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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Monday 17 January 2022 – Morning

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873

Unit 4: Principles of electrical and electronic engineering

Time allowed: 1 hour 30 minutes plus your additional time allowance

You must have:
the Formula Booklet for Level 3
Cambridge Technical in Engineering
(with this document)
Insert for Question 1(a)(ii)
a ruler (cm/mm)
a scientific calculator

Please write clearly in black ink.

**Centre
number**

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**Candidate
number**

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First name(s) _____

Last name _____

**Date of
birth**

D	D	M	M	Y	Y	Y	Y
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READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working.

Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION

The total mark for this paper is 60.

The marks for each question are shown in brackets [].

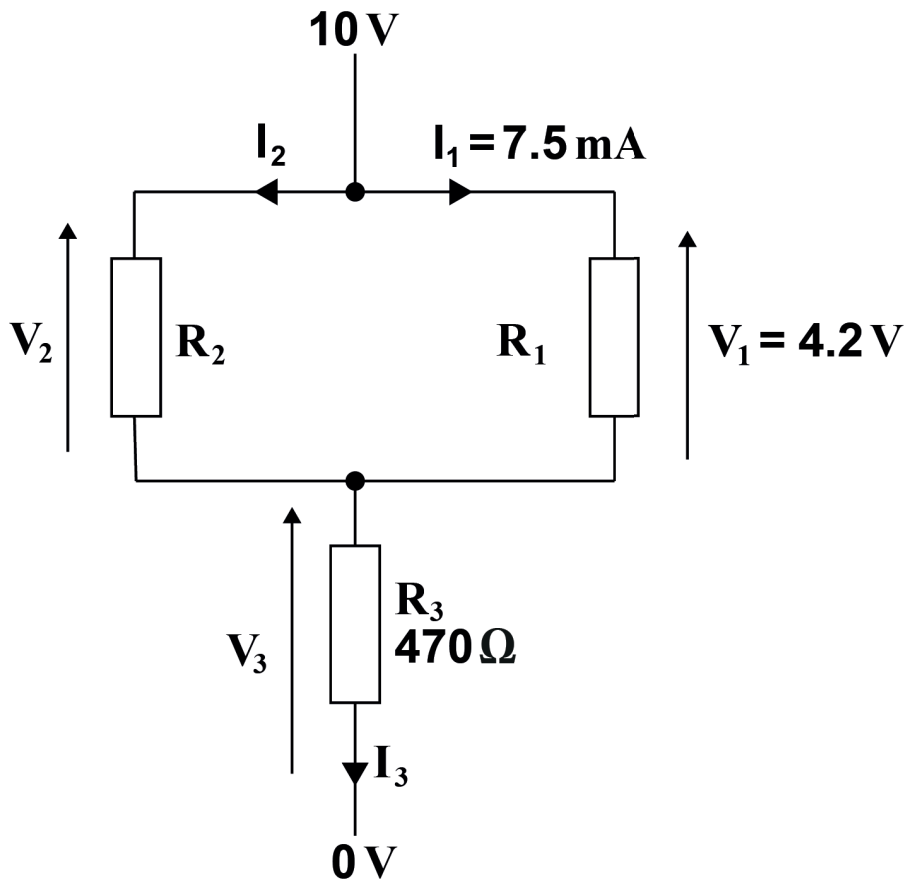
ADVICE

Read each question carefully before you start your answer.

Answer ALL the questions.

1 The circuit diagram in Fig. 1 shows a network of resistors.

Fig. 1



(a) A voltmeter is used to measure the voltage V_1 .

(i) Draw ON Fig. 1 to show how a voltmeter should be connected to measure the voltage V_1 . [1]

- (ii) A multimeter is used as a voltmeter to measure the voltage V_1 .

Fig. 2a on the Insert shows a multimeter with the dial in the off position.

Draw an arrow ON Fig. 2b on the Insert showing the correct position of the dial to precisely measure the voltage V_1 . [1]

- (b) Calculate the value of the resistor R_1 .

$R_1 =$ _____ Ω [1]

- (c) Calculate the voltage V_3 .

$V_3 =$ _____ V [1]

5

(d) Calculate the current I_3 .

$I_3 =$ _____ A [1]

(e) Calculate the value of the resistor R_2 .

$R_2 =$ _____ Ω [2]

- (f) Calculate the resistance of the network of resistors.

resistance of the network of resistors =

_____ Ω [2]

- 2 (a) A sine wave alternating current (AC) supply of frequency $f = 455 \text{ kHz}$ is connected in series with a resistor (R), a capacitor (C) and an inductor (L).
- (i) Draw a diagram of the circuit.
Label all components. Use the space below. [2]

(ii) The value of inductor $L = 240 \mu\text{H}$.

Calculate the reactance X_L of the inductor
when the frequency $f = 455 \text{ kHz}$.

$X_L =$ _____ Ω [3]

(iii) The reactance of the capacitor $X_C = 910 \Omega$
when the frequency $f = 455 \text{ kHz}$.

Calculate the value of the capacitor (C).

Give the units for your answer.

$C =$ _____ [3]

(iv) The value of the resistor $R = 330\ \Omega$.

Calculate the impedance (Z) of the circuit at a frequency of 455 kHz.

$Z =$ _____ Ω [2]

(v) Calculate the amplitude of the current in the circuit when it is supplied with a sine wave of amplitude 15 V at a frequency of 455 kHz.

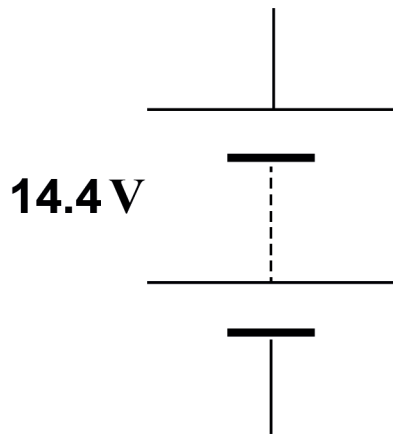
Use the equation $I = \frac{V}{Z}$

$I =$ _____ A [1]

3 An electric food mixer uses a shunt-wound DC motor.

- (a) Draw ON Fig. 3 to show how a field winding and armature should be connected to a 14.4 V power supply in a shunt-wound DC motor. [2]**

Fig. 3



- (b) Complete the sentences in the paragraph below by choosing the most appropriate words from the list.

Use each word once, more than once or not at all.

constant

increased

infinite

reduced

zero

A shunt-wound DC motor maintains a fairly constant speed regardless of load.

When the motor is running with no load, it spins at high speed.

When a load is applied to the motor, the speed reduces, and the EMF generated in the armature is

_____.

This means that the current in the armature is increased and so the torque is _____.

The current in the field winding is

_____.

All of this keeps the load speed of the motor close to its no-load speed. [3]

(c) The shunt-wound motor has a field winding resistance (R_f) of $48\ \Omega$ and an armature winding resistance (R_a) of $18\ \Omega$.

(i) Calculate the current in the field winding (I_f) when $14.4\ \text{V}$ is supplied to the motor.

$I_f =$ _____ A [1]

(ii) The motor operates from a $14.4\ \text{V}$ power supply (V).

When the motor is turning at high speed, it produces a back EMF (E) of $12.2\ \text{V}$.

Calculate the armature current (I_a) in the motor.

Use the equation $V = E + I_a R_a$

$I_a =$ _____ A [2]

- (iii) Calculate the total current (I_t) drawn from the power supply when the motor is turning at high speed.

$I_t =$ _____ A [1]

- 4 (a) The block diagram opposite and circuit diagram for a power supply are shown in Fig. 4.

Graphs A-E in Fig. 5 show how voltage can change over time.

In Fig. 4, the letter A indicates that Graph A shows the way that voltage changes over time at this point in the circuit.

Fill in the TWO blank boxes IN Fig. 4 to show which graph (B, C, D or E) represents the way that voltage changes over time at each point in the circuit. [2]

Fig. 4

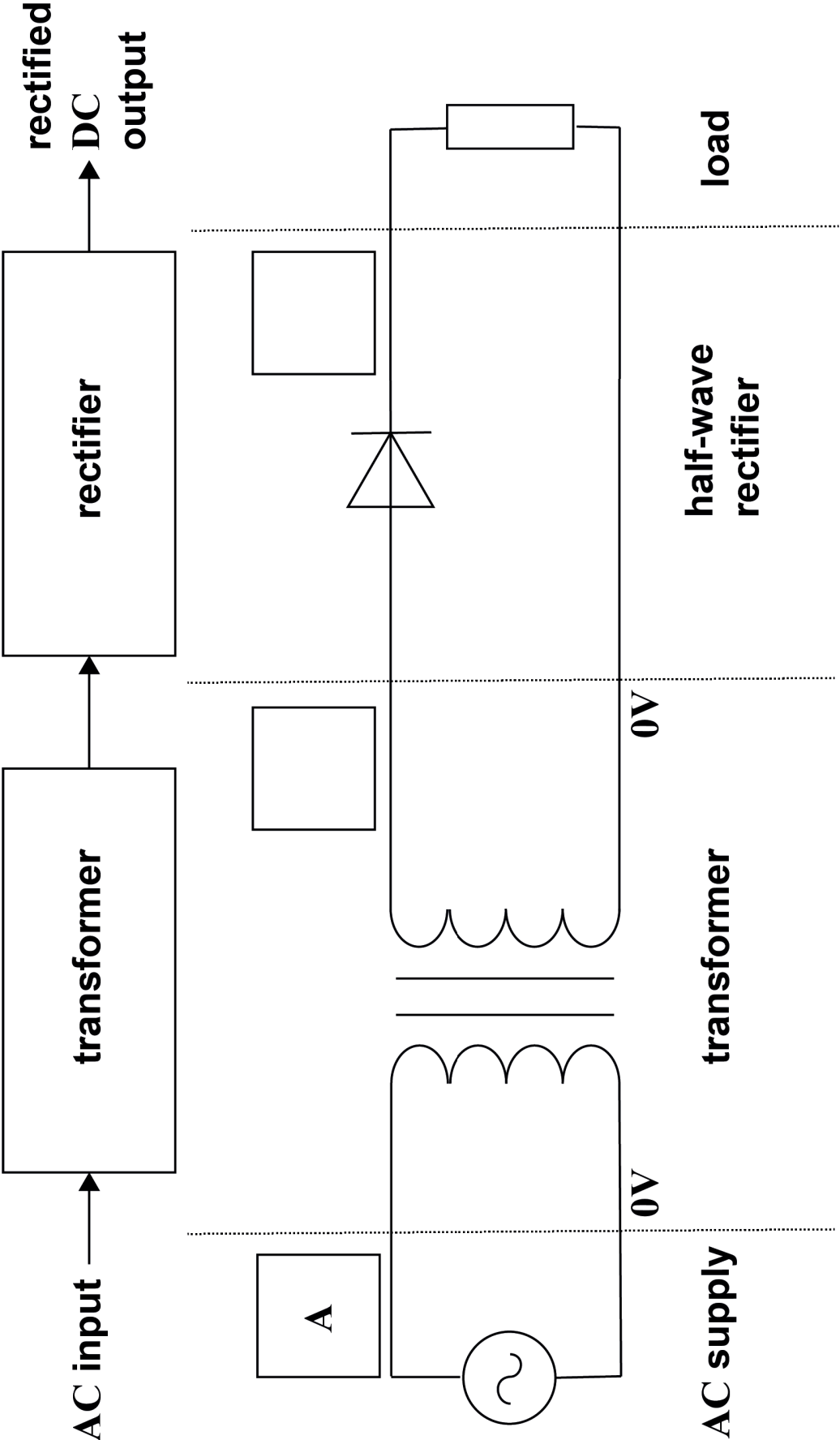
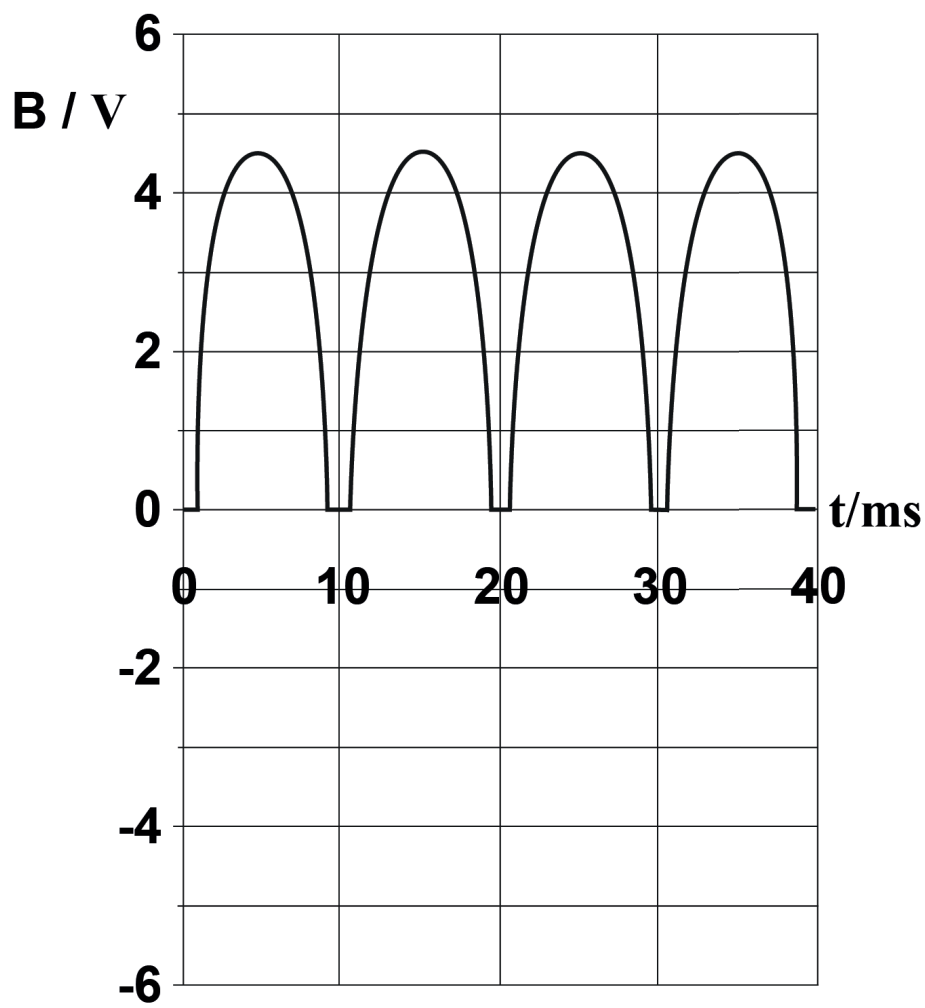
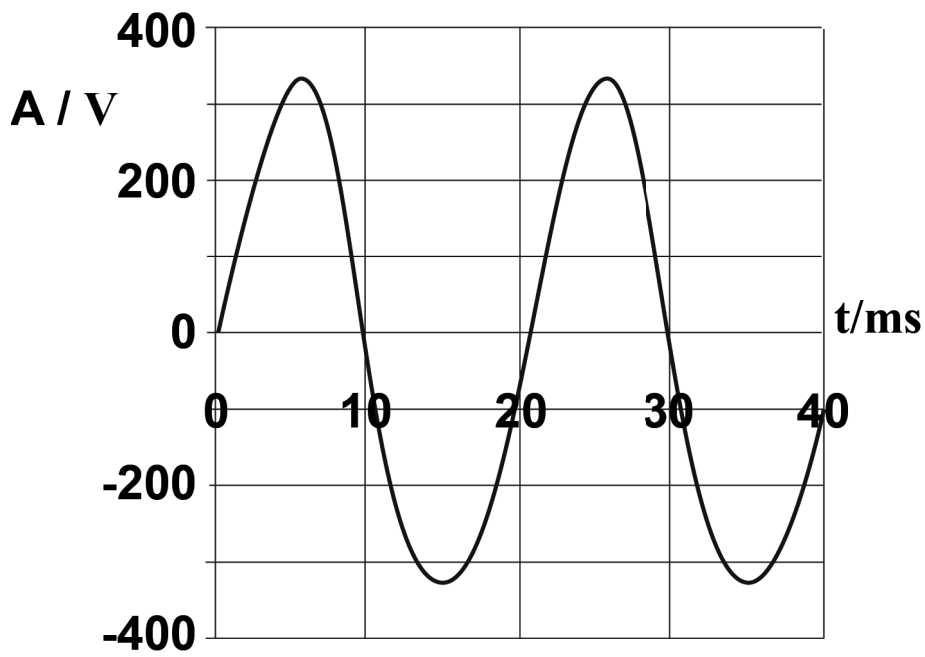
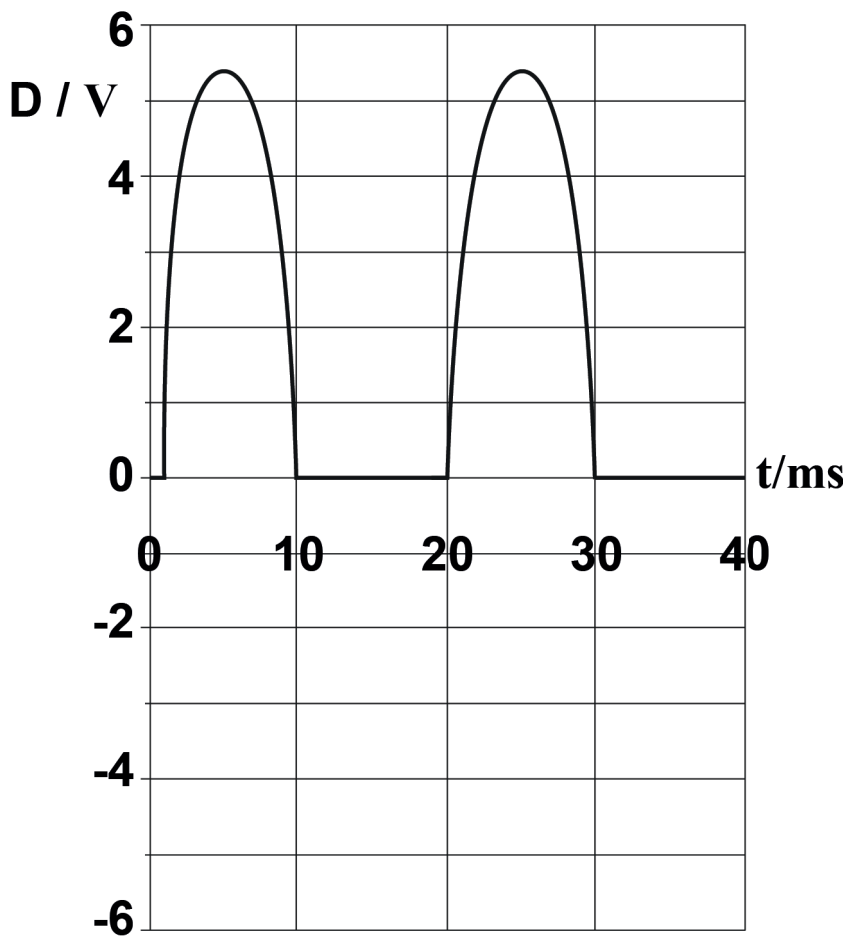
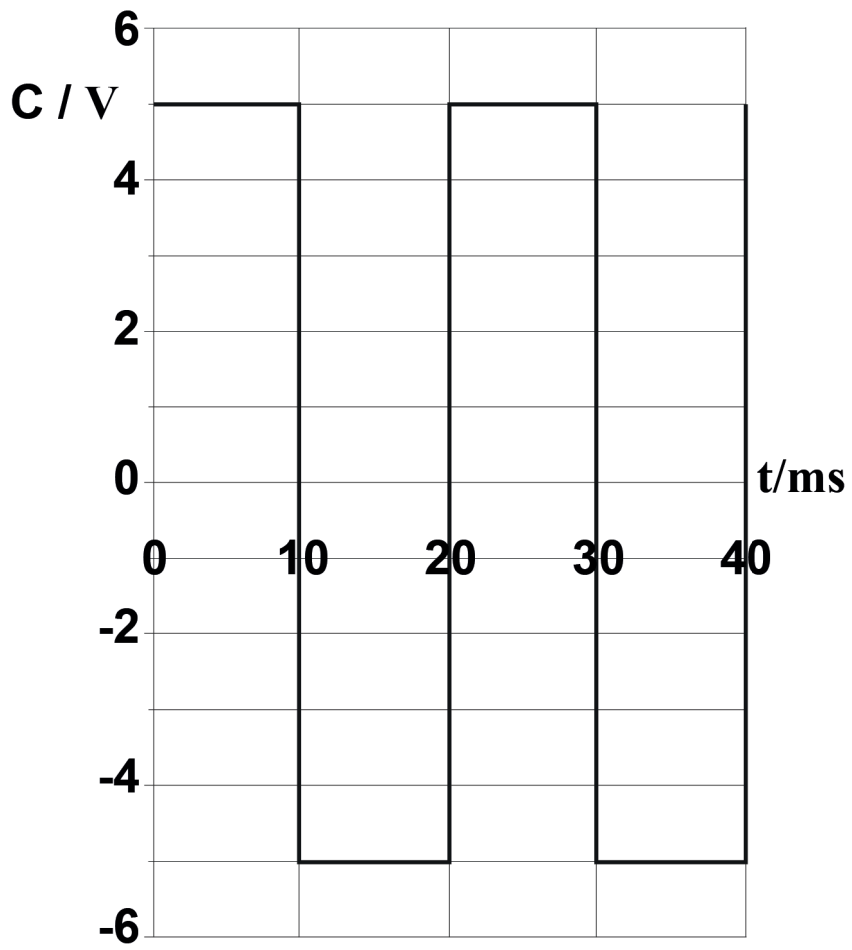


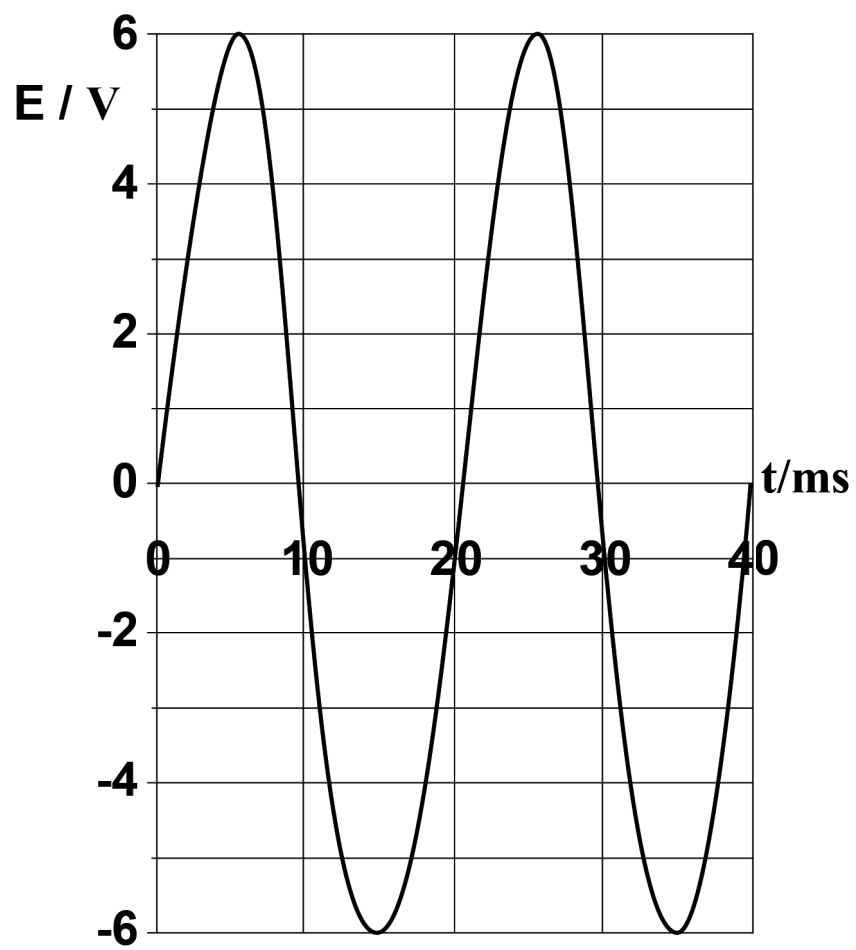
Fig. 5



15



16



(b) An incomplete block diagram of a stabilised power supply is shown opposite in Fig. 6.

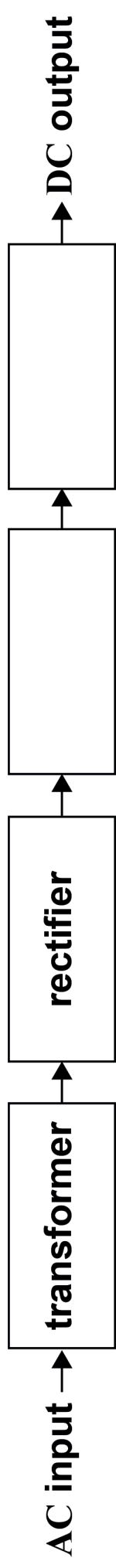
(i) Add the names of the TWO missing blocks to complete the stabilised power supply. [2]

(ii) A stabilised power supply has good load regulation.

Explain what is meant by good load regulation.

[2]

Fig. 6



(c) An LED is used to show that the DC output of a 3.3 V power supply is operating.

(i) Complete Fig. 7 to show how an LED and current limiting resistor can be used to show that the power is operating. Label the parts in your diagram. [3]

Fig. 7

+3.3 V ———

0 V ———

(ii) Explain the function of the current limiting resistor in Fig. 7.

[2]

- 5 (a) The table shows the input voltage (V_{in}), output voltage (V_{out}) and voltage gain of three different amplifiers.

Complete the table with the missing values.

Use the equation: Voltage Gain = $\frac{V_{out}}{V_{in}}$ [3]

Input voltage (V_{in})	Output voltage (V_{out})	Voltage gain
3.0	1.5	
-2.5		3
	6	-1.5

- (b) Calculate the resistors for a non-inverting operational amplifier, constructed from an operational amplifier (op-amp) with a voltage gain of 1.5.

Use the equation: Voltage Gain = $1 + \frac{R_F}{R_2}$

$R_F =$ _____ k Ω

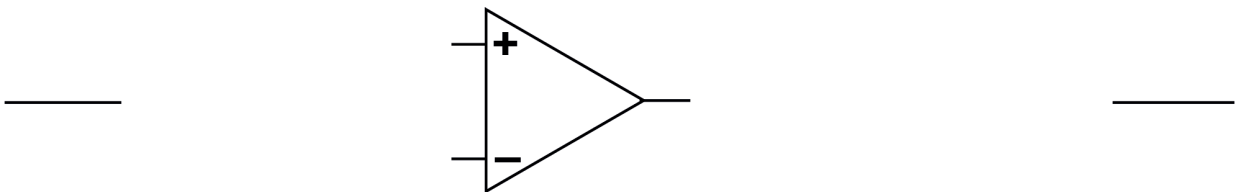
$R_2 =$ _____ k Ω

[2]

(c) Complete Fig. 8 to show a non-inverting amplifier.

Label the input, output, R_F and R_2 . [5]

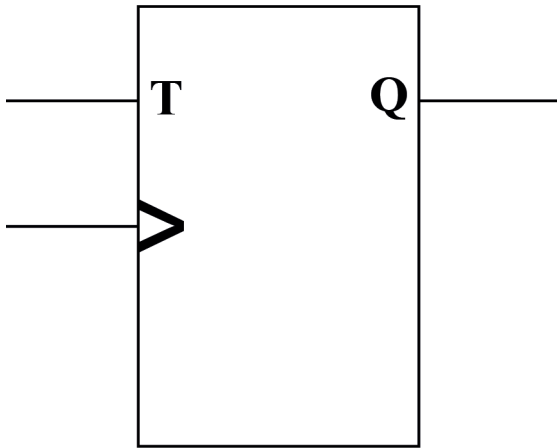
Fig. 8



0 V _____

- 6 (a) The circuit symbol for a T-type flip-flop is shown in Fig. 9.

Fig. 9



Draw a line to join the start of each sentence to the most appropriate end of sentence about the behaviour of a T-type flip-flop.

There will be some end of sentences without a connecting line. [2]

Start of sentence

End of sentence

When a T-type flip-flop is triggered and T is low, ...

...Q changes.

...Q stays the same.

When a T-type flip-flop is triggered and T is high, ...

...T changes.

...the clock is \overline{T} .

(b) A partially complete truth table for a logic gate is shown below.

A	B	Q
0	0	1
		0
		0
		0

(i) Complete the truth table by filling in columns A and B. [1]

(ii) Name the logic gate described by the truth table.

[1]

(iii) Draw the circuit symbol for the logic gate described by the truth table.

Label the inputs A and B and label the output Q. [1]

(iv) Put a ring around the correct Boolean expression for the logic gate described by the truth table. [1]

$$Q = A + B$$

$$Q = \overline{A + B}$$

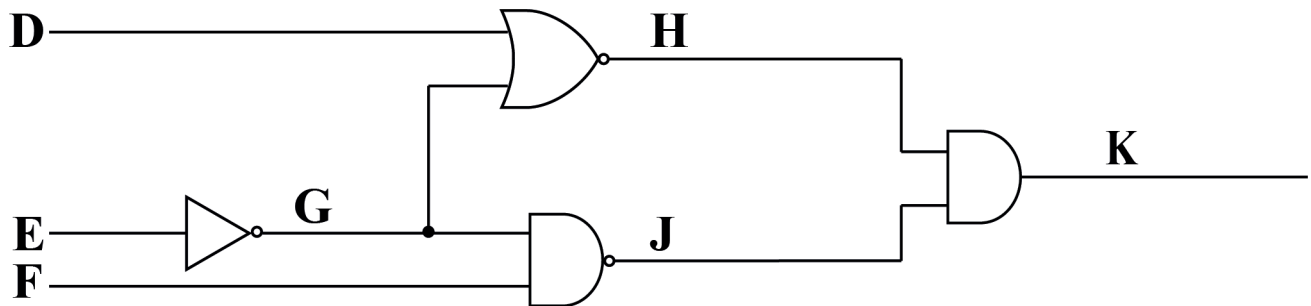
$$Q = A \cdot B$$

$$Q = \overline{A \cdot B}$$

$$Q = A \oplus B$$

(c) Fig. 10 shows a logic gate circuit.

Fig. 10



Complete the truth table for this circuit. [4]

D	E	F	G	H	J	K
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 1(d) or 6(c).

This image shows a single page of white paper with horizontal blue ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.



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