CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

# ENGINEERING

05822–05825, 05873

## Unit 4 January 2023 series

Version 1

# Contents

# Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

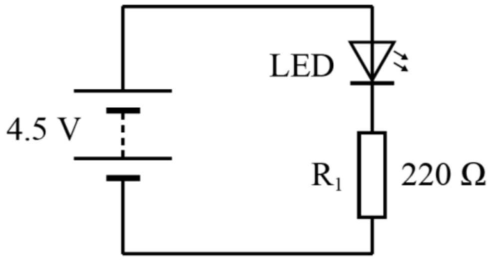
# Unit 4 series overview

The vast majority of candidates found this paper accessible with very few instances of no response observed. Candidates were able to recall key definitions and diagrams with the higher ability able to explain the function of key components and apply the correct equations to circuits.

| Candidates who did well on this paper generally did the following: | Candidates who did less well on this paper generally did the following: |
|---|---|
| • had learned definitions and key information from the specification (e.g. advantages of single and three phase power)<br>• had brought a pencil and eraser to the exam and used these to clearly draw diagrams and graphs<br>• read the question carefully following instructions on how to label diagrams, when to give units, etc. | • did not consider the number of marks allocated to a question when formulating a response<br>• did not give a clear enough response e.g. giving "cheaper" as an advantage with no explanation as to why it is cheaper<br>• were unable to recall circuit symbols or draw diagrams accurately<br>• did not show full working out for calculations or performed incorrect algebraic manipulation of equations. |

## Question 1 (a)

**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]**

The vast majority of candidates answered this question successfully. Some arithmetic errors were observed and candidates should be encouraged to use their calculators for these simple subtractions to avoid this.

## Question 1 (b)

**(b)** Calculate the current through the LED.

Give the units for your answer.

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

The most common error was to use the 1.2V diode voltage rather than the resistor voltage from Question 1 (a) and known resistance. Most candidates that gave a unit were credited for it but a significant minority omitted the unit showing it is important to read the question carefully.

## Question 1 (c)

**(c)** Calculate the power dissipated in the LED.

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

The majority of candidates were given the mark here for multiplying their Question 1 (b) by the 1.2V to find the power dissipated.

## Question 1 (d)

**(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 $R_1$.

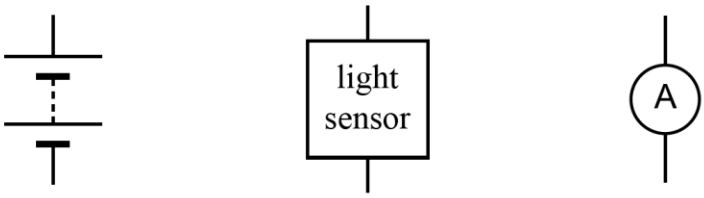
Smallest value for $R_1$ = ................................................ Ω **[3]**

The majority of candidates converted successfully to Watts but there are a significant minority that need more confidence in using prefixes. Most of the calculation errors were either from using the incorrect voltage (that across the LED not the resistor) or an incorrect algebraic manipulation of the formula.

## Question 1 (e)

**(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]**

Many candidates were able to connect the components in series. This was made more difficult by the placement of the components but similar questions have been set in previous examinations so candidates should be familiar with how to tackle these. Those candidates that redrew the circuit moving the components to a more convenient location had not adequately answered the question and could not be credited.

## Question 1 (f)

**(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.

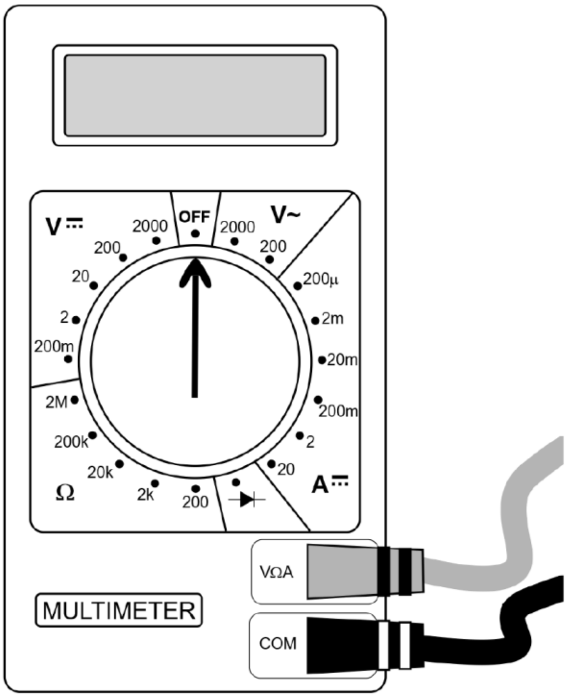



**Fig. 1a**

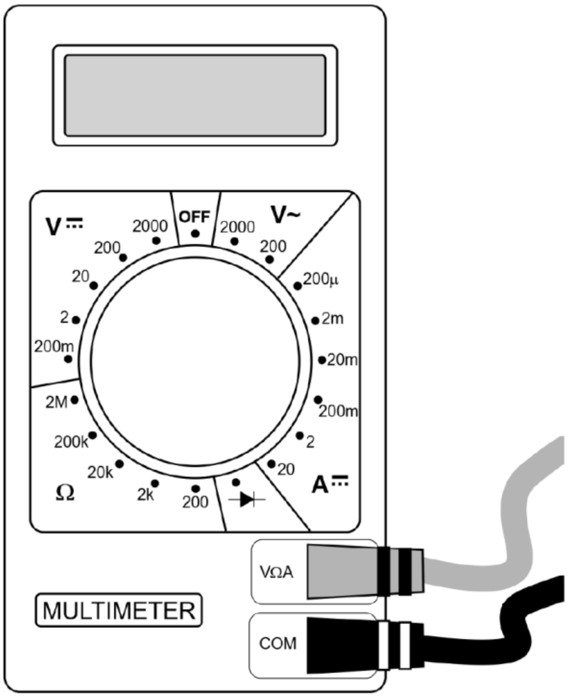



**Fig. 1b**

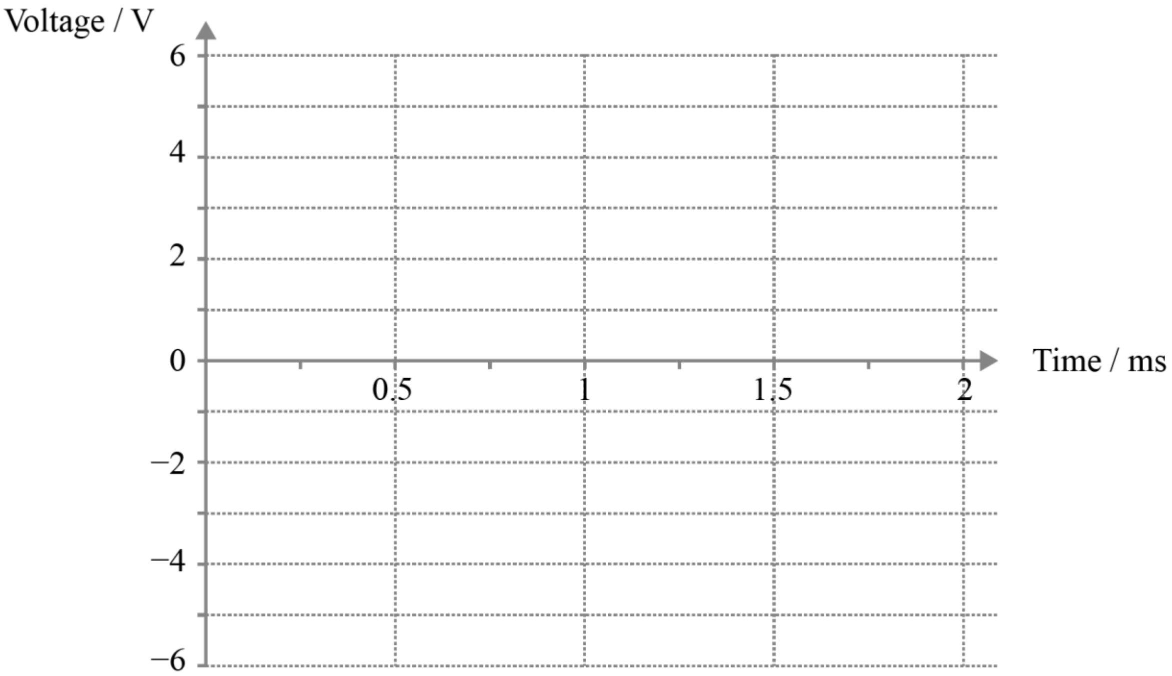
**[1]**

Many candidates were able to identify the setting to be used. The majority of incorrect responses were to choose the closest value of 200µ rather than the closest value above the measured value, or to attempt to draw the arrow where 250µA would appear on the scale (i.e. between two settings).

## Question 2 (a)

**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.



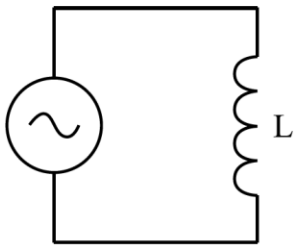

**[3]**

The majority of candidates were credited with drawing a sine wave oscillating from -4 to 4. The third mark point proved more difficult with even candidates that had calculated the correct period often then choosing to draw a period of 1ms or 2ms. Candidates that attempted the wave in pencil were also more successful.

## Question 2 (b)

**(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]**

The resistor symbol was well drawn by the vast majority of candidates with the capacitor symbol proving more of a challenge.

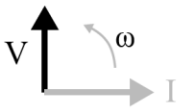
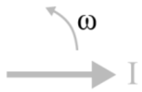
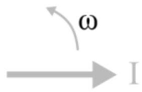
### Assessment for learning

Candidates should be familiar with the symbols for key components in this topic.

## Question 2 (c)

**(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]**

Candidates were less successful with the resistor phasor diagram than the capacitor with a minority gaining full marks.

## Question 2 (d)

**(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]**

A minority of candidates were able to state the impedance of the resistor as 360Ω with many attempting a calculation attempting to include extra components in this purely resistive circuit. Candidates that selected the correct equation for the capacitor and did not include any other components were usually given the mark. Most candidates were given the unit mark for the resistor with a minority able to recall the units of capacitance.

### Assessment for learning

Units should be learned for all electrical quantities.

Candidates should be familiar with the conversion of prefixes to standard form.

## Question 3 (a)

**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.

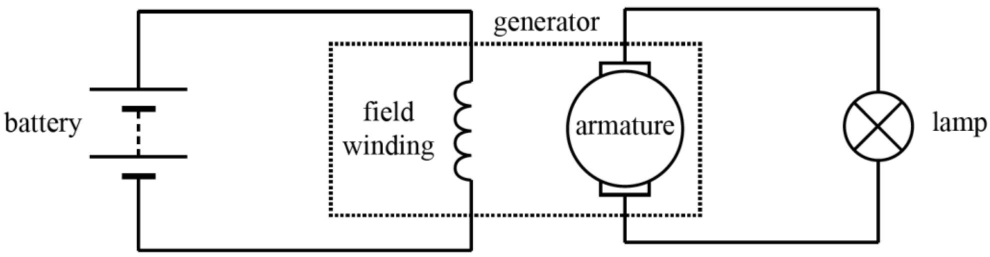



**Fig. 2**

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

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

The majority of candidates were able to calculate the current using Ohm's Law with the most common error being to add the armature resistance to the field winding resistance.

## Question 3 (b) (i)

**(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]**

The vast majority of candidates were able to use the power formula to calculate the armature current.

## Question 3 (b) (ii)

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

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

This question was handled less successfully with common mistakes being to use the formula for a motor rather than a generator, substituting the incorrect value for voltage or incorrectly rearranging the formula. Responses that showed clear working and substituted before rearranging were more likely to be given marks.

## Question 3 (c)

**(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]**

**Misconception**

A significant number of candidates gave responses discussing a motor showing confusion between motors and generators. There were also many responses discussing the slowing down of armature rotation even though the question states this was not the case. The vast majority of candidates were able to be given the mark for stating that the brightness decreases with the further 2 marks proving more challenging.

## Question 3 (d)

**(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.

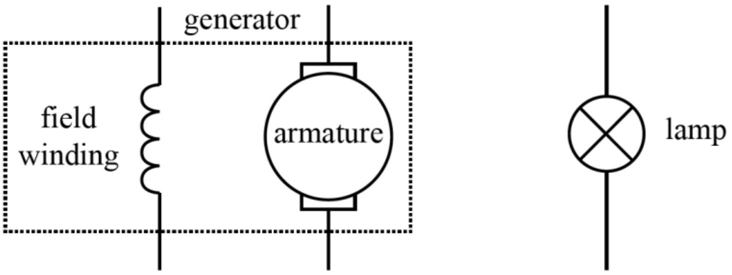



**Fig. 3**

**[2]**

Although many candidates were able to draw a series circuit there were a significant number drawing shunt wound or including a power supply into the circuit.

## Question 4 (a) (i)

**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]**

Many candidates were able to clearly state an advantage. The mark was not given for vague explanations such as "cheaper" without an explanation as to why. A minority of candidates attempted to mention the safety of single over three phase power and were not given the mark for their response.

## Question 4 (a) (ii)

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

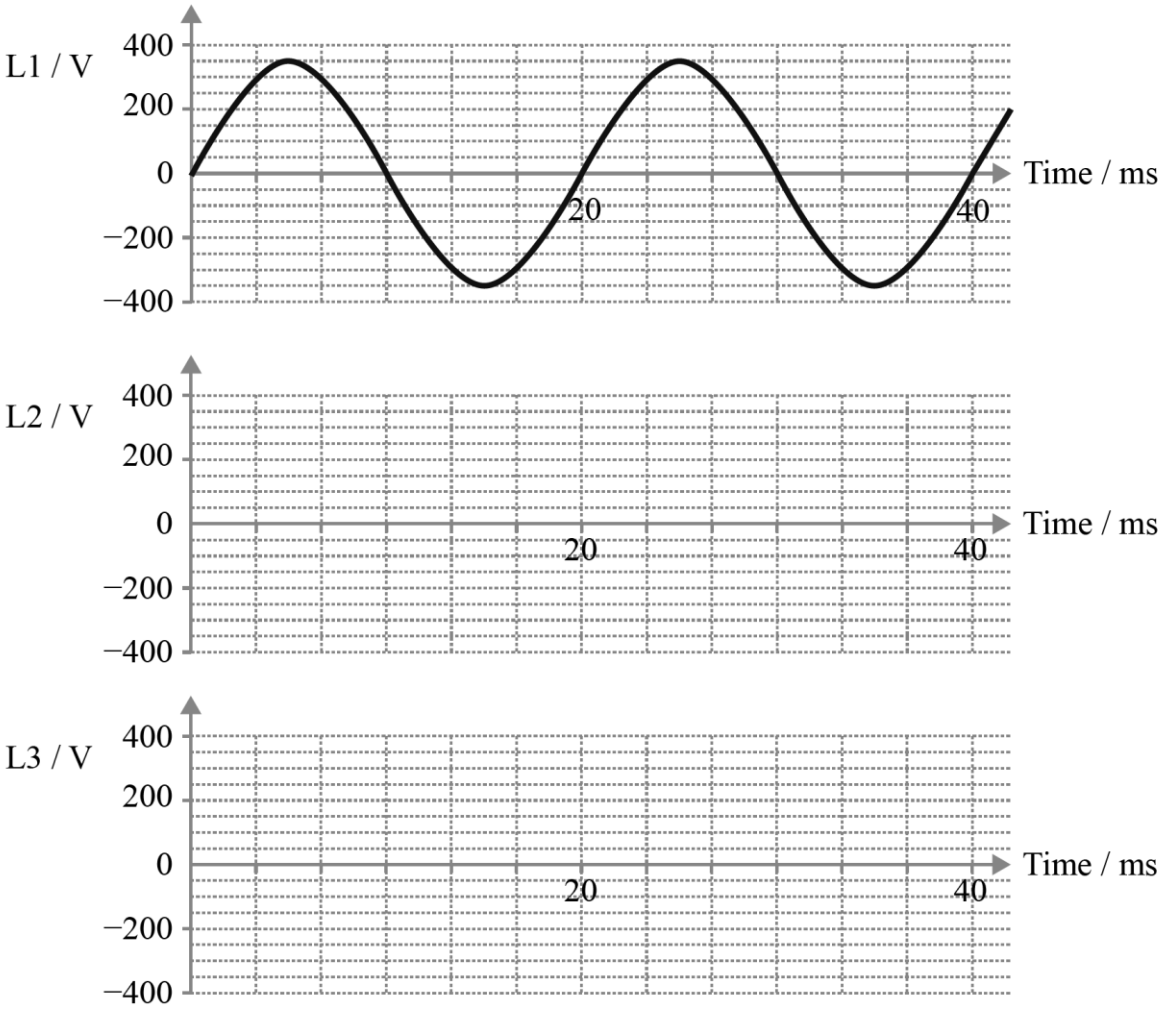
..........................................................................................................................

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

As with Question 4 (a) (i) the mark was not given for short statements e.g. "cheaper" without a qualifying statement and it appeared that some candidates were confusing single and three phase supplies with AC and DC.

## Question 4 (a) (iii)

**(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]**

Many candidates were able to draw Level 2 and Level 3 as sine waves with the same period and amplitude as Level 1. The second 2 mark points were less successful with a minority of candidates able to draw the waves each out of phase by 120° (the most common response was phase differences of 90° and 180°).

**Assessment for learning**

Successful candidates drew their waves in pencil, marking with a cross the key points e.g. peaks and troughs before then joining them with a smooth curve.

## Question 4 (b) (i)

**(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]**

Many candidates were given this mark for responses which had to be clear that the current was changing direction periodically.

## Question 4 (b) (ii)

**(ii)** Describe direct current.

..........................................................................................................................

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

**Misconception**

The vast majority of responses were successful but there was still a significant number stating the misconception that direct current flows directly to the component taking the shortest/quickest route.

## Question 4 (b) (iii)

**(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]**

The majority of candidates completed the circuit successfully for 2 marks.

## Question 4 (b) (iv)

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

..................................................................................................................................

..................................................................................................................................

..................................................................................................................................

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

Many candidates missed that this was a 3 mark question, with many simply stating that the diode allowed current to flow in one direction. Responses that were given full marks clearly explained how the diode conducted when in forward bias, during the positive half of the wave cycle or when current was flowing clockwise round the circuit and that it did not conduct during the negative half of the wave cycle so there was no anticlockwise flow of current.

## Question 5 (a) (i)

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

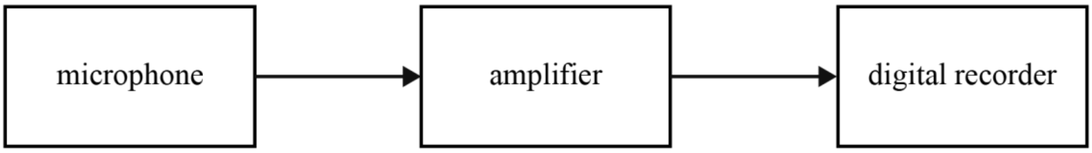



**Fig. 5**

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

**(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]**

The majority of candidates were able to calculate the gain with the most common errors being not to handle the prefix appropriately or to take the microphone voltage as the output and digital recorder as the input. Also, although gain is dimensionless, many candidates gave an answer in volts.

## Question 5 (a) (ii)

**(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]**

This question was well handled although a substantial amount of responses gave a negative value for the resistance of the resistor.

## Question 5 (b) (i)

**(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.

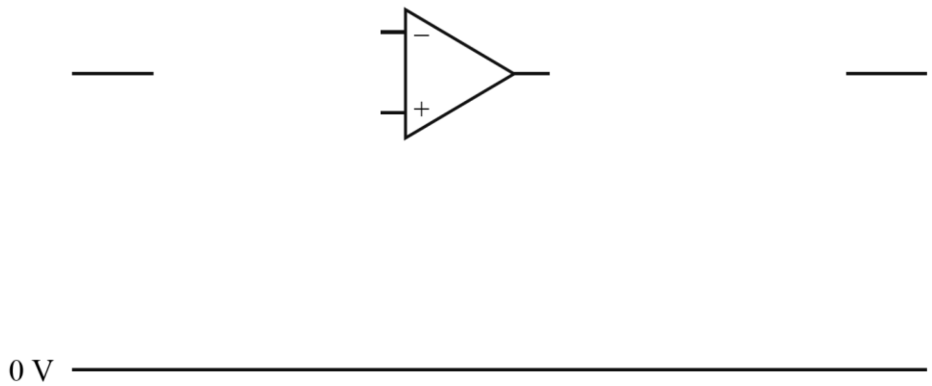



**Fig. 6**

**[5]**

A substantial amount of candidates did not read the question carefully and did not label the connections to the microphone and digital recorder, instead labelling them as input and output. Also, the values of the resistors were required on the diagram and this was often omitted. Several instances of positive feedback were also noted.

## Question 5 (b) (ii)

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

1 ..........................................................................................................................

..........................................................................................................................

2 ..........................................................................................................................

..........................................................................................................................

**[2]**

Many responses were given marks here, although a common error was to state that resistance should be increased or decreased but not stating which particular resistor. There were also many responses referring to changing input voltages which was incorrect.

## Question 6 (a)

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

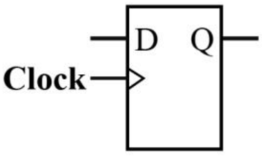



**Fig. 7**

**(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.

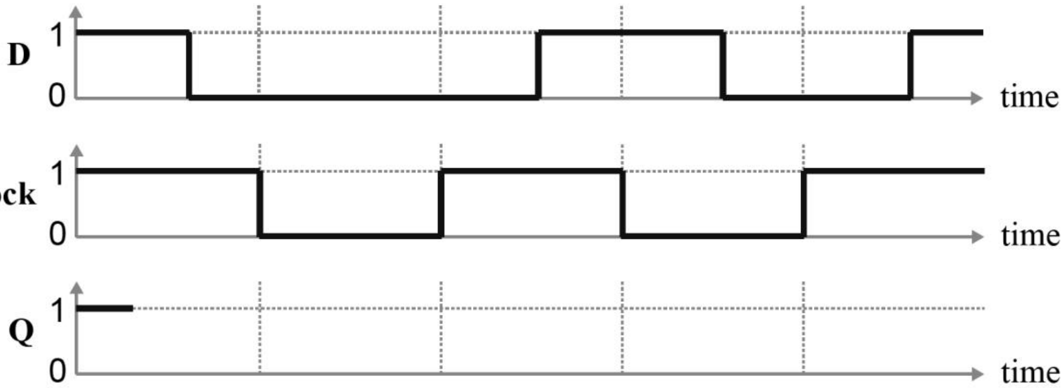



**Fig. 8**

**[2]**

A lower performance was noted on this question which showed a range of marks given to candidates.

## Question 6 (b) (i)

**(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**.

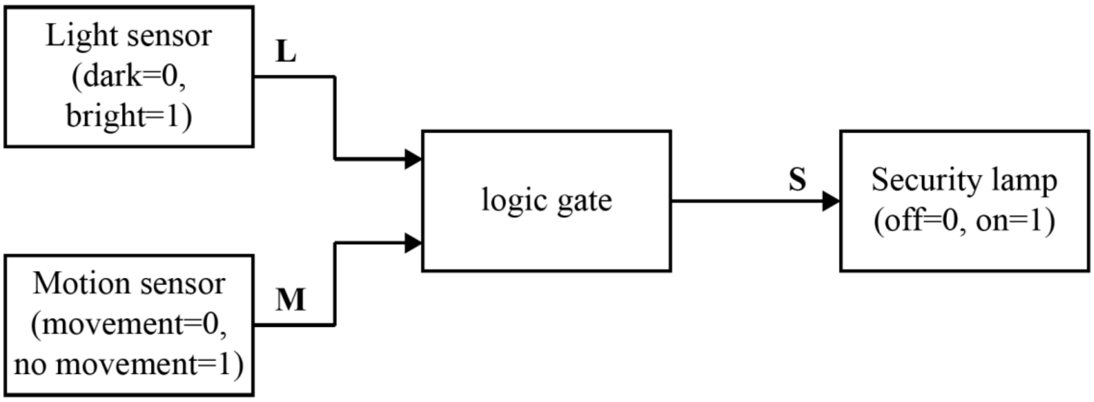



**Fig. 9**

**(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]**

Almost all candidates were able to complete columns L and M correctly. The majority were also able to complete column S to show a NOR gate with the most common error being to provide the response for an AND gate.

## Question 6 (b) (ii)

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

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

The majority of candidates that had the correct truth table were able to identify it as a NOR gate although other answers were observed with the most common error being to identify it as a NAND gate.

## Question 6 (b) (iii)

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

**[1]**

Many candidates were able to draw the symbol for a NOR gate but a substantial amount of drawings were ambiguous, highlighting the importance of clear diagrams. Very few responses clearly labelled the inputs as L and M and the output as S even though it was clearly referring to the gate in Fig.9.

## Question 6 (c)

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

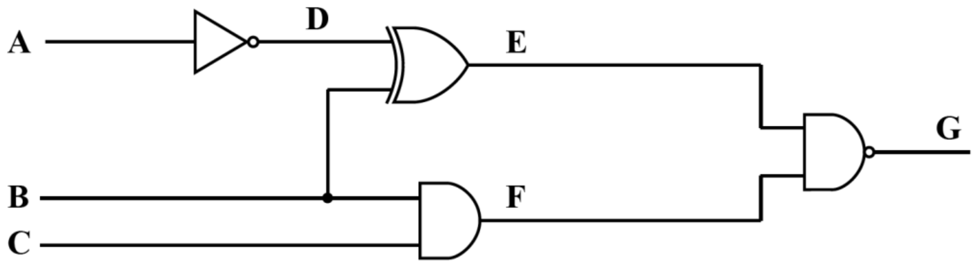



**Fig. 10**

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]**

Many candidates were given full marks with the XOR and NAND gate proving the most challenging.

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