OCR
Oxford Cambridge and RSA

Monday 16 January 2023 – 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
C304/2301

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 |

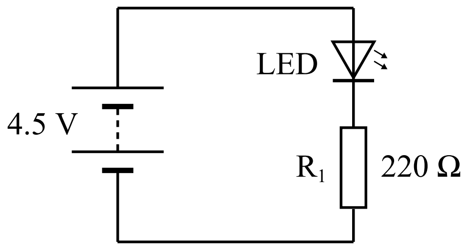
INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- 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 **20** pages.

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

Answer **all** the questions.

1 An engineer builds the circuit below to operate an LED.



(a) The voltage across the LED is 1.2 V.

Calculate the voltage across the resistor R_1.

Voltage across resistor R_1 = ... V **[1]**

(b) Calculate the current through the LED.

Give the units for your answer.

Current through the LED = ... **[2]**

(c) Calculate the power dissipated in the LED.

Power dissipated in the LED = ... W **[1]**

(d) The engineer decides to use a lower value of resistor for R_1 to make the LED brighter.

The voltage across the LED remains 1.2 V.

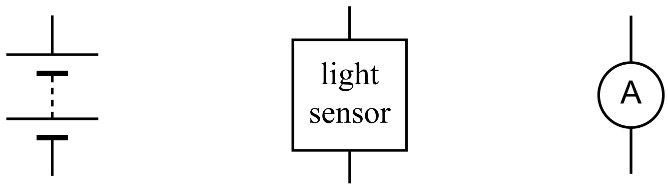
The maximum power dissipated in the resistor is 250 mW.

Calculate the smallest value resistor that can be used for R_1.

Smallest value for R_1 = ... Ω **[3]**

(e) A light sensor is used to detect the brightness of light from the LED.

Complete the circuit to show how the battery and ammeter should be connected to measure the current through the light sensor.



[1]

(f) A multimeter is used as an ammeter to measure the current through the light sensor.

The current through the light sensor is about 250 μA.

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 current through the light sensor.

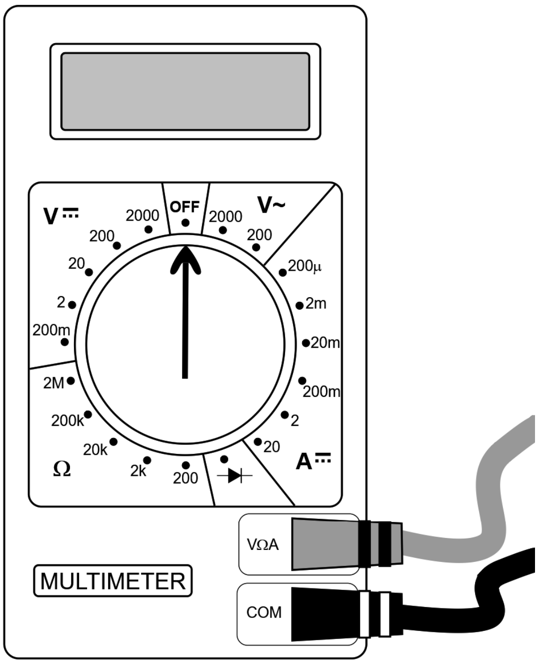


Fig. 1a

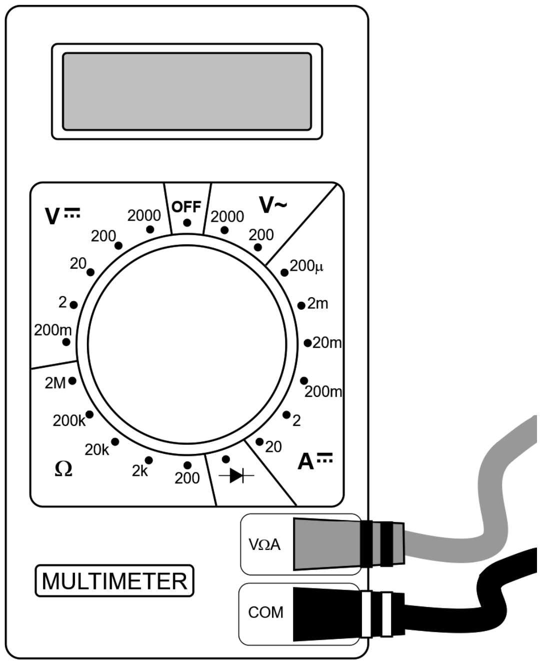


Fig. 1b

[1]

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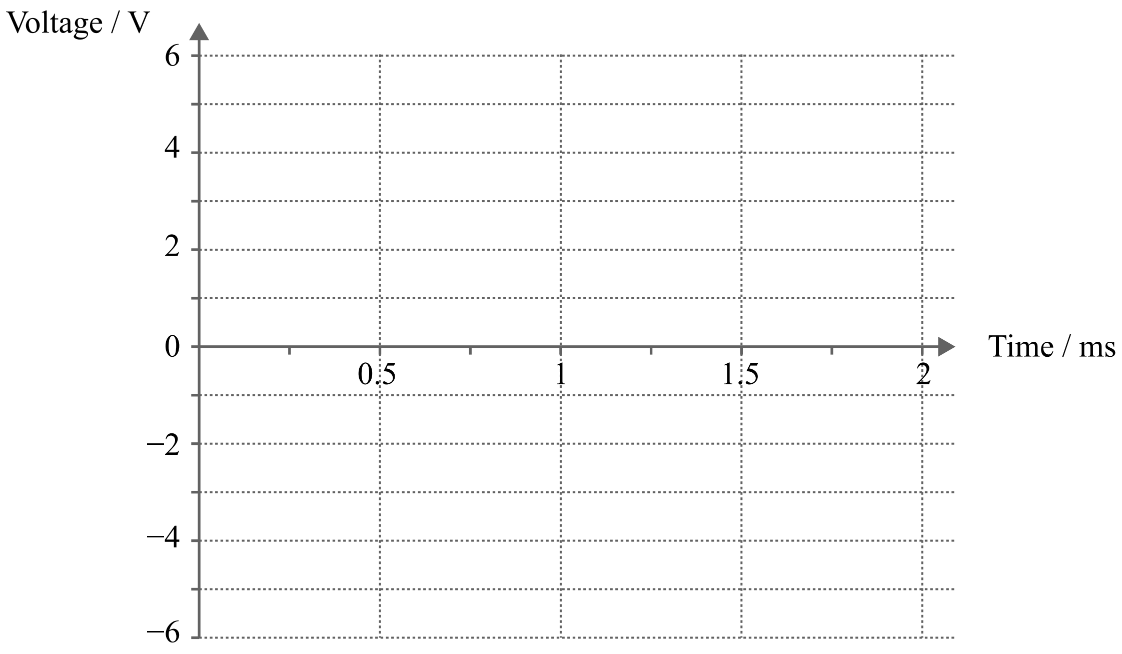
Turn over for the next question

2 **(a)** A generator produces a sine wave of amplitude 4 V and frequency 2.0 kHz.

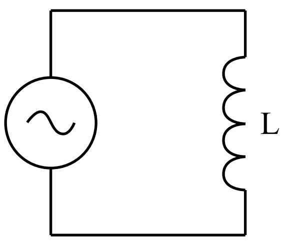
Draw a graph on the grid below to show how the voltage of the generator varies with time.



[3]

(b) The table below shows the circuit diagram of a generator in series with an inductor (L).

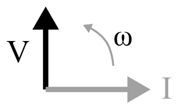
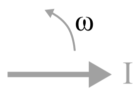
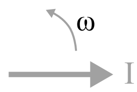
Complete the table to show the circuit diagram for a generator in series with a resistor (R) and for a generator in series with a capacitor (C).

Component		
Inductor (L)	Resistor (R)	Capacitor (C)
		

[2]

(c) The table below shows the phasor diagram for an inductor (L) in series with a generator.

Complete the table to show the phasor diagram for a resistor (R) in series with a generator and for a capacitor (C) in series with a generator.

Component		
Inductor (L)	Resistor (R)	Capacitor (C)
		

[2]

(d) The table below shows the value of an inductor to give an impedance of 360 Ω at 2.0 kHz.

Complete the table to show the value of the resistor (R) to give an impedance of 360 Ω at 2.0 kHz and the value of the capacitor (C) to give an impedance of 360 Ω at 2.0 kHz.
Give the units for each answer.

Component		
Inductor (L)	Resistor (R)	Capacitor (C)
$L = 2.9 \times 10^{-2}$ H	R = ...	C = ...

[4]

3 A separately excited DC generator connected to a lamp is shown in **Fig. 2**.

The field winding is connected to a 12 V battery.

The generator has a field winding resistance of 21 Ω and an armature resistance of 1.8 Ω.

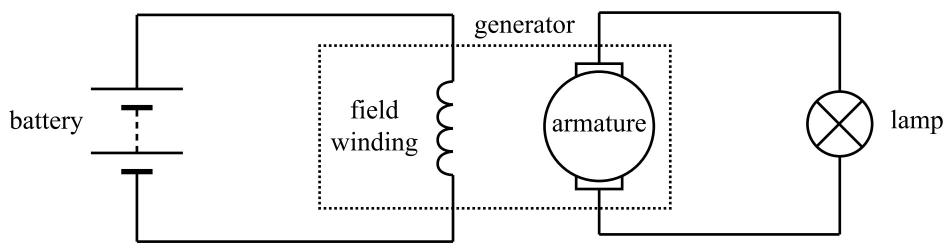


Fig. 2

(a) Calculate the current in the field winding, I_f.

I_f = ... A **[1]**

(b) When the generator is turned at a speed of 1500 rpm the voltage across the lamp is 24 V with a power of 65 W and the lamp glows brightly.

(i) Calculate the current in the armature, I_a.

I_a = ... A **[1]**

(ii) Calculate the EMF generated in the armature, E.

E = ... V **[2]**

(c) The generator continues to turn at a speed of 1500 rpm but the voltage of the supply to the field winding is reduced to 6 V.

Explain the effect of reducing the battery voltage on the generator and lamp.

....

....

....

....

....

....

.... **[3]**

(d) Separately excited DC generators are used for testing in laboratories but have the disadvantage of needing a power supply for their field winding.

Draw on **Fig. 3** to show how the generator from **Fig. 2** can be connected as a series-wound self-excited DC generator to the lamp so that the battery is no longer needed.

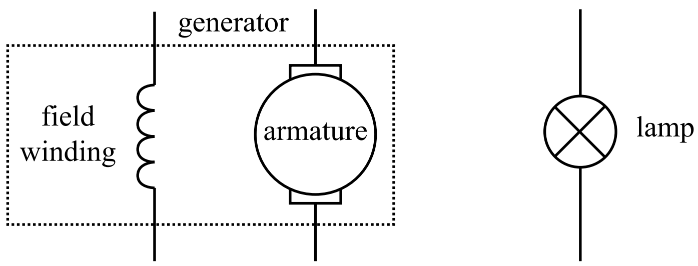


Fig. 3

[2]

4 **(a)** Electricity is usually supplied to houses and flats using a single phase 2-wire system. Electricity is usually supplied to industrial premises using a three phase 4-wire system.

(i) State **one** advantage of using a single phase 2-wire system.

....

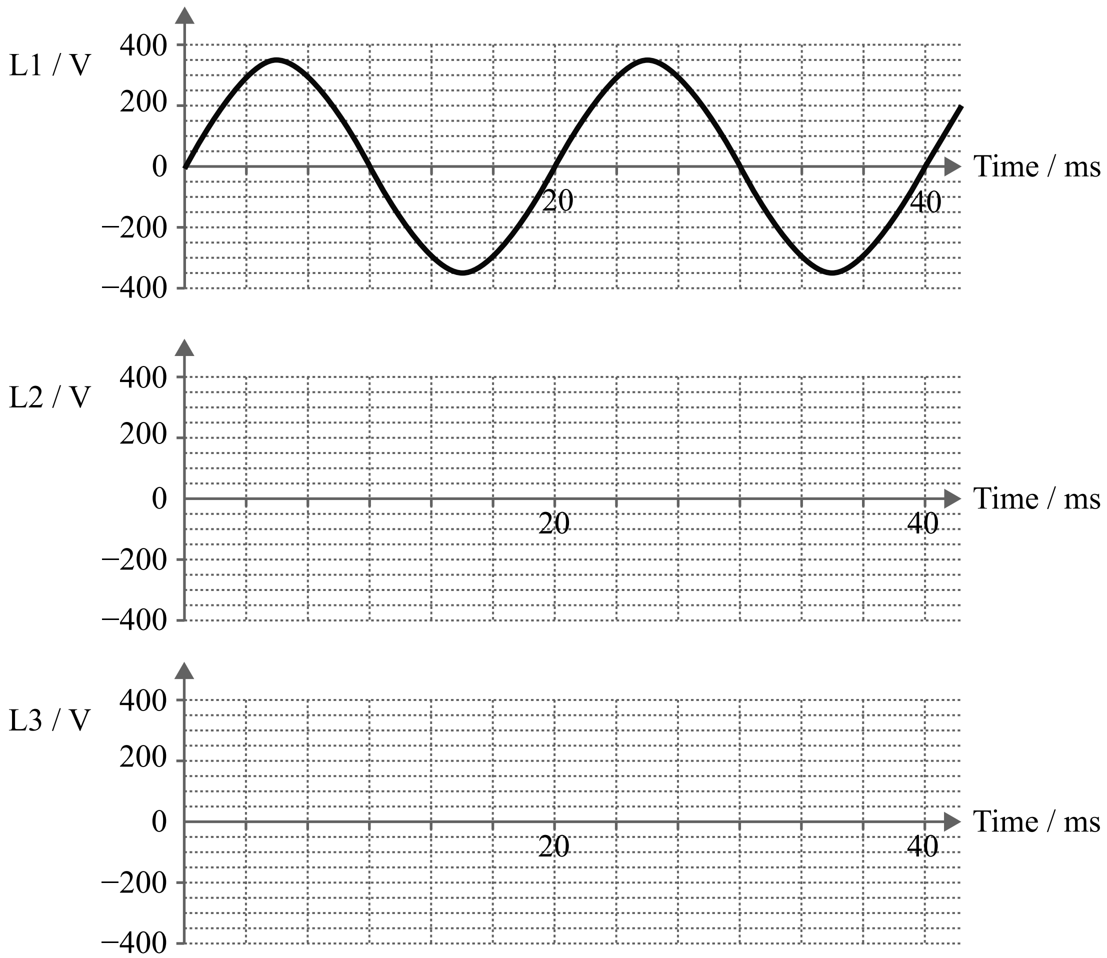
.... **[1]**

(ii) State **one** advantage of using a three phase 4-wire system.

....

.... **[1]**

(iii) Complete the graphs for L2 and L3 to show how the voltage varies with time for each of the phases in a three phase supply.



[3]

(b) Many electronic devices require a low voltage direct current supply to be produced from a high voltage alternating current supply.

(i) Describe alternating current.

....

.... **[1]**

(ii) Describe direct current.

....

.... **[1]**

(iii) Draw on **Fig. 4** to show how a single diode can be used to make a rectifier to convert alternating current to direct current.

Fig. 4

[2]

(iv) Explain how your circuit rectifies alternating current into direct current.

....

....

....

.... **[3]**

5 An amplifier is used to amplify the signal from a microphone. The system is shown in **Fig. 5**.

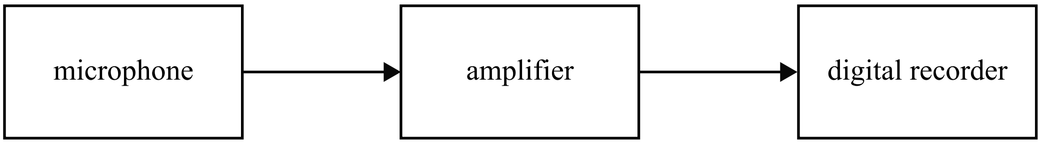


Fig. 5

(a) Use the equation: Voltage gain $= \frac{V_{out}}{V_{in}} = -\frac{R_F}{R_{in}}$

(i) The signal from the microphone has an amplitude of 8 mV.

The signal to the digital recorder has an amplitude of 0.4 V.

Calculate the voltage gain of the amplifier.

Voltage gain = ... **[1]**

(ii) An op-amp inverting amplifier is used for the amplifier in **Fig. 5**.

Calculate resistor values to produce the required voltage gain.

R_F = ...Ω

R_{in} = ...Ω
[1]

(b) **(i)** Complete the circuit diagram in **Fig. 6** of the op-amp inverting amplifier.

Label the connections to the microphone and digital recorder.

Label the resistors with their values.

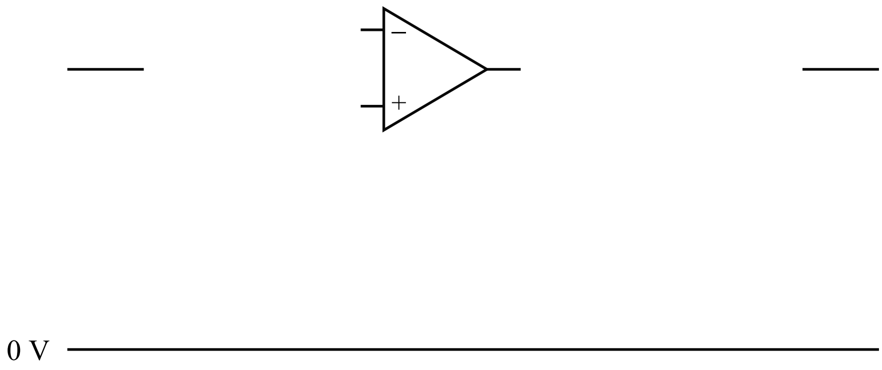


Fig. 6

[5]

(ii) State **two** different ways that you could change your completed circuit to increase the gain of the amplifier.

1 ....

....

2 ....

....

[2]

6 The circuit symbol for a rising edge triggered D-type flip-flop is shown in **Fig. 7**.

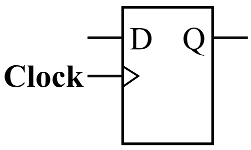


Fig. 7

(a) **Fig. 8** shows a timing diagram for a rising edge triggered D-type flip-flop.

The **D** and **Clock** signals have been completed; **Q** starts at logic 1.

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

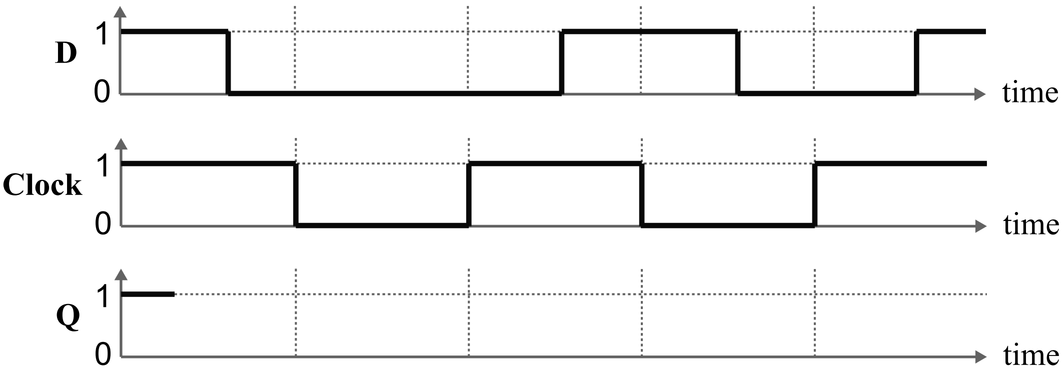


Fig. 8

[2]

(b) A logic system turns a security lamp on when it is dark and movement is sensed.

A diagram of the system is shown in **Fig. 9**.

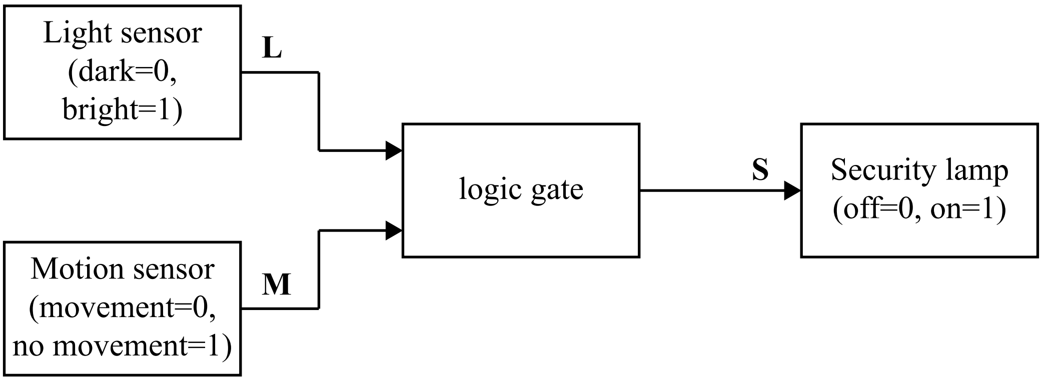


Fig. 9

(i) Complete the truth table for the logic gate that will make the security lamp turn on only when it is dark and movement is sensed.

L	**M**	**S**

[2]

(ii) Name the logic gate in **Fig. 9**.

.... **[1]**

(iii) Draw the circuit symbol for the logic gate used in **Fig. 9**.

[1]

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

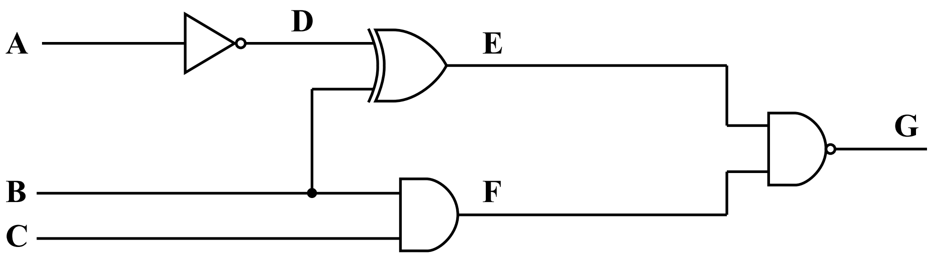


Fig. 10

Complete the truth table for this logic circuit.

A	**B**	**C**	**D**	**E**	**F**	**G**
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

[4]

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(b).

C304/2301