OCR

Oxford Cambridge and RSA

Wednesday 15 January 2025 – 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

C304/2501

You must have:
• the Formula Booklet for Level 3 Cambridge
• Technical in Engineering (inside this document)
• a ruler (cm/mm)
• a scientific calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number [ ][ ][ ][ ][ ]   Candidate number [ ][ ][ ][ ]

First name(s) _____

Last name _____

Date of birth [D][D][M][M][Y][Y][Y][Y]

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.
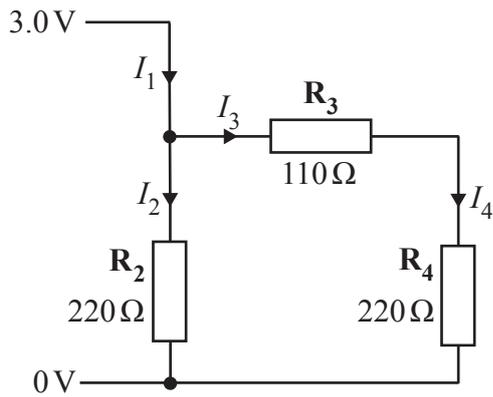
INFORMATION
• The total mark for this paper is **60**.
• The marks for each question are shown in brackets **[ ]**.
• This document has **16** pages.

ADVICE
• Read each question carefully before you start your answer.

C304/2501   OCR is an exempt Charity   **Turn over**

1 The diagram below shows a network of resistors.

(a) Calculate the current I_2.

$I_2 =$ .... A **[1]**

(b) Calculate the total resistance of R_3 and R_4 in series.

total resistance of R_3 and $R_4 =$ .... Ω **[1]**

(c) Calculate the current I_3.

$I_3 =$ .... A **[1]**

(d) Explain why $I_3 = I_4$ making reference to Kirchhoff's Law.

....

.... **[1]**

(e) Calculate the voltage across R_2.

voltage across $R_2 =$ .... V **[1]**

(f) Calculate the current I_1.

value of $I_1 =$ .... A **[1]**

(g) An engineer removes R_4 from the circuit to check its resistance.

(i) Give **one** reason why it is necessary to remove R_4 from the circuit before checking its resistance with an ohmmeter.

....

.... **[1]**

(ii) Draw on the diagram below to show how an ohmmeter should be connected to measure the resistance of R_4.

$$R_4$$
$$220\,\Omega$$
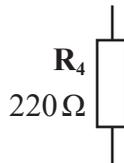
[1]

(iii) A multimeter is used as an ohmmeter to measure the value of R_4.

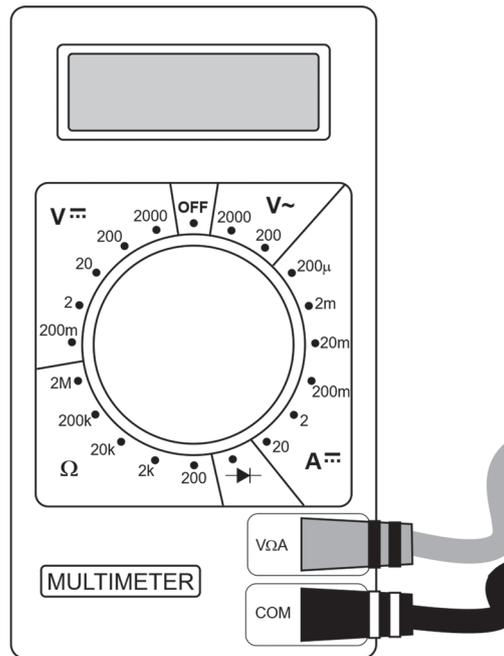The value of R_4 is about $220\,\Omega$.

Fig. 1a shows a multimeter with the dial in the off position.

Draw an arrow on **Fig. 1b** showing the correct position of the dial to precisely measure the resistance of R_4.

Fig. 1a   **Fig. 1b**

[1]

Turn over
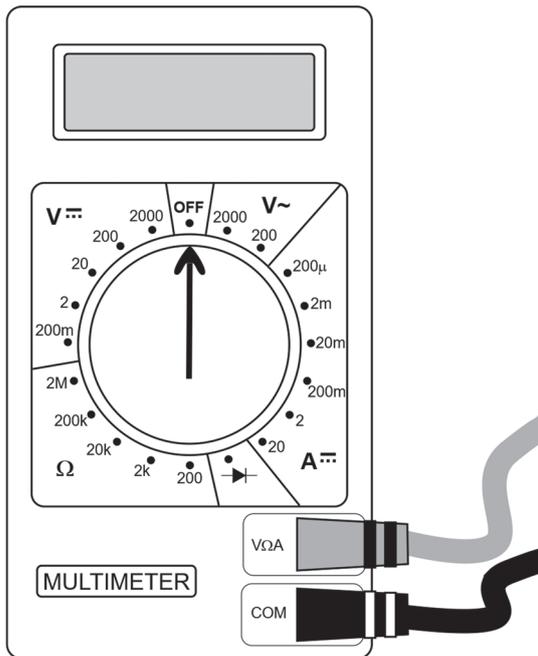
2   A simple AC generator has a frequency $f = 440\,\text{Hz}$ of amplitude $V = 8\,\text{V}$. The generator produces a sine wave so that the voltage v at time t obeys the equation:

$v = V \sin(\omega t)$ where $\omega = 2\pi f$

(a) Calculate the period (T) of the generator.

$T =$ .... s **[1]**

(b) Calculate the angular frequency (ω) of the generator.

$\omega =$ .... rad s^{-1} **[1]**

(c) Calculate the voltage (v) at time $t = 2\,\text{ms}$.

$v =$ .... V **[3]**

(d) A capacitor is connected to the $440\,\text{Hz}$ AC generator.

Calculate the reactance (X_C) of a capacitor of capacitance $C = 22\,\text{nF}$ connected to a $440\,\text{Hz}$ AC supply.

$X_C =$ .... Ω **[3]**

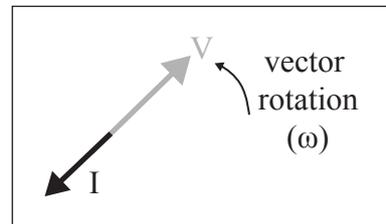**(e)** Phasor diagrams show the phase relationship between the voltage (V) and current (I) in a circuit.
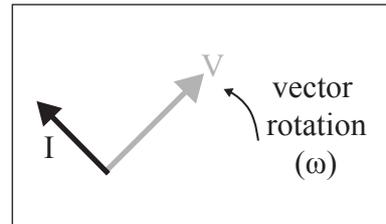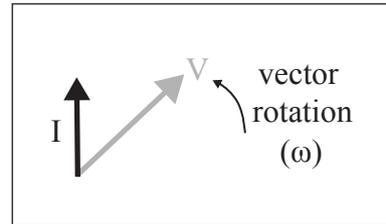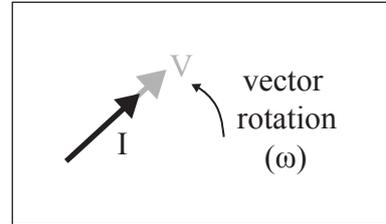
Draw a line to join each circuit diagram to the appropriate phasor diagram.

There will be three phasor diagrams with no connecting line.
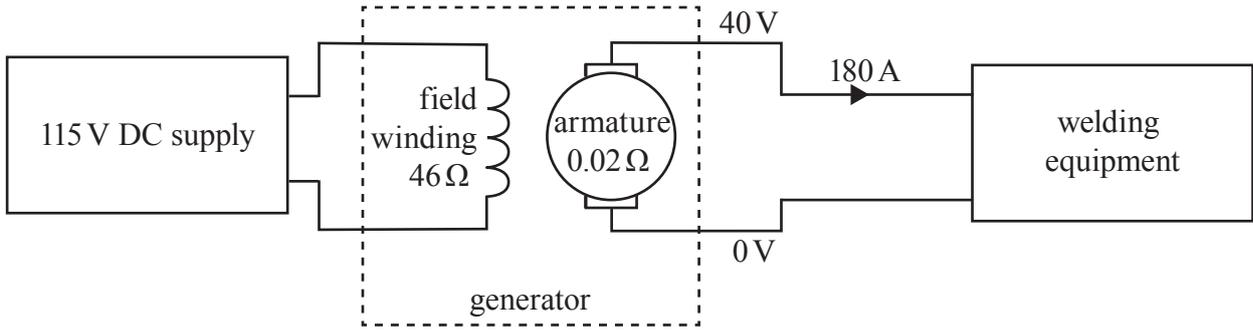
Circuit diagram   **Phasor diagram**

[3]

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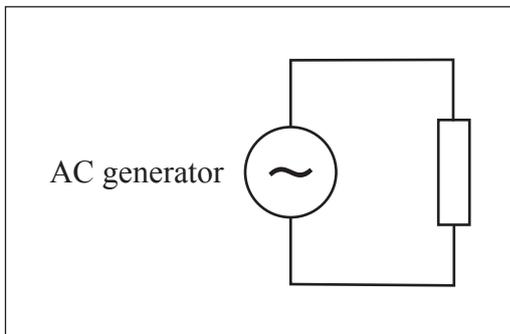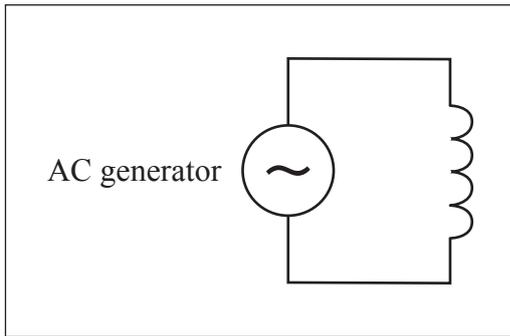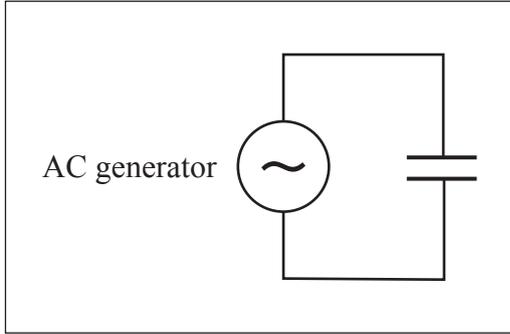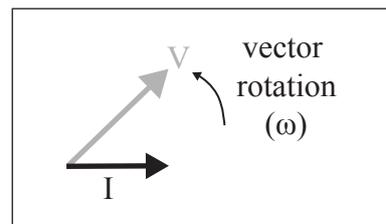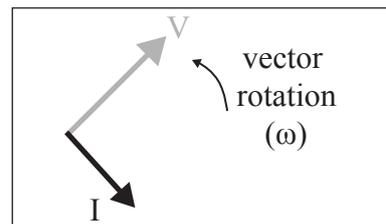
3 The diagram below shows a generator used to provide a 40 V DC supply to welding equipment.

(a) Draw a (ring) around the type of generator shown in the diagram.

AC generator	Separately excited DC generator	Series-wound self-excited DC generator	Shunt-wound self-excited DC generator

[1]

(b) The field winding of the generator has a resistance of 46 Ω.

Calculate the current in the field winding.

current in field winding = ... A **[2]**

(c) Calculate the power delivered to the field winding by the 115 V DC supply.

power delivered to the field winding = ... W **[1]**

(d) Tick (✓) the most appropriate end of the sentence.

The purpose of the DC supply is to …

… act as a backup power supply for the welding equipment. ☐

… produce a strong magnetic field in the generator. ☐

… provide all of the energy required for the welding equipment. ☐

… provide the power needed to make the generator turn. ☐

[1]

(e) The generator supplies 180 A to the welding equipment at a voltage of 40 V.

The armature has a resistance of 0.02 Ω.

(i) Calculate the EMF produced in the armature.

Give the units in your answer.

EMF produced in the armature = ... unit .... **[3]**

(ii) State **one** reason why the resistance of the armature needs to be so small.

....

....

.... **[1]**

(iii) Calculate the power dissipated in the armature.

power dissipated in the armature = ... W **[1]**

(f) Complete the paragraph below about the generator using the most appropriate term in each gap.

Choose terms from the following list.

Each term may be used once, more than once or not at all.

decreases   **increases**   **is zero**   **stays the same**

A resistor is placed in series with the field winding and the 115 V DC supply.

When the value of the resistor is increased, the current in the field winding

.... and therefore the EMF induced in the armature

....
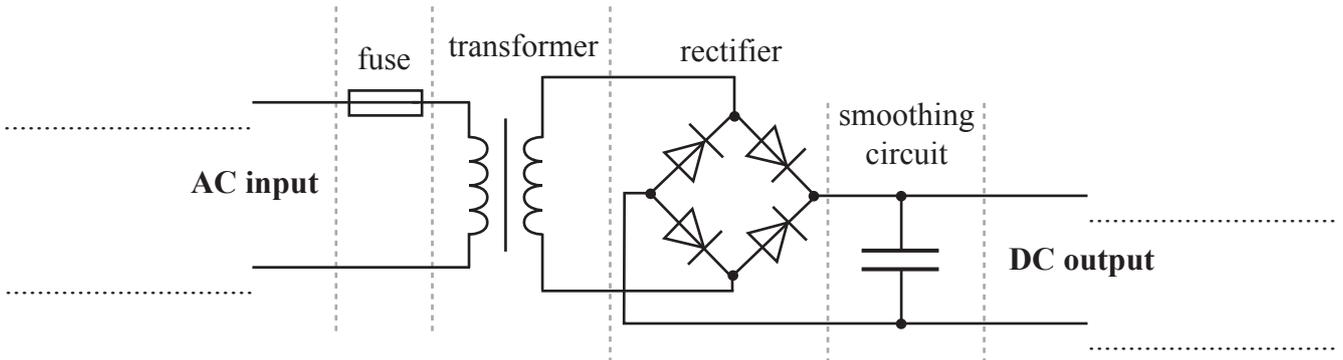
[2]

Turn over

4 A diagram of a power supply is shown below.

(a) Label the AC input and DC output connections on the diagram.

Use the labels:

live　　　　**negative**　　　　**neutral**　　　　**positive**

[3]

(b) The power supply produces a DC output from an AC input.

Explain the difference between AC and DC.

....

....

.... **[2]**

(c) A stabilising circuit is added to the power supply to improve the load regulation of the power supply.

(i) Describe where the stabilising circuit should be placed in the diagram.

....

.... **[1]**

(ii) Explain what is meant by 'load regulation'.

....

....

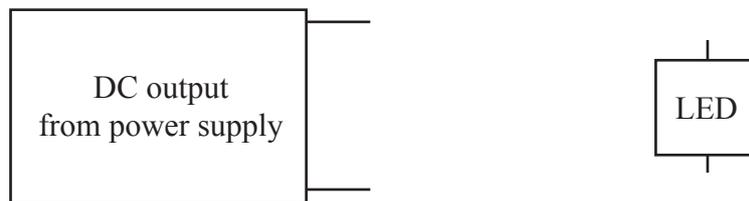... **[2]**

(d) An LED is added to the DC output of the power supply. The LED glows to show that the power supply is working.

If too much current flows through the LED it will be damaged.

Draw on the diagram below to show how the LED should be connected to the DC output from the power supply.

Include a resistor to protect the LED in your circuit.

[1]

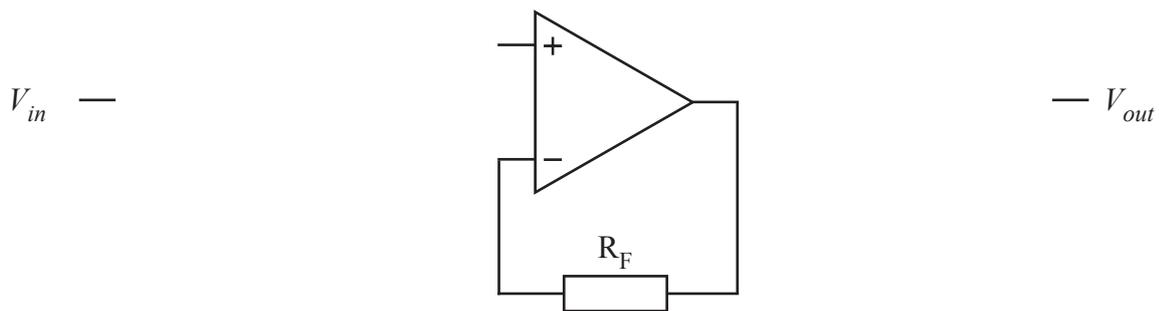**5** A class of engineering students are building a non-inverting op-amp with a voltage gain of 12 to practise using the equation:

$$\text{Voltage Gain} = \frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_2}.$$

(a) The input voltage of the amplifier is 200 mV.

Calculate the output voltage of the amplifier.

$V_{out} =$ .... V **[2]**

(b) Complete the diagram below to show the circuit of a non-inverting op-amp.

0 V ─────────────────────────────────

[3]

(c) A student asks the teacher for a 24 Ω resistor to use as the feedback resistor, R_F.

The teacher says that a 24 Ω resistor would draw a lot of current from the op-amp.

Draw a (ring) around the characteristic of an ideal op-amp that means it can supply as much current as is needed.

Infinite input impedance	Infinite open-loop gain	Zero input offset voltage	Zero output impedance

[1]

(d) The teacher says that real op-amps can only supply a limited current therefore large values of resistors need to be used.

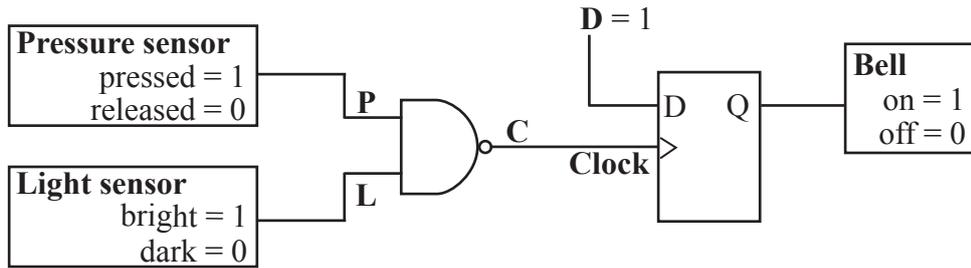The resistors all need to have values **greater than 1 kΩ**.

Calculate suitable values of the resistors R_F and R_2 to give the non-inverting op-amp amplifier a voltage gain of 12.

$R_F =$ .... Ω

$R_2 =$ .... Ω

[2]

6 The diagram below shows an alarm system containing a logic gate and a rising edge triggered D-type flip-flop.

(a) State the name of the logic gate in the alarm system.

.... **[1]**

(b) Complete the truth table for the logic gate in the alarm system.

P	L	C

[2]

(c) Describe the conditions of the light sensors and pressure sensor required to make **C** low.

....

.... **[1]**

(d) A timing diagram for the rising edge triggered D-type flip-flop is shown below.

D is held at logic 1 and **Q** starts at logic 0.

The **Clock** signal is shown on the timing diagram.

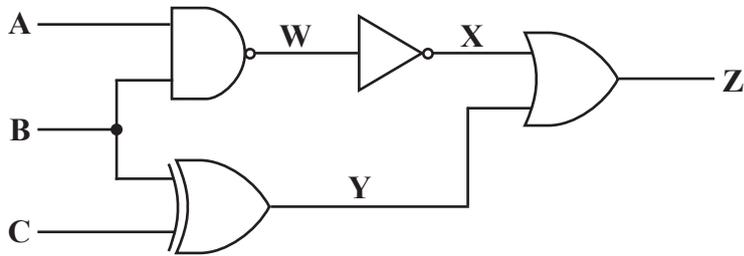Complete the timing diagram to show how **Q** varies with time.
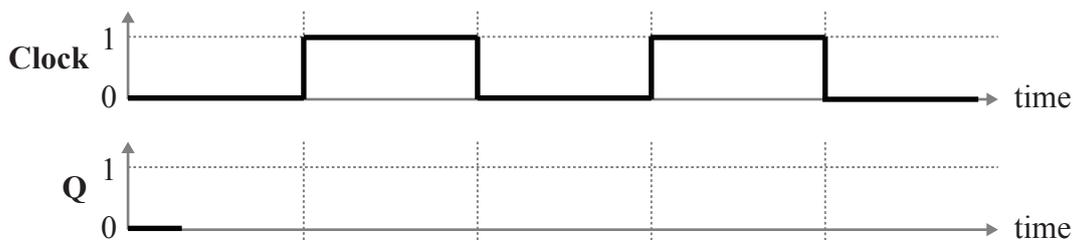
[2]

(e) Suggest a reason for including the D-type flip-flop in the alarm system.

....

.... **[1]**

(f) A logic circuit is shown below.

Complete the truth table for the logic circuit.

A	B	C	W	X	Y	Z
0	0	0	1	0	0	0
0	0	1	1	0	1	1
0	1	0	1	0	1	1
0	1	1	1	0	0	0
1	0	0	1	0	0	0
1	0	1	1	0	1	1
1	1	0	0	1	1	1
1	1	1	0	1	0	1

[4]

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.