i) Calculate the current taken by the heater.

Current = …… A **[2]**

(ii) Calculate the power used.

Power = …… W **[2]**

(iii) Calculate the energy used.

Energy used = …… Wh **[2]**

(b) A battery has six cells connected in series. Each call has an electromotive force (e.m.f.) of 1.2 volts and an internal resistance of 0.2 ohms.

Calculate the maximum power that this battery can transfer to an external load.

Maximum power = …… W **[4]**

2 The instantaneous value of an alternating current is given by i = 10 sin 314.2 t amperes.

(a) For the a.c. current:

(i) state the peak value

Peak value = …….. A **[1]**

(ii) calculate the frequency

Frequency = …….. Hz **[2]**

(iii) calculate the periodic time

Periodic time = …….. s **[2]**

(iv) calculate the current after 12 milliseconds.

Current = …….. A **[3]**

(b) Sketch a sine wave showing the position of the current calculated in part **(iv)**

[2]

3 (a) Explain the difference between a motor and a generator.

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.....**[2]**

(b) Show with a diagram how the field winding is connected to the armature of a shunt wound self excited generator.

[2]

(c) A d.c. shunt wound generator has armature resistance of 0.2 ohms and shunt field resistance of 40 ohms. The generator is delivering 50 amperes at 240 volts. Calculate:

(i) the field current

Field current = …….. A **[2]**

(ii) the armature current

Armature current = …….. A **[2]**

(iii) the generated e.m.f.

Generated e.m.f = …….. V **[2]**

4 (a) Explain what is meant by

(i) an alternating current supply

.....

.....**[1]**

(ii) a direct current supply

.....

.....**[1]**

(b) Draw a labelled block diagram of a stabilised power supply showing:
ac input, dc output, smoothing circuit, transformer, stabilising circuit and rectifier.

[3]

(c) Explain with the aid of a labelled diagram how full wave rectification of an a.c. waveform can be obtained by using four diodes in a bridge configuration.

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.....**[5]**

5 (a) State **three** characteristic properties of an ideal operational amplifier.

1 .....

2 .....

3 .....**[3]**

(b) Explain with the aid of labelled diagrams the difference between a non-inverting operational amplifier and an inverting operational amplifier.

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.....**[5]**

(c) In a negative feedback amplifier the gain is 750.
Calculate the overall gain when the feedback fraction is 1/250.

Overall gain = …… **[2]**

6 (a) Complete the table by naming each component from its graphical symbol shown.

Graphical Symbol	Component
	
	

[2]

(b) For a two-input NOR gate, complete the truth table showing the outputs.

Input A	Input B	Output OR gate	Output NOR gate

[2]

(c) (i) Explain the meaning of the term 'bistable multivibrator'.

.....

.....**[1]**

(ii) In the space provided, draw the symbol for a D-type bistable complete with labels D, Q, CK and $\overline{Q}$.

[1]

(iii) State the meaning of the labels, D, Q, CK and $\overline{Q}$ for the D-type bistable.

D.....

Q.....

CK .....

$\overline{Q}$ .....**[4]**

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE

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SPECIMEN

Sample Assessment Material
Level 3 Cambridge Technicals in Engineering

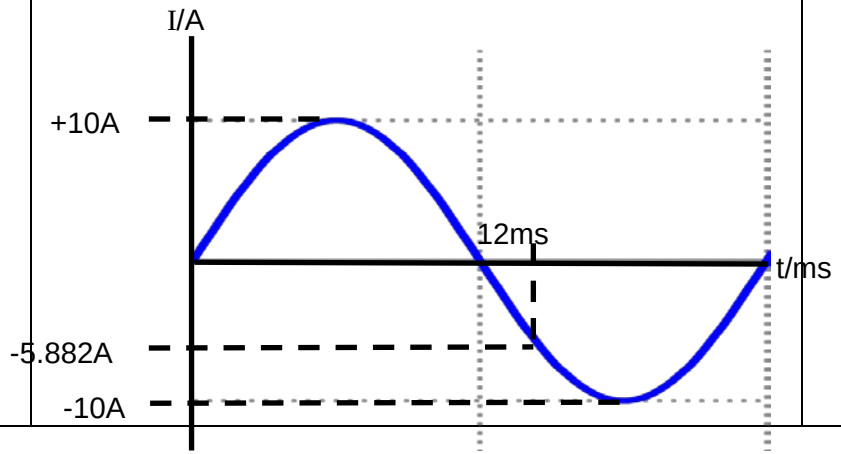
UNIT 4: Principles of electrical and electronic engineering

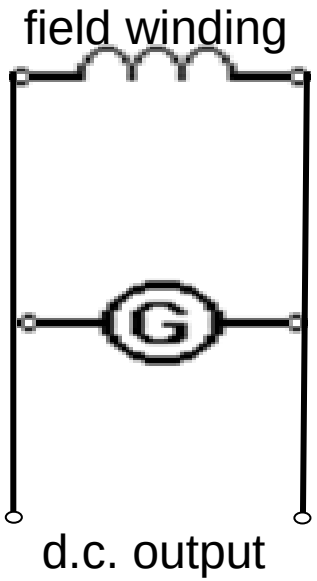
MARK SCHEME

Duration: 1 hour 30 minutes

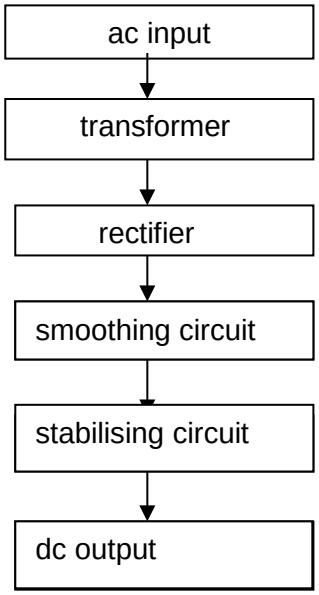
MAXIMUM MARK 60

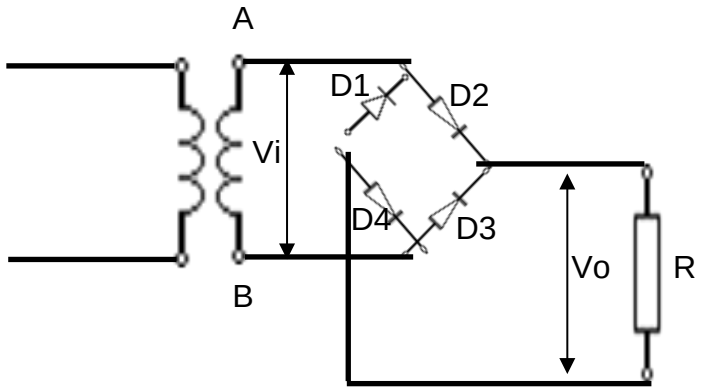
Question			Answer	Marks	Guidance
1	(a)	(i)	$I = V/R$ $= 240/60$ $= 4A$	1 1	(This mark is for applying knowledge from Unit 2 LO3 Resistance and Ohms Law) Award one mark for correct numerical result
		(ii)	$P = V I$ $= 240 \times 4$ $= 960$ W	1 1	(This mark is for applying knowledge from Unit 2 LO3 potential difference) Award one mark for correct numerical result
		(iii)	$W = Pt$ $= 960 \times 2$ $= 1920$ Wh	1 1	(This mark is for applying knowledge from Unit 2 LO3 use of the formulae for electrical power (P) and energy (W)) Allow ecf from (ii) for power Award one mark for correct numerical result
	(b)		Internal resistance of battery $r = 6 \times 0.2 = 1.2\ \Omega$ Because of maximum power transfer the internal resistance of the battery equals the resistance of the external load. Load resistance $R = 1.2\ \Omega$ Total e.m.f. of battery $= 6 \times 1.2 = 7.2$ V Load current $I = E/(r + R)$ $= 7.2/(1.2 + 1.2)$ $= 3$ A Maximum Power $P = I^2R$ $= 3^2 \times 1.2$ $= 10.8$ W	1 1 1 1	

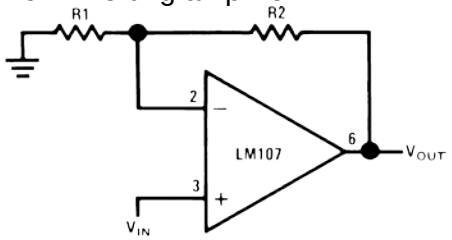
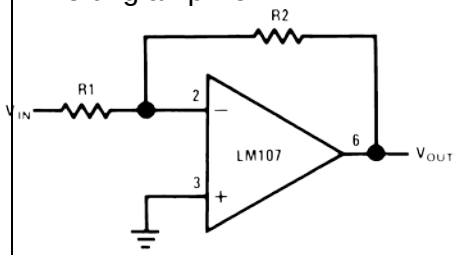
Question			Answer	Marks	Guidance
2	(a)	(i)	By inspection peak value = 10 A	1	Award one mark for correct numerical result (This mark is for applying knowledge from Unit 1 LO4 sine cosine and tangent operations)
		(ii)	$2\pi ft = 314.2t$ $f = 314.2t/2\pi t$ $f = 50$ Hz	1 1	Award one mark for correct numerical result
		(iii)	$T = 1/f$ $= 1/50$ $= 0.02$ s	1 1	Award one mark for correct numerical result
		(iv)	$i = 10 \sin 314.2t$ $= 10 \sin (314.2 \times 12 \times 10^{-3})$ $= 10 \sin (3.7704$ radians$)$ $= 10 \times (-0.5882)$ $= -5.882$ A	 1 1 1	Award one mark for correct numerical result
	(b)			2	Award one mark for the correct drawing of the sine wave shape and award one mark for correct labelling of axes. (Values plotted on the graph are not required for marks but are shown for illustrative purposes)

Question			Answer	Marks	Guidance
3	(a)		Motors convert electrical energy into mechanical energy, **but** generators convert mechanical energy into electrical energy	1 1	
	(b)		 Diagram – Shunt wound self excited generator – The field winding is connected in parallel or shunt with the armature	2	Award one mark for showing an armature and one mark for the correct position of the field winding

Question			Answer	Marks	Guidance
	(c)	(i)	Field current I_f = V/R = 240/40 = 6 A	1 1	Award one mark for correct numerical result
		(ii)	Armature current $I_a = I_f + I_L$ = 6 + 50 = 56 A	1 1	Award one mark for correct numerical result
		(iii)	Generated e.m.f. = $V + I_a R_a$ = 240 + (56 x 0.2) = 251.2 V	1 1	Award one mark for correct numerical result

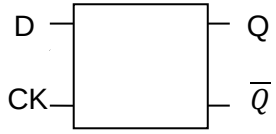
Question			Answer	Marks	Guidance
4	(a)	(i)	An alternating current is one that continually changes direction – giving the shape of a sine wave	1	
		(ii)	A direct current flows in one direction only	1	
	(b)			3	Award three marks if all blocks are in the correct order Award one mark for correctly positioning the input and award one mark for correctly positioning the output and one mark for correctly positioning the other four items

Question	Answer	Marks	Guidance
(c)		2	Correct drawing of the AC input (transformer/Vi) and the DC output (resistor/Vo) – 1 mark Correct drawing of the full-wave bridge rectifier (4 diodes) - 1 mark
	Diagram – Bridge Rectifier Circuit	1	
	If A is positive with respect to B during the first half cycle, D_2 and D_4 conduct and current takes the path AD_2RD_4B.	1	
	On the next half cycle When B is positive, D_1 and D_3 are forward biased and current follows the path BD_3RD_1A.	1	
	The current is unidirectional during both half-cycles of the input V_i voltage. The output V_o is a varying dc voltage.		

Question			Answer	Marks	Guidance
5	(a)		• Infinite voltage gain • Infinite input impedance • Infinite bandwidth • Zero output impedance • Zero output when the differential inputs are identical	3	Award one mark for correct response up to a maximum of three marks
	(b)		Non-inverting amplifier  Inverting amplifier  Differences: Non-inverting input + (Terminal 3) NIA - goes to $V_{in.}$ IA - goes to earth Inverting input – (Terminal 2)	1 1 1 1	Be aware that the resistor symbol is not a BS symbol

Question			Answer	Marks	Guidance
			NIA - goes to R_1 and R_2. Feedback from the output is applied to the inverting terminal 2 IA - V_{in} goes via R_1 and to the inverting terminal 2 Feedback from the output is applied to the inverting terminal 2	1	
	(c)		Overall gain = A/(1 + βA) = 750/(1 + [1/250] x750) = 750/(1 + 3) = 750/4 = 187.5	1 1	Award one mark for correct application of the formula One mark for the correct solution (Both marks require direct application of knowledge from Unit 1 LO1 application of algebra)

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td>
<table>
<tr><th>Graphical Symbol</th><th>Component</th></tr>
<tr><td>  </td><td>AND Gate</td></tr>
<tr><td>  </td><td>OR Gate</td></tr>
</table>
</td><td>1

1</td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><th>Input A</th><th>Input B</th><th>Output OR gate</th><th>Output NOR gate</th></tr>
<tr><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></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td></tr>
</table>
</td><td>2</td><td>Award one mark for a correct OR gate output and one mark for a correct NOR gate output</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>The bistable or flip-flop is a switching circuit with two outputs, one which is ‘high’ when the other is ‘low’ and vice versa</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>D type bistable 
</td><td>1</td><td>Correct answer only</td></tr>
</table>

Question			Answer	Marks	Guidance
		(iii)	D is the data input CK is the clock pulse input Q is the output $\overline{Q}$ is the complementary output	1 1 1 1	

[Paper Total: 60]