CAMBRIDGE TECHNICALS

OCR
Oxford Cambridge and RSA

Examiners' report

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

ENGINEERING

OCR Level 3 Cambridge Technical in Engineering Principles

Certificate: 05822

OCR Level 3 Cambridge Technical in Engineering

Extended Certificate: 05823

Foundation Diploma: 05824

Diploma: 05825

Extended Diploma: 05873

Unit 4 Summer 2025 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 Teach Cambridge.

Unit 4 series overview

This paper was accessible to the majority of candidates with very few no responses given to candidates that didn't attempt a question and therefore left it blank. Candidates were able to display their knowledge on the topics in a variety of ways both through calculation and explanation. Questions where candidates had to complete electric or electronic diagrams allowed them to demonstrate their practical knowledge of these.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• were confident enough in their understanding that they could apply their knowledge to new situations, e.g. understanding how a series-wound motor would operate under no load conditions • had memorised the op amp circuit diagrams/understood how to construct them and completed the diagram neatly and accurately • were able to substitute into and rearrange formula correctly • were able to select the correct formula from the formula booklet.	• were unable to handle power of ten prefixes successfully • lacked confidence in completing circuit diagrams resulting in responses being crossed out and reattempted or short circuits being included in the diagram • had not memorised the truth tables for the given logic gates • had not learned the definitions in the specification, e.g. that for the motor or generator • did not show working out for calculation questions.

Question 1 (a)

1 A student takes measurements on a battery.

(a) The battery provides current to resistor R_1.
An ammeter measures current through the resistor.
Complete the diagram below by adding a symbol for the ammeter and the connections needed to measure current through resistor R_1.

[2]

Although the majority of candidates were able to draw an ammeter in series with the other components a large minority showed the ammeter incorrectly connected in parallel across the resistor.

Question 1 (b) (i)

(b) The ammeter shows a current of 34 mA when a 220 Ω resistor is used.

(i) Calculate the voltage across the 220 Ω resistor.

voltage across 220 Ω resistor = ... V **[2]**

Most candidates were able to successfully apply Ohm's law with the most common error being in the conversion of mA to A.

Question 1 (b) (ii)

(ii) Calculate the power dissipated in the 220 Ω resistor.

power dissipated in the 220 Ω resistor = ... W **[1]**

Most candidate were able to correctly calculate the power dissipated.

Question 1 (c) (i)

(c) The student changes the value of the resistor in the circuit and takes some more measurements.

(i) Complete the table of results below by calculating the missing values in the last **three** rows.

resistor value / Ω	current / mA	voltage across resistor / V	power dissipated in resistor / W
22	132	2.9	0.39
33	114	3.8	0.43
47	97	4.5	0.44
68		5.4	0.42
100	62		0.38
150	46	6.9	

....

....

....

....

[3]

Most candidates were given marks for this question. There was a substantial number of power of ten errors from the mA conversion.

Assessment for learning

Candidates should commit the common prefixes to memory and be confident using them. In questions like this where there is a table of results candidates should be shown how to check their results against the others in the same column as this can be helpful in identifying power of ten errors.

Question 1 (c) (ii)

(ii) The student was told that the internal resistance of the battery should be about 47 Ω. Explain how the student's results support what they were told about the battery.

....

....

....

.... **[2]**

Candidates that identified this question was in regard to max power theorem scored well. Most were able to identify that maximum power transfer occurred at resistance of 47 Ohms. A large number of candidates then misunderstood the data in the table assuming these were values of internal rather than load resistance and so did not score full marks for stating that max power transfer occurs when load resistance equals internal resistance.

Question 2 (a)

2 A student investigates a circuit with an inductor, capacitor and resistor in series with an AC supply.

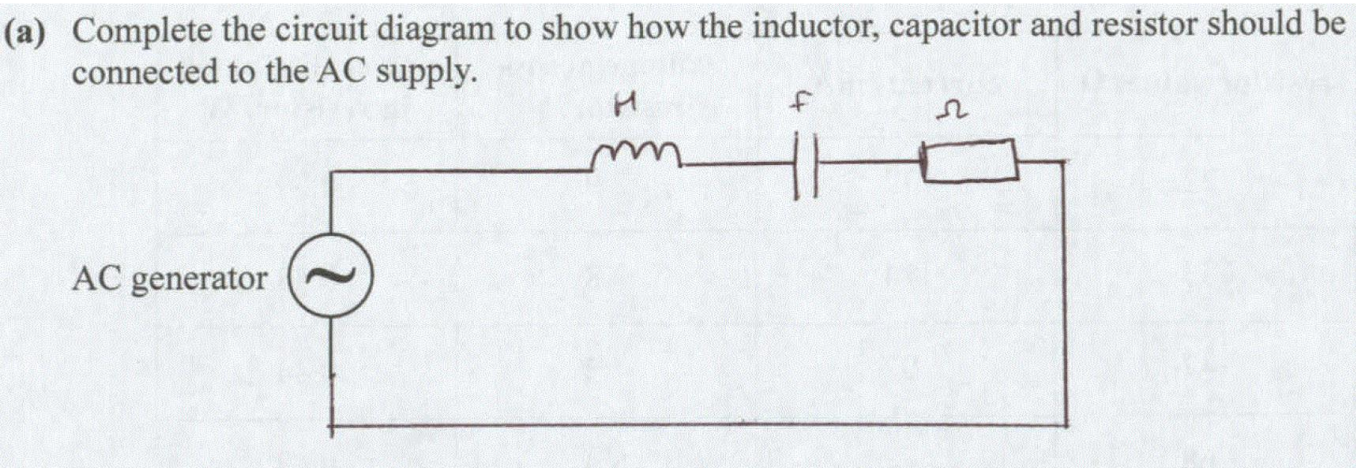
(a) Complete the circuit diagram to show how the inductor, capacitor and resistor should be connected to the AC supply.

AC generator 

[4]

The resistor symbol was drawn successfully by almost all candidates. The capacitor and inductor proved more challenging with many candidates missing them out altogether, making up their own symbol or in the case of the capacitor drawing an ambiguous symbol that could be mistaken for a cell.

Exemplar 1


(a) Complete the circuit diagram to show how the inductor, capacitor and resistor should be connected to the AC supply.

The candidate here has clearly drawn each of the symbols required and used a ruler.

Question 2 (b)

(b) The student uses an inductor of value $L = 220\,\mu\text{H}$.

Calculate the reactance of the inductor, X_L, when the frequency of the AC supply is $f = 350\,\text{Hz}$.

X_L = ... Ω **[2]**

The equation was well applied by most, however a large number of candidates made a power of ten error for the incorrect conversion of micro-Henry to Henry.

Question 2 (c)

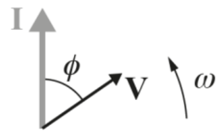
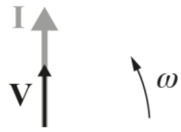
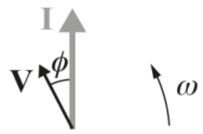
(c) The student investigates the effect of changing the frequency, f, of the AC supply on the phase angle, ϕ, between the voltage and current from the AC supply.

The values of the resistor, capacitor and inductor are as follows:

- $R = 3.3\,\Omega$
- $C = 3.2 \times 10^{-4}\,\mathrm{F}$
- $L = 220\,\mu\mathrm{H}$

Calculate the missing values to complete the table.

Include the units for your phase angles.

frequency f/Hz	reactance of inductor X_L/Ω	reactance of capacitor X_C/Ω	impedance of series RLC circuit Z/Ω	phase angle ϕ	phasor diagram
100	0.14	5.0	5.9		
600	0.83	0.83		0°	
1450	2.0		3.7		

....

....

....

....

[4]

Candidates struggled with these more difficult formulae with those showing working out tending to be more successful. Common errors included the attempted calculation of impedance in an RLC circuit but using the formula for a RI or RC circuit thus omitting a value of reactance.

Question 3 (a)

3 A series-wound DC motor is used to drive an electric scooter.

(a) The scooter uses a 24 V battery to supply electricity to the motor.

The armature has a resistance of 6.0 Ω and a field coil resistance of 0.5 Ω.

When the scooter is travelling at 15 mph the EMF generated in the armature, $E = 19$ V.

Use the equation for the DC series-wound motor to calculate the armature current, I_a.

I_a = ... A **[3]**

This equation was handled much better by candidates than in previous series although many did struggle with the rearrangement of the equation.

Question 3 (b)

(b) The instructions for the scooter contain a warning that the motor should not be connected to the battery when the wheels are not in contact with the ground.

Explain the reason for the warning in the instructions by referring to the behaviour of a series-wound DC motor.

....

....

.... **[2]**

This was a difficult question for most candidates. Many recalled that a series-wound DC motor had a high torque on startup/at low speeds or commented that the speed of the motor would get faster and faster with no load but fewer were able to show an understanding of the circuit by commenting on the effect on current, EMF, etc. Common misconceptions were that there would be a high current or that the ground that was being referred to was electrical ground as opposed to the surface the scooter was to be ridden on.

Question 3 (c) (i)

(c) When users want to slow down the scooter, they operate a switch that disconnects the battery and connects the motor to a resistor.

The motor then behaves as a series-wound self-excited DC generator.

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

....

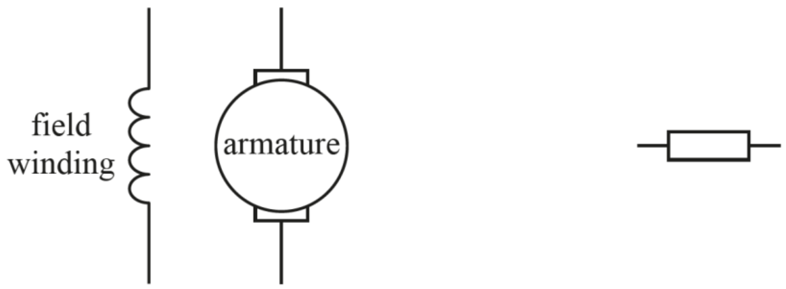
....

.... **[2]**

Candidates will have seen this question before in past series and although the majority were able to give the correct response there was a significant minority that were unsure of the definitions of a motor and a generator.

Question 3 (c) (ii)

(ii) Complete the diagram to show how the armature and field winding of the series-wound self-excited DC generator should be connected to the resistor.



[1]

Candidates should be able to connect components in series even if they are laid out in an unusual manner like this, but many were unable to do so and instead connected components in parallel or included short circuits. Some successful candidates drew the more common rectangular series circuit next to the response and this may have assisted them in deciding on the correct connections.

Question 3 (c) (iii)

(iii) Complete the sentences to explain how the series-wound DC generator is used to slow down the scooter.

Choose words from the following list.

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

decreases **increases** **maintains** **oscillates**

Connecting the resistor to the generator causes a large current to flow through the field winding, which .... the EMF generated in the armature and the voltage from the generator causing heating of the resistor. This .... the torque required to turn the generator and decreases the speed of the scooter.

[2]

Most candidates scored at least one mark here with a small minority achieving full marks.

Question 4 (a)

4 A farm is supplied with electricity using a single phase 3-wire system.

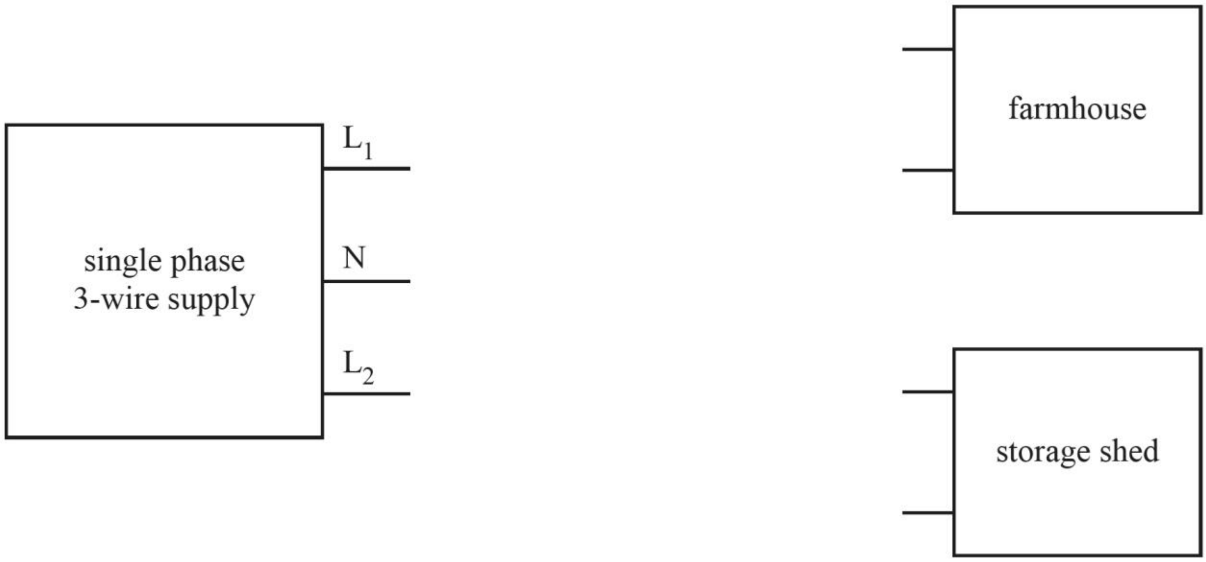
The electricity supply has a neutral wire, N, and two live wires, L_1 and L_2.

The voltage between a live wire and the neutral wire is 230 V AC.

One of the live wires is used to supply 230 V AC electricity to the farmhouse where the people live.

The other live wire is used to supply 230 V AC electricity to the storage shed for fridges that keep the produce fresh.

(a) Show how L_1, L_2 and N should be connected to the farmhouse and to the storage shed.



[2]

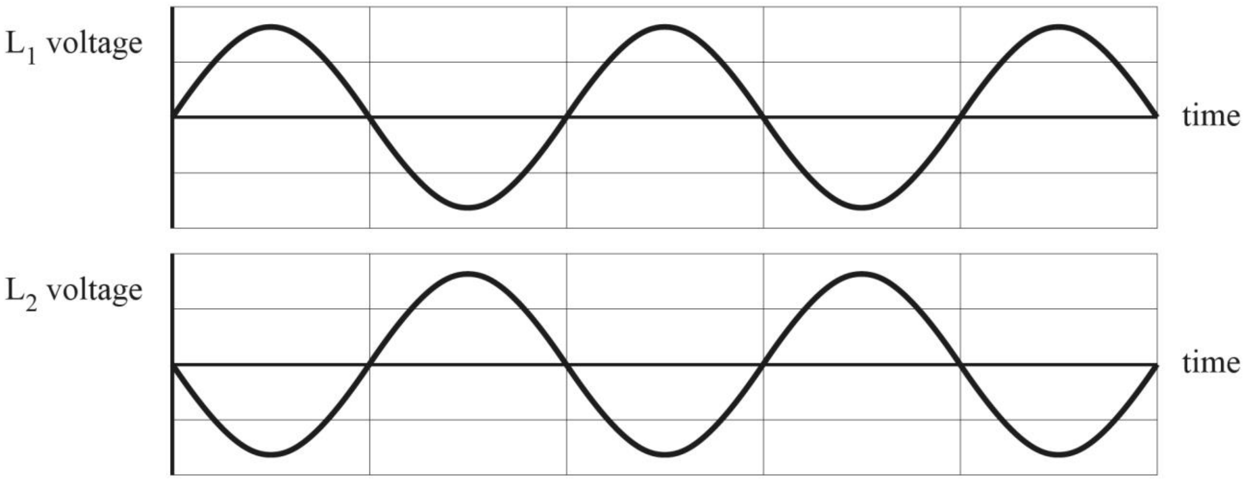
The majority of candidates were able to draw the connections correctly but although it is possible to give the correct response without crossing lines some struggled with how to show if crossed lines meant wires were or were not connected.

Assessment for learning

As part of drawing electrical and electronic diagrams candidates should be shown how to show if crossed lines indicate wires that are connected or separate, e.g. by using a dot to indicate a connection or a bump to indicate one wire is passing over the other without being connected.

Question 4 (b)

(b) The graphs below show how the voltages of L_1 and L_2 vary with time.



State the phase difference between L_1 and L_2.

.... **[1]**

Many candidates were able to give the correct answer of 180 degrees with the most common incorrect responses being either 90 degrees or an attempt to answer the question as a fraction of a wavelength rather than an angle.

Question 4 (c)

(c) The fridges and power supply are protected by a circuit breaker.

Explain how the circuit breaker protects the power supply and fridges.

....

....

.... **[2]**

The majority of candidates were able to answer this question correctly however many referred to a fuse rather than a circuit breaker or gave the explanation that 'a circuit breaker breaks the circuit' which is not enough to be given marks.

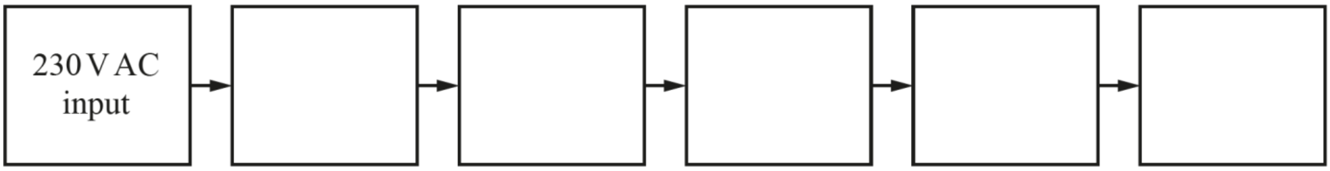
Question 4 (d)

(d) The fridges are controlled by an electronic circuit that operates from 5 V DC.

Complete the block diagram of a stabilized power supply for the electronic circuit.

Choose from the terms below.

DC output	**rectifier**	**smoothing circuit**	**stabilising circuit**	**star**	**transformer**



[5]

This question was well answered with the most common error being the stabilising and smoothing circuits being in the incorrect order.

Question 5 (a)

5 An engineer is building an op-amp inverting amplifier to amplify the signal from a force sensor.

The op-amp inverting amplifier has a voltage gain of –20.

The equation of the amplifier is given by:

$$\textit{Voltage Gain} = \frac{V_{out}}{V_{in}} = -\frac{R_F}{R_{in}}$$

(a) The input voltage of the amplifier, $V_{in} = 160\,\text{mV}$.

Calculate the output voltage of the amplifier, V_{out}.

$V_{out} =$ .... V **[3]**

Most candidates were able to use the given equation to calculate Vout with the most common errors being the incorrect conversion of mV to V and giving a positive value as the final answer (even if a negative value was calculated).

Question 5 (b)

(b) The engineer uses a feedback resistor, $R_F = 100\,k\Omega$.

Calculate the value of the input resistor, R_{in}, in ohms.

R_{in} = ... Ω **[2]**

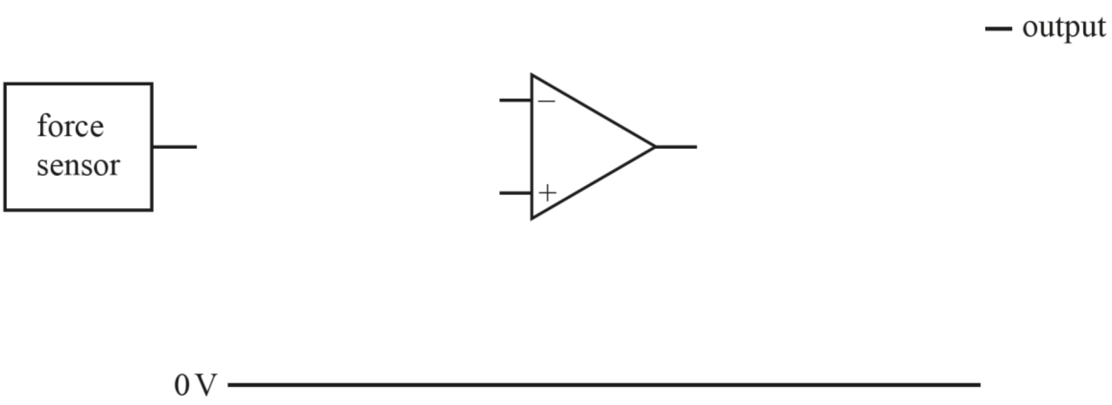
The conversion of kilo Ohms to Ohms was generally well handled although a significant number of candidates ended up with a negative value for resistance which they gave on the answer line even although this could not be the correct value as resistance is always positive.

Question 5 (c)

(c) Complete the circuit diagram of the op-amp inverting amplifier.

Show the connections to the force sensor and the output.

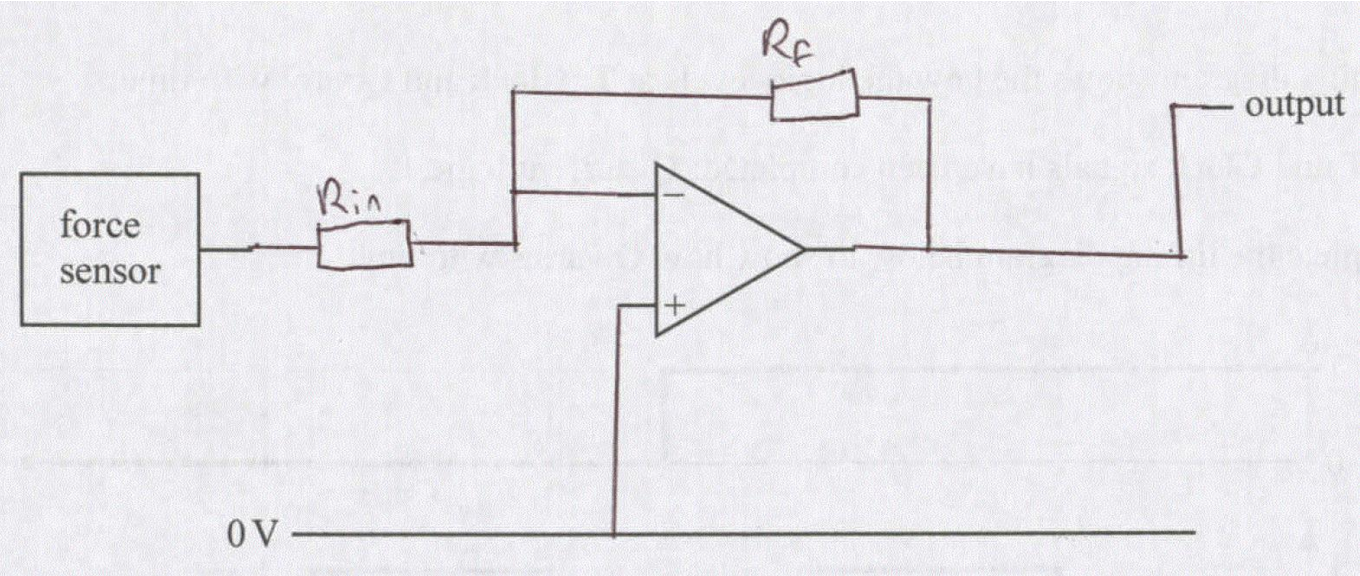
Label the resistors R_F and R_{in}.



[5]

Although this question has appeared many times in previous series candidates still struggled with completing the electronic diagram. Most were given the marks for correct connection of output and inverting input with the negative feedback loop proving the most challenging mark to get.

Exemplar 2

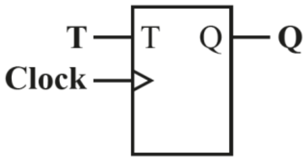


The candidate has clearly drawn the resistors and connections neatly with a ruler.

Question 6 (a)

6

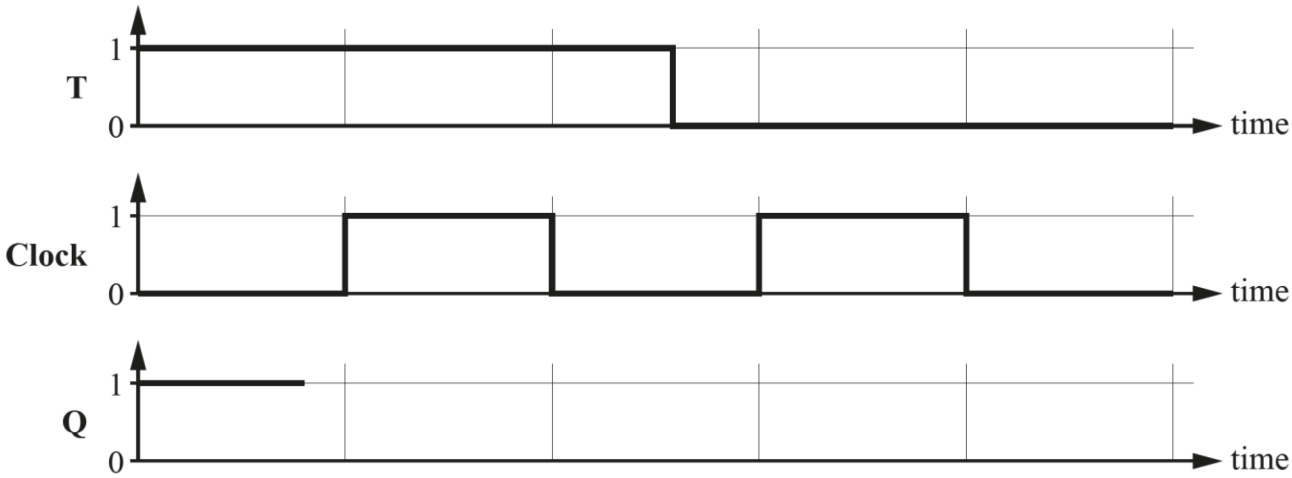
(a) The circuit symbol for a rising edge triggered T-type flip-flop is shown below.



A timing diagram shows the how the logic levels at **T**, **Clock** and **Q** vary with time.

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

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



[2]

A small minority of candidates were able to complete the diagram successfully.

Question 6 (b) (i)

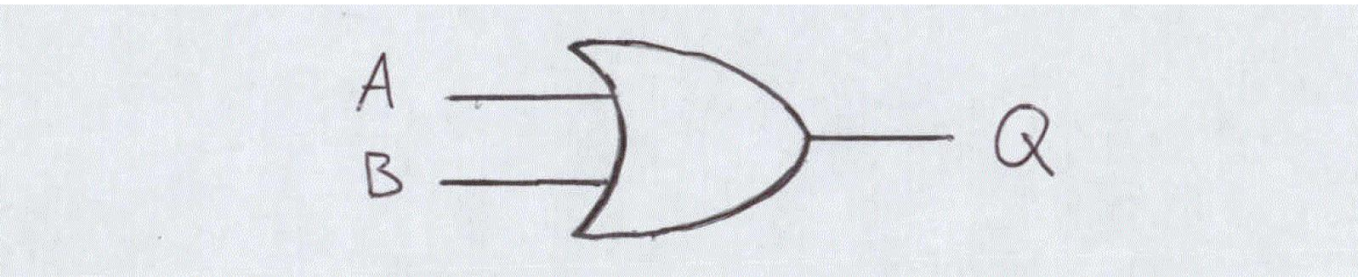
(b) An OR gate with output **Q** and inputs **A** and **B** is used in a circuit.

(i) Draw the circuit symbol for an OR gate.

[1]

The majority of candidates were able to draw the gate successfully however there were a minority of diagrams that were not clearly an OR gate and could also have been an AND gate. It is important that candidates practice clearly drawing the gates listed on the specification so that there is no ambiguity in their drawings.

Exemplar 3



There is no ambiguity here this is clearly an OR gate.

Question 6 (b) (ii)

(ii) Complete the truth table for an OR gate.

A	B	Q

[2]

Most candidates were able to successfully complete the truth table.

Question 6 (b) (iii)

(iii) Which of the following is the correct Boolean expression for an OR gate?

Tick (✓) **one** box.

$\mathbf{Q = A \cdot B}$ ☐

$\mathbf{Q = A + B}$ ☐

$\mathbf{Q = A \oplus B}$ ☐

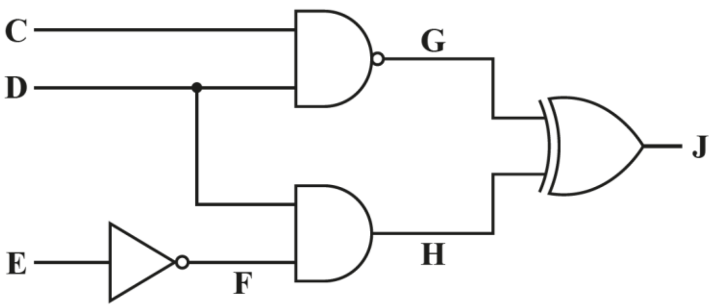
$\mathbf{Q = \overline{A \cdot B}}$ ☐

[1]

Many candidates were able to identify the correct expression with the most common incorrect responses being that for an AND gate then XOR,

Question 6 (c)

(c) A logic circuit is shown below.



Complete the truth table for the logic circuit.

C	D	E	F	G	H	J
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]

Column F was completed correctly by most candidates with G then J offering the most challenge.

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