CAMBRIDGE TECHNICALS

OCR
Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 4 Summer 2024 series

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. A selection of candidate answers is also provided. 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

Candidates were able to attempt all of the questions with limited no responses observed and with a good spread of marks across the ability range.

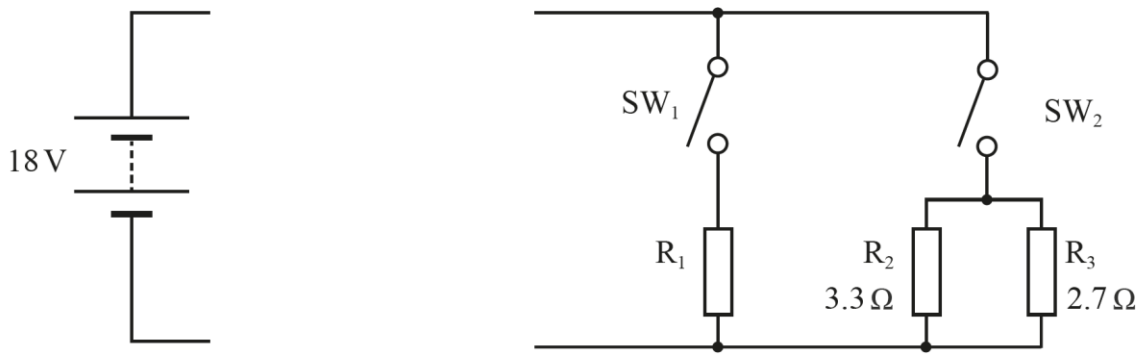
Calculations were well answered with many showing the required level of working out and giving accurate responses although some units are still not well recalled.

Candidates found it more difficult to tackle the explanation/definition questions by using the correct engineering terminology.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• had come prepared with the correct equipment (pencil and eraser) to be able to tackle the diagram/graphical questions • clearly crossed out prior responses before replacing them (particularly in truth tables) • had learned the circuit diagrams and symbols outlined in the specification • read the question carefully and answered fully, in particular if units were asked to be given or components labelled with their values.	• were unable to recall the correct units for variables • did not consider prefixes in calculations • did not show full working out for calculations or performed incorrect algebraic manipulation of equations • tried to give definitions as a long explanation in their own words rather than a standard definition using engineering terminology.

Question 1 (a)

1 An incomplete circuit diagram of an electric heater is shown below.



(a) Complete the circuit diagram so that current flows through the resistors when switches SW_1 and SW_2 are closed.

Include an ammeter and a voltmeter in the circuit to measure the circuit current and the battery voltage.

[2]

This question was well attempted by the majority of candidates. Common errors were ammeters drawn in parallel/voltmeters drawn in series.

Question 1 (b)

(b) Calculate the current though R_2 when switch SW_2 is closed.

Current through R_2 = ... A **[1]**

This was successfully attempted by the majority of candidates.

Question 1 (c)

(c) Calculate the power dissipated by R_2 when switch SW_2 is closed.

Power in R_2 = ... W **[1]**

Most candidates were able to apply a power equation successfully.

Question 1 (d)

(d) Calculate the combined resistance of R_2 and R_3 in parallel.

Resistance of R_2 and R_3 in parallel = ... Ω **[2]**

Most candidates were able to achieve marks on this question with a notable minority giving the answer for 1/R instead of R.

Question 1 (e) (i)

(e) When switch SW_1 is closed and switch SW_2 is open the power dissipated in R_1 is 1.1 kW.

(i) Calculate the value of R_1.

Value of R_1 = ... Ω **[2]**

Those candidates that chose to start with P=IV to find the current were less successful as many stopped there giving the current value as the final answer rather than using it to find R. Those that chose the equation linking P, V and R were more likely to achieve full marks.

Question 1 (e) (ii)

(ii) Calculate the energy dissipated by R_1 when the switch is turned on for 8 minutes.

Give the units for your answer.

Energy = ... **[3]**

The majority of candidates converted the time into seconds and applied the correct equation. Marks were lost mainly on the incorrect selection of units for energy.

Question 2 (a)

2

(a) What is 'a simple AC generator'?

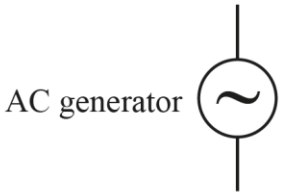
.....

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

The majority of candidates gave a response describing the conversion of mechanical/kinetic energy to electrical energy.

Question 2 (b)

(b) The diagram below shows a simple AC generator symbol.



Draw on the diagram to show a 330 Ω resistor and a 6.8 μF capacitor connected in series with the AC generator.

Label the resistor and the capacitor with their values.

[2]

In this question often candidates did not know the symbol for the capacitor.

Assessment for learning

Candidates are expected to be able to draw electrical components symbols.

Question 2 (c) (i)

(c) The AC generator produces a sine wave of frequency 120 Hz.

(i) Calculate the reactance of the capacitor (X_C) at 120 Hz.

Reactance of capacitor (X_C) = ... Ω **[2]**

The majority of candidates were able to successfully use the values given (including use of the micro prefix) and the correct equation for a correct response.

Question 2 (c) (ii)

(ii) State the reactance of the resistor at 120 Hz.

Reactance of resistor = ... Ω **[1]**

Very few candidates were able to state that the reactance of a resistor was zero Ohms. Of those that saw the 'state' command, the vast majority opted for the value of the resistor's resistance, with many calculations demonstrated.

Question 2 (c) (iii)

(iii) Calculate the impedance of the resistor and capacitor in series at 120 Hz.

Impedance of resistor and capacitor = ... Ω **[2]**

This was typically handled well by candidates with error carried forward allowed from their capacitor reactance.

Question 2 (c) (iv)

(iv) Calculate the phase angle ϕ between the voltage from the generator and the current through the resistor and capacitor.

Give the units for your answer.

ϕ = ... **[2]**

Candidates struggled with the application of this formula and the successful responses often lost a mark due to the omission of units.

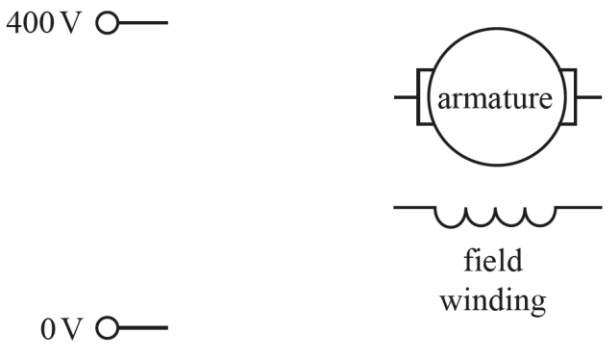
Question 3 (a) (i)

3 A factory uses a conveyor belt to move parts to a packaging machine at a steady speed.

(a) A shunt-wound DC motor is used to operate the conveyor belt in the factory.

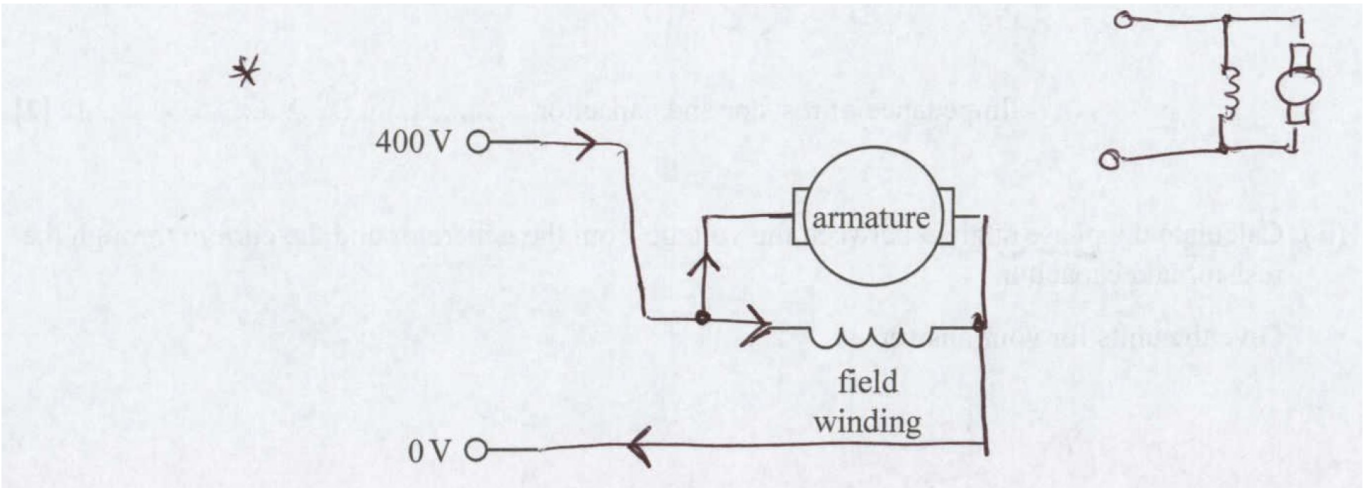
The motor is operated from a 400 V power supply.

(i) Draw on the diagram below to show how the field winding and armature in a shunt-wound DC motor should be connected to a 400 V power supply.



[1]

Exemplar 1



This type of question is often asked but often candidates struggle to make the correct connections. In Exemplar 1 the candidate has drawn the circuit in a more recognisable format to the right of the page then used this to complete the appropriate connections as asked. This proved to be a successful strategy (although current direction was not asked for and is not required here).

Question 3 (a) (ii)

(ii) Suggest why a shunt-wound DC motor was used for the conveyor belt rather than a series-wound DC motor.

.....

.....

.....

..... **[2]**

Candidates who realised the key point was the constant speed required for the conveyor belt were able to achieve at least 1 mark. Those making comment on the performance of a shunt and series were not able to gain full credit.

Assessment for learning

When a question asks why one device is chosen as opposed to another, typically the candidate should be looking to give a comment on each type of device.

Question 3 (a) (iii)

(iii) The field winding has a resistance (R_f) of 10 kΩ.

Calculate the current in the field winding (I_f) when it is connected to the 400 V supply.

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

This question was answered well by the majority of candidates.

Question 3 (a) (iv)

(iv) The armature has a resistance (R_a) of 12 Ω.

When the motor is running at full speed the current in the armature (I_a) is 2.0 A.

Calculate the EMF (E) in the shunt-wound DC motor when the motor is connected to the 400 V supply and running at full speed.

Give the units for your answer.

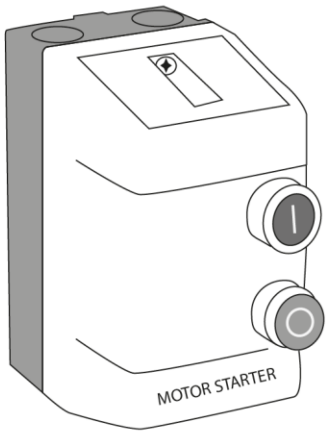
E = ... **[3]**

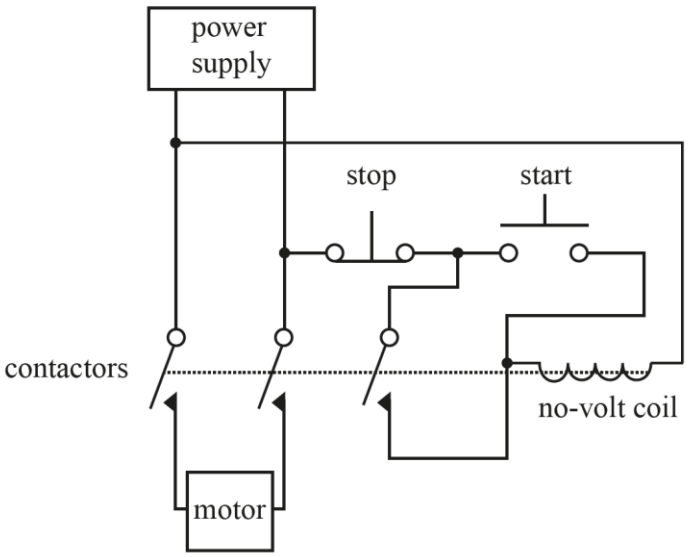
This tricky rearrangement was handled well by many candidates, although the units of EMF do not appear to be well known and a large minority of candidates selected an incorrect formula.

Question 3 (b)

(b) The motor for the conveyor belt is controlled by a motor starter containing a no-volt coil.

The diagram shows the motor starter and its circuit diagram.





Complete the sentences below using the most appropriate word in each gap.

Choose words from the following list.

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

oscillating **reversed** **stopped** **turning**

When the start switch is pressed, the motor starts turning. After the switch is released, the motor is ..... .

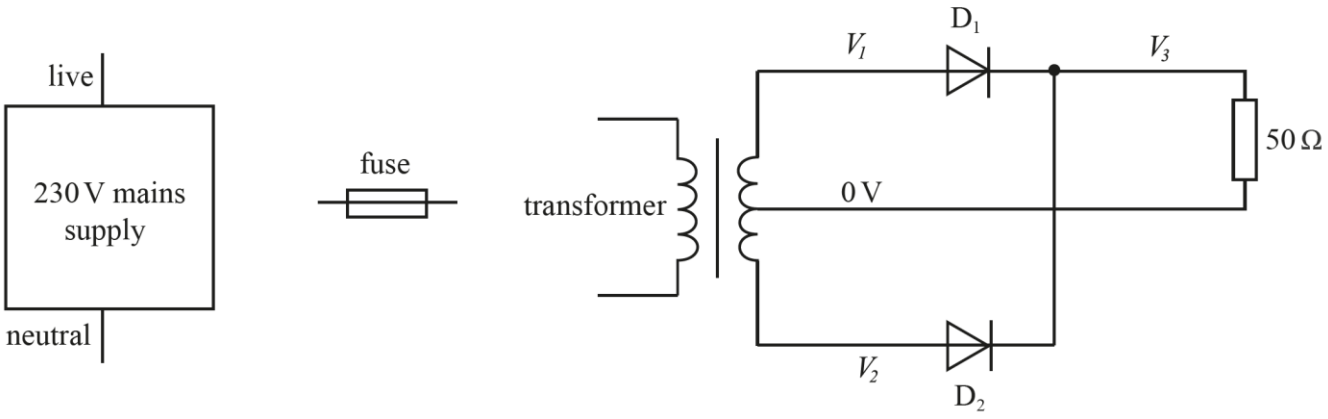
The motor is turning when the power supply fails and provides no power to the motor for 15 minutes. After the power supply is restored, the motor will be ..... .

[2]

For this question, full marks were only gained by a minority of candidates. The most common incorrect response was the reversal of stopped and turning. A significant number of candidates selected the incorrect responses of oscillating and reversed.

Question 4 (a) (i)

4 The diagram below shows an incomplete circuit diagram for a power supply.



(a) The circuit is protected by a fuse.

(i) Draw on the diagram above to show how to connect the 230 V mains supply, fuse and transformer.

[2]

This question was answered well by most candidates, even though quite a few either connected both the live and neutral wires to the same side of the fuse or created a short circuit.

Question 4 (a) (ii)

(ii) Explain how the fuse protects the circuit.

.....

.....

.....

..... **[2]**

Most candidates were awarded marks on this question; the most successful candidates clearly stated that the heating effect of an unusually high current causes the fuse to melt creating a gap in the circuit and therefore preventing the flow of current from damaging the components.

Question 4 (a) (iii)

(iii) Circuit breakers are sometimes used instead of fuses.

State **one** advantage of using a circuit breaker instead of a fuse.

.....

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

Most candidates responded with the fact that a circuit breaker can be reset once the fault has been repaired whereas the melted fuse would have to be replaced. Any explanations of other advantages were often unclear.

Question 4 (b) (i)

(b) The diodes in the power supply form a rectifier.

(i) State the purpose of the rectifier in a power supply.

.....

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

Many candidates were able to recall the purpose of a rectifier.

Question 4 (b) (ii)

(ii) Which of the sentences most appropriately describes the state of the diodes in the power supply when $V_1 = +55\,V$ and $V_2 = -55\,V$?

Tick (✓) **one** box.

Both D_1 and D_2 are conducting ☐

D_1 is conducting but D_2 is not conducting ☐

D_2 is conducting but D_1 is not conducting ☐

Neither D_1 nor D_2 are conducting ☐

[1]

All four responses were seen. Some candidates appeared to have sketched the path of the current on the diagram which may have helped.

Question 4 (c) (i)

(c) A 2200 µF capacitor is added to the circuit in parallel with the 50 Ω resistor to smooth the output of the power supply.

(i) Calculate the time constant (τ) of the RC circuit.

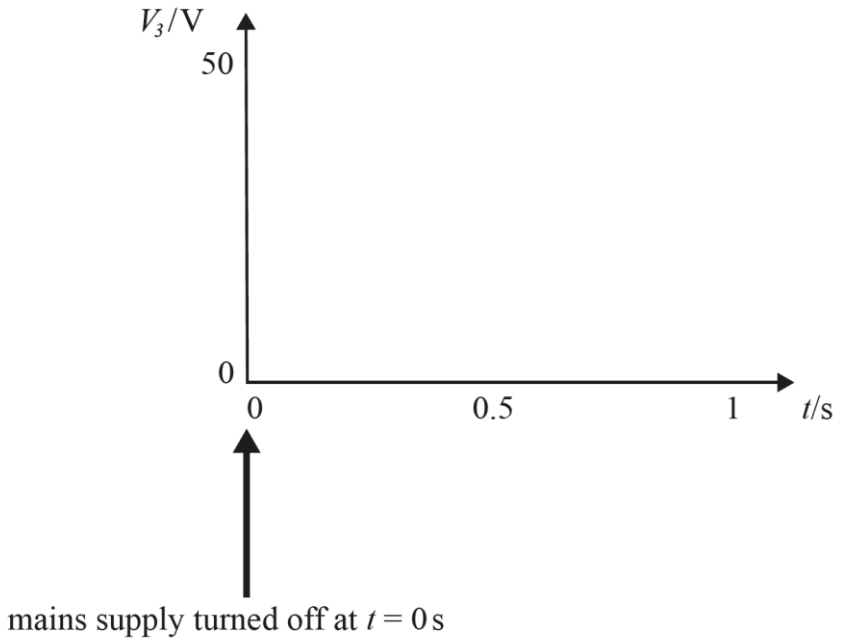
τ = ... s **[1]**

Calculation was typically handled well with errors made more in the use of the micro prefix than application of the formula.

Question 4 (c) (ii)

(ii) Sketch a graph below to show how the voltage across the capacitor (V_3) changes with time (t) when the mains supply to the power supply is turned off.

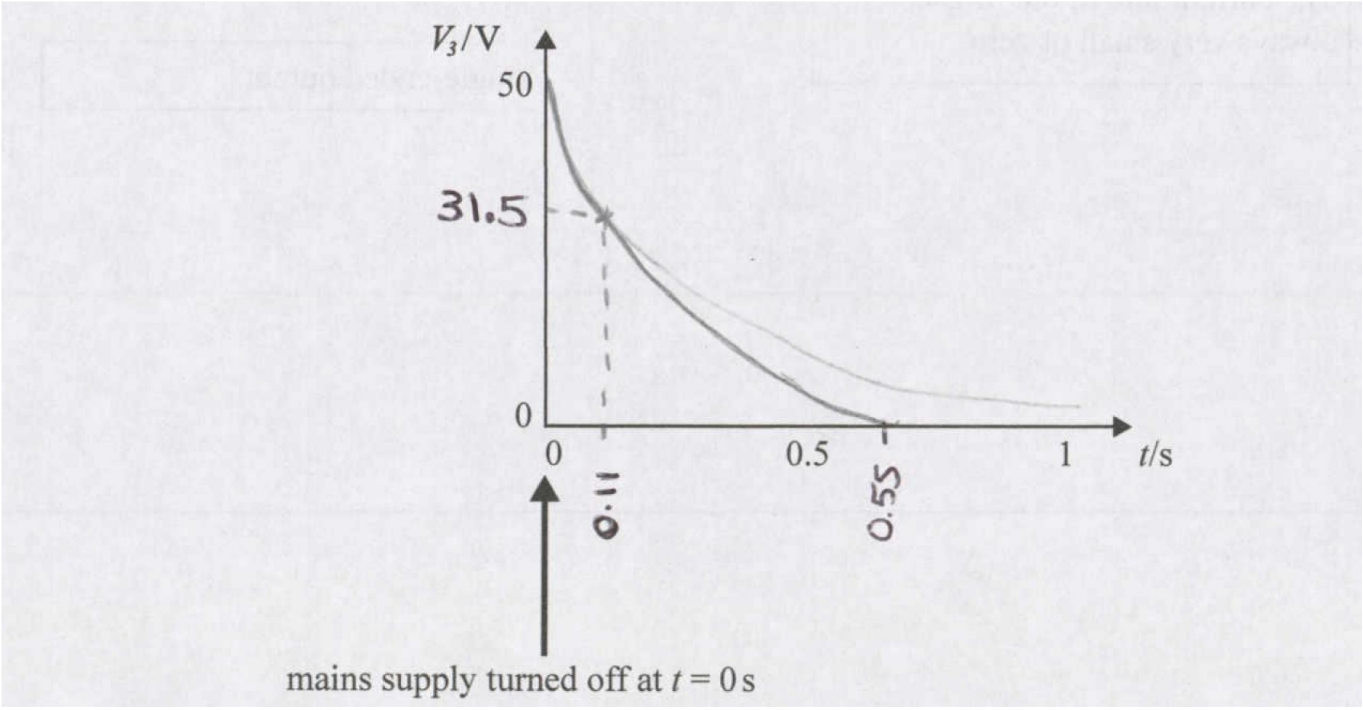
The voltage V_3 is 50 V when the mains supply is turned off at time $t = 0$ s.



[2]

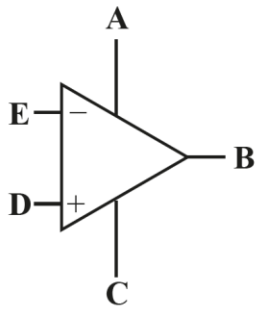
Only a small minority of candidates was awarded full marks on this question, which needed knowledge from Unit 2. Successful candidates recalled (or used the formula booklet to realise) that this is an exponential decay curve. Some also recalled that the capacitor would be discharged after 5 time constants and could effectively show this shape, as shown in Exemplar 2.

Exemplar 2



Question 5 (a)

5 The diagram below shows the symbol of an operational amplifier (op-amp).



(a) Identify the connections on the op-amp by putting the appropriate letters in the answer spaces.

Input connections: ..... and ..... .

Output connection: ..... .

Supply voltage connections: ..... and ..... .

[2]

The correct output connection was identified by all but a few with the majority of candidates having a successful attempt at recognising the other connections.

Question 5 (b)

(b) Draw a line in the diagram below to join each behaviour of an op-amp to the most appropriate characteristic of an op-amp.

There will be one characteristic with no connecting line.

Behaviour of an op-amp	Characteristic of an op-amp
	High input impedance.
A significant current can flow into or out of B.	
	Low output impedance.
The current into or out of E is always very small or zero.	
	Single-ended output.

[2]

Only a few candidates were able to select the correct characteristics related to the stated behaviours.

Question 5 (c) (i)

(c) An inverting op-amp is used to amplify the signal from a temperature sensor.

The voltage gain of the inverting op-amp is −12.

The formula for the voltage gain of an inverting op-amp is:

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

(i) Calculate the output voltage (V_{out}) of the op-amp when the signal from the temperature sensor is 0.3 V.

Output voltage (V_{out}) = ... V **[1]**

The majority of candidates were able to use the formula to calculate voltage. However, many omitted the negative sign in their final answer.

Question 5 (c) (ii)

(ii) Draw the circuit diagram of an inverting op-amp with a voltage gain of −12.

Label all components with suitable values.

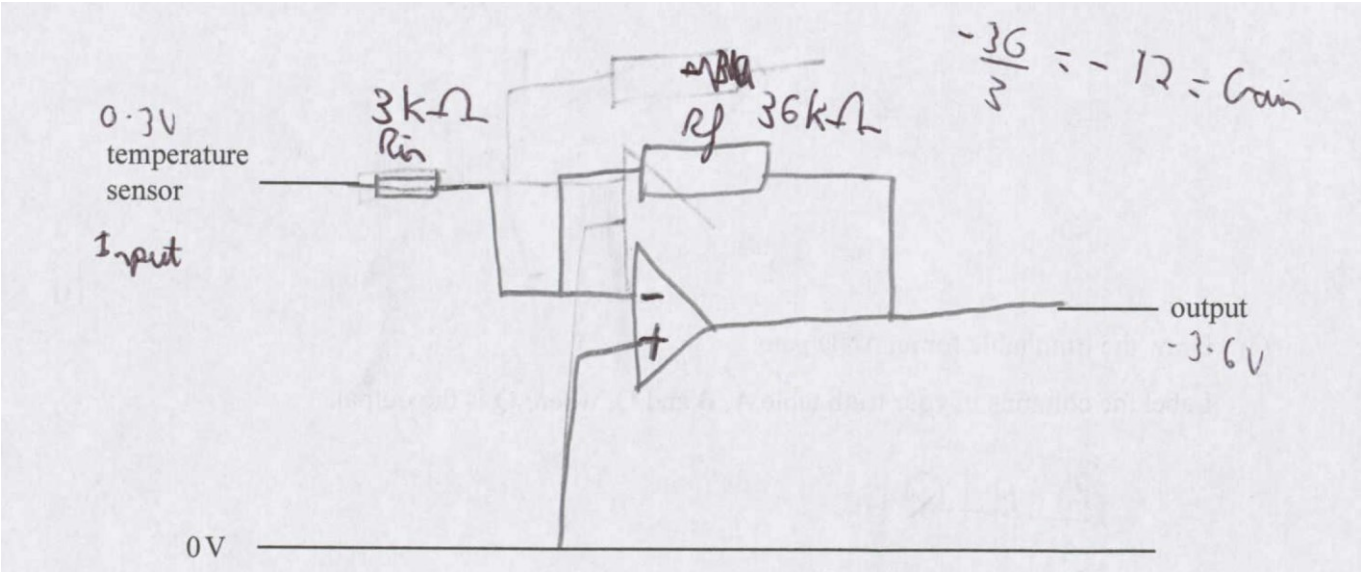
Draw the connections to the 0 V, output and temperature sensor.

[5]

Candidates in general had not adequately learned the inverting op-amp circuit to enable them to draw it without aid. Most could draw the op amp symbol but there were many responses where the feedback loop did not connect to the inverting input or wasn't shown at all. Although the question asked for components to be labelled with suitable values very few candidates labelled the resistors with a calculated value.

Exemplar 3 shows a full mark answer.

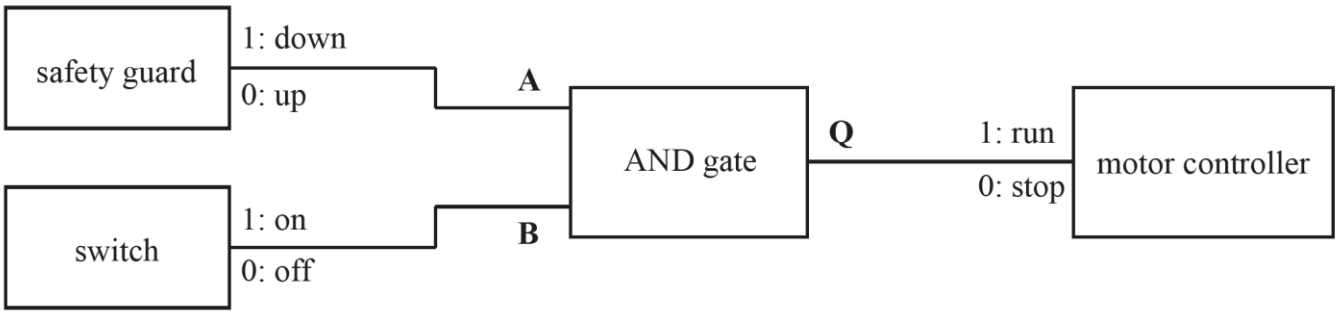
Exemplar 3



Question 6 (a) (i)

6

(a) The block diagram below shows a digital electronic circuit to control the motor in a drill.



(i) State what 'digital electronic circuit' means.

.....

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

Candidates in general struggled with this question and there were a wide variety of responses.

Assessment for learning

The definition of a digital electronic circuit is given in the specification. Candidates should commit this definition to memory in addition to others found there as they could be asked to recall it.

Question 6 (a) (ii)

(ii) Give an example from the diagram to show that this is a digital electronic circuit.

.....

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

Successful candidates were those that gave a clear example from the diagram. Others attempted an explanation of the circuit similar to the previous question which could not be awarded marks.

Question 6 (b)

(b) Draw the symbol for an AND gate in the space below.

[1]

Most candidates successfully drew the AND gate with marks mostly lost for the omission of input and output connections.

Question 6 (c)

(c) Draw the truth table for an AND gate.

Label the columns in your truth table **A**, **B** and **Q**, where **Q** is the output.

[2]

Most candidates were able to recall the truth table for the AND gate.

Question 6 (d)

(d) Describe the conditions needed for the motor to run.

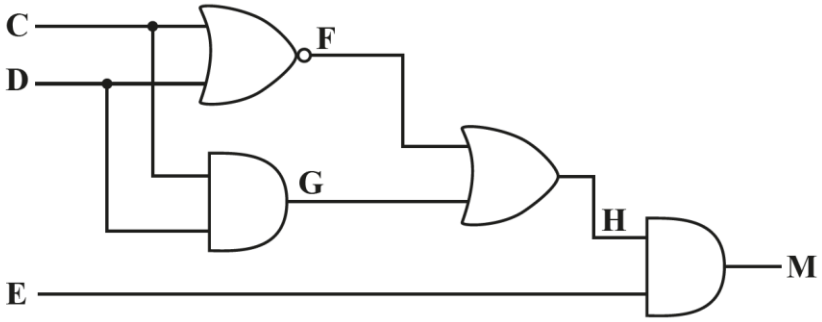
.....

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

The majority of candidates were able to give the conditions required.

Question 6 (e)

(e) The diagram below shows a logic circuit.



Complete the truth table for the logic circuit.

C	D	E	F	G	H	M
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]

This question was well attempted in general, with the NOR gate causing most difficulty.

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