CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 4 January 2025 series

Version 1

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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.

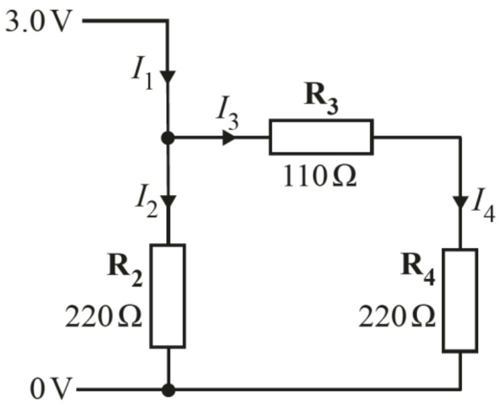
Unit 4 series overview

The paper was accessible to candidates, with most attempting all questions. Candidates were familiar with the formula sheet, successfully transferring the appropriate information across and using it in calculations. The different question styles were able to give candidates the opportunity to demonstrate their various skills and knowledge within the topic.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• included formula, working out process and answer in calculation questions and completed unit conversions as needed • completed diagrams clearly using a ruler and pencil • were familiar with the definitions in the specification, e.g. for load regulation • were familiar with the units for variables within the topic, e.g. recalling that the unit of EMF is V.	• did not show full working out process in calculation questions • had not learned the conversions for the common unit prefixes • did not clearly cross out or erase incorrect responses before providing an alternative (particularly in the logic table questions) • had not learned definitions for key terms such as AC, DC and load regulation.

Question 1 (a)

1 The diagram below shows a network of resistors.



(a) Calculate the current I_2.

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

Most candidates were able to apply Ohm's law successfully.

Question 1 (b)

(b) Calculate the total resistance of $\mathbf{R_3}$ and $\mathbf{R_4}$ in series.

total resistance of $\mathbf{R_3}$ and $\mathbf{R_4}$ = ... Ω **[1]**

Most candidates successfully answered this question.

Question 1 (c)

(c) Calculate the current I_3.

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

Few candidates were successful in this question, with the most common incorrect response being to use R_3 in the calculation without adding R_4 in series.

Question 1 (d)

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

....

.... **[1]**

Successful candidates were able to make reference to the first law in terms of conservation of charge or make a valid comment regarding this part of the circuit being in series. A few made an incorrect reference to Kirchoff's second law which refers to conservation of energy.

Question 1 (e)

(e) Calculate the voltage across $\mathbf{R_2}$.

voltage across $\mathbf{R_2}$ = ... V **[1]**

This question was typically well answered, with some candidates using their value for I_2 in an Ohm's Law calculation and others stating the voltage from the diagram.

Question 1 (f)

(f) Calculate the current I_1.

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

Assessment for learning

All calculations should be shown with full working out process. This question assessed the application of Kirchoff's First Law, but if an error was made in Question 1 (a) or Question 1 (c), the candidate could gain an 'error carries forward' mark if full working was shown.

Question 1 (g) (i)

(g) An engineer removes $\mathbf{R_4}$ from the circuit to check its resistance.

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

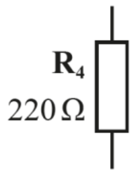
....

.... **[1]**

Many candidates were given this mark, although many did not give a clear answer or sufficient detail. A few chose to state that it was to prevent the power supply from damaging the ohmmeter. Most candidates explained that it should be removed to prevent the measurement of a combined resistance including other resistors in the circuit.

Question 1 (g) (ii)

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



[1]

Most candidates were able to correctly add the ohmmeter to the diagram. The most common incorrect response was to add a power supply to the circuit.

Question 1 (g) (iii)

(iii) A multimeter is used as an ohmmeter to measure the value of $\mathbf{R_4}$.

The value of $\mathbf{R_4}$ is about 220 Ω.

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 $\mathbf{R_4}$.

Fig. 1a

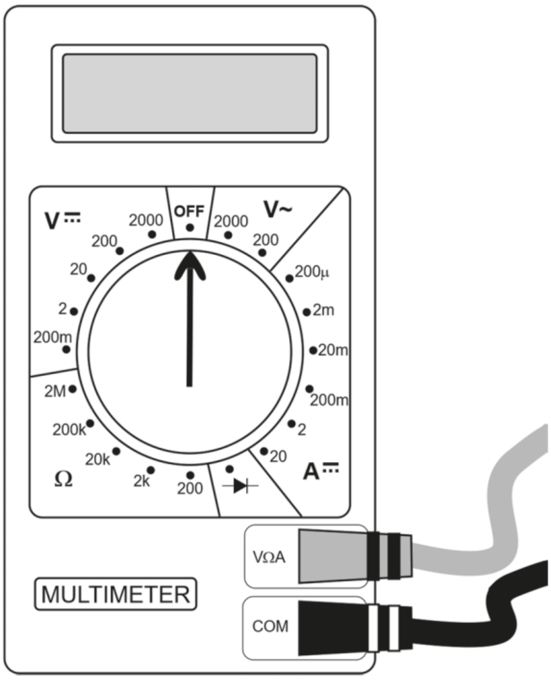
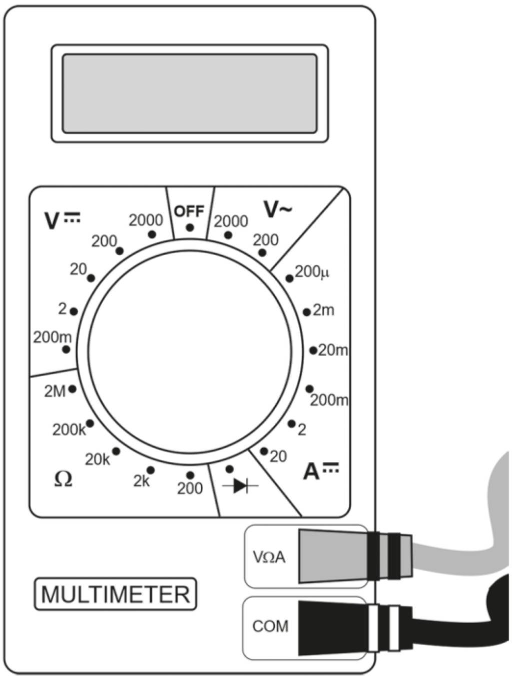


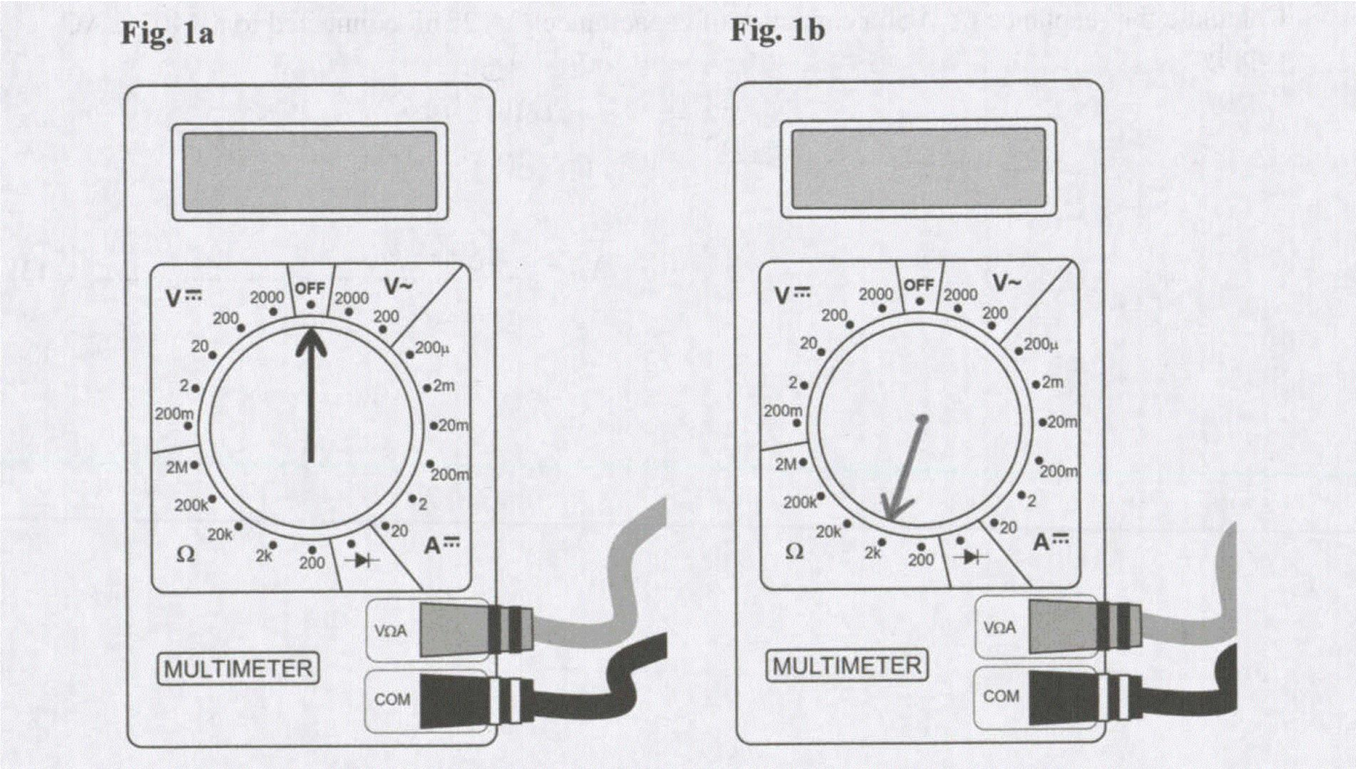
Fig. 1b



[1]

Most candidates gave a correct response of 2k Ohms for this question. The most common incorrect response was either on 200 Ohms or between 200 and 2k Ohms.

Exemplar 1



When asked to complete a diagram candidates should do this carefully as in the exemplar, using a ruler.

Question 2 (a)

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]**

Most candidates were able to calculate the period from the frequency using the formula given in the formula booklet.

Question 2 (b)

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

ω = ... rad s^{-1} **[1]**

Candidates were generally able to use the equation provided to calculate the angular frequency and give a numerical response.

Question 2 (c)

(c) Calculate the voltage (v) at time $t = 2$ ms.

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

Although most candidates got marks on this question, few were given full marks. The common errors were the incorrect or missing conversion of milliseconds and calculators being set to degrees rather than the required radians. If working out process was shown, partial marks were given.

Question 2 (d)

(d) A capacitor is connected to the 440 Hz AC generator.

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

X_C = ... Ω **[3]**

Although candidates handled this calculation well, many lost a mark by not converting nano Farads correctly to Farads.

Assessment for learning

Candidates should be aware that marks are given for unit conversions and so be familiar with prefixes.

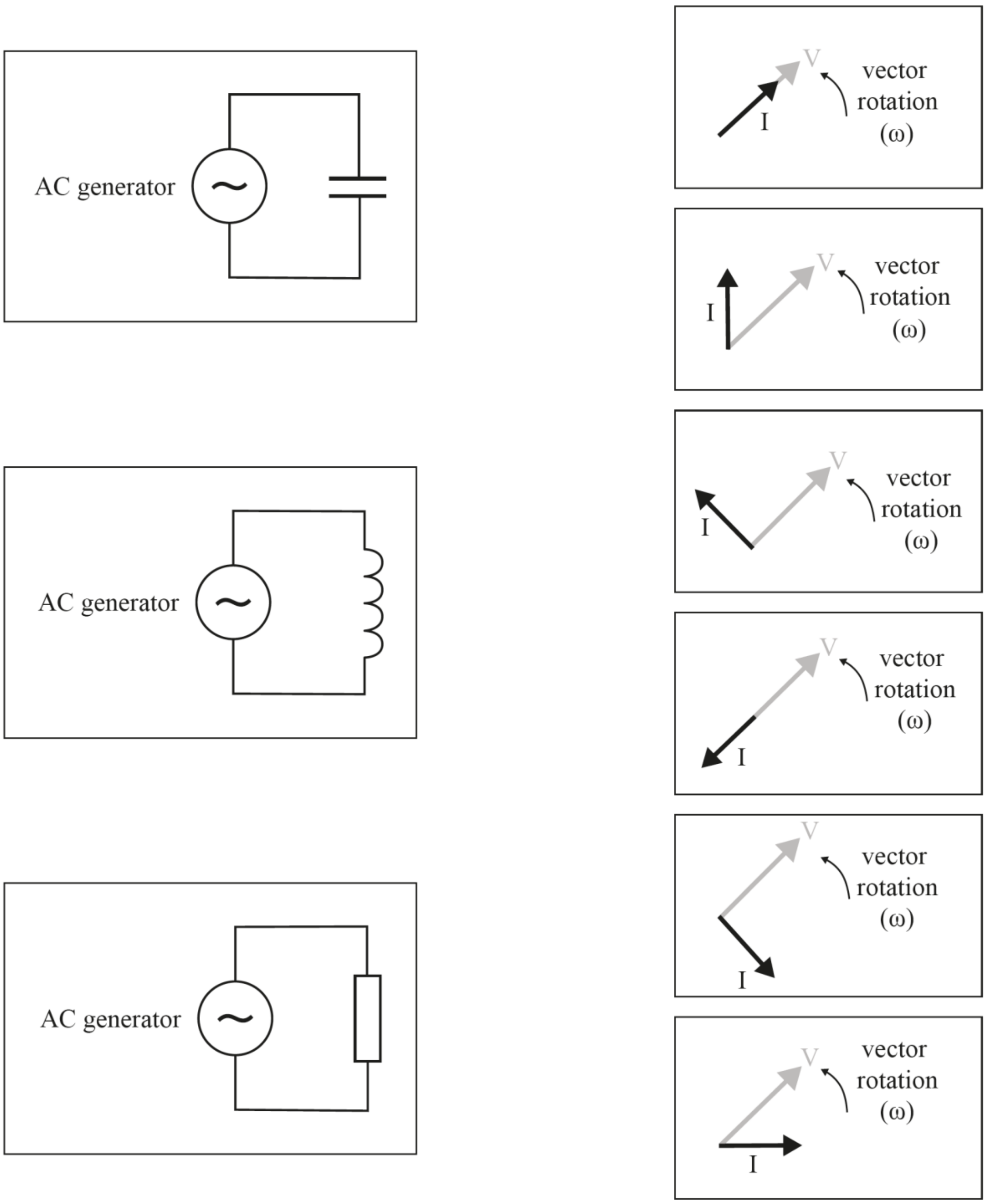
Question 2 (e)

(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**

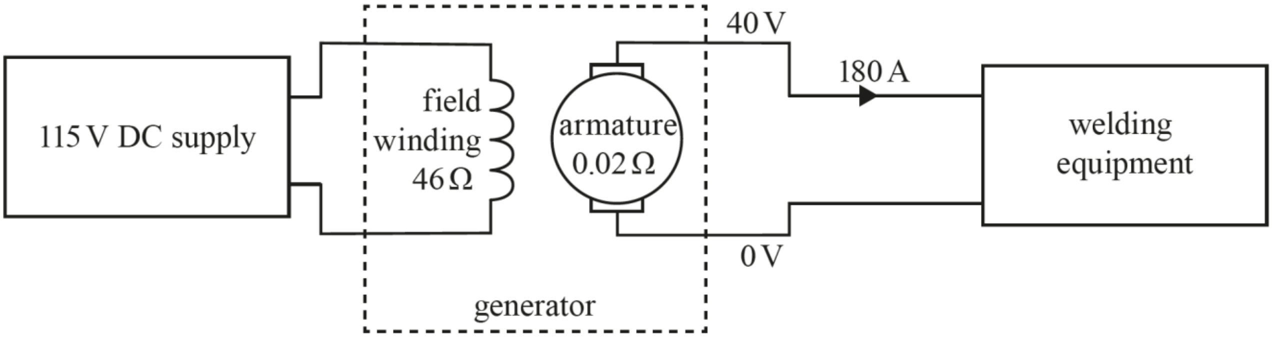


[3]

Very few candidates were able to get full marks for this question, perhaps due to the unconventional positioning of the vectors. However, candidates are expected to know the phase relationship between current and voltage in these three circuits and should be familiar with it represented as a phasor diagram.

Question 3 (a)

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]

Few candidates got the correct answer here. The most common incorrect choice was the shunt-wound self-excited DC generator.

Question 3 (b)

(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]**

Most candidates were given full marks for this calculation.

Question 3 (c)

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

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

Most candidates were able to use a power equation from the formula sheet to calculate the correct answer.

Question 3 (d)

(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]

Few candidates chose the correct response. The most common incorrect response was '… provide the power needed to make the generator turn'.

Question 3 (e) (i)

(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]**

The most successful candidates started by copying the correct equation from the formula sheet then substituting and rearranging with working out being able to achieve partial marks. Most candidates were unable to recall the correct unit for EMF, and a range of incorrect responses were given.

Question 3 (e) (ii)

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

....

....

.... **[1]**

The more successful candidates were able to give a clear explanation relating to the circuit diagram and the welding equipment shown. Many responses were more general and not specific to the circuit and scenario given in the question.

Question 3 (e) (iii)

(iii) Calculate the power dissipated in the armature.

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

Many candidates were able to select and apply the power equation from the formula sheet.

Question 3 (f)

(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]

Many correct responses given, with candidates typically getting at least 1 mark.

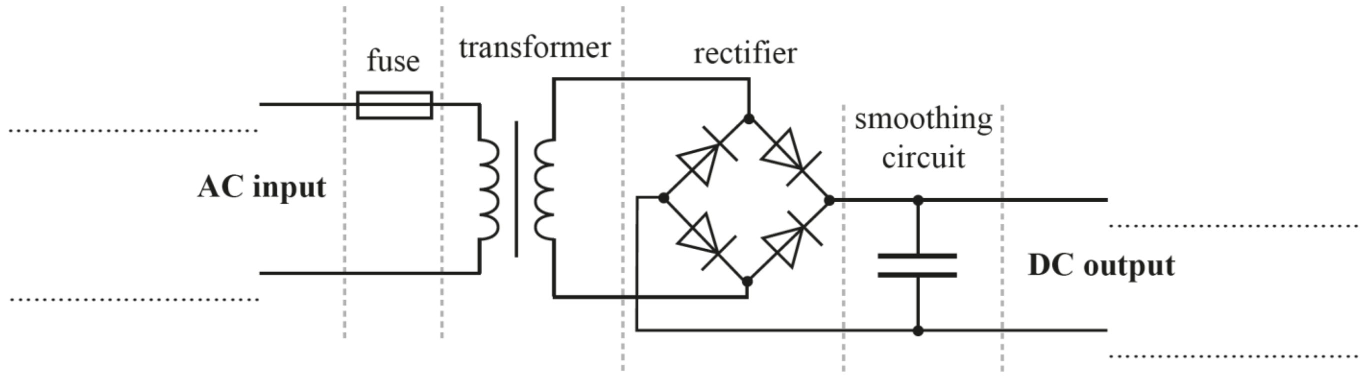
Question 4 (a)

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]

Few candidates were able to successfully label all four connections, and a variety of incorrect responses were given.

Question 4 (b)

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

Explain the difference between AC and DC.

....

....

.... **[2]**

Candidates were more likely to get a mark for a definition of DC than AC, where the definition required comment on the direction of current changing periodically over time. Many responses were not written clearly and could be interpreted to say that current was flowing in both directions simultaneously so could not be given marks. Reference to positive and negative currents was also often given, but this was not enough to be a description of direction without a vector reference.

Question 4 (c) (i)

(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]**

Most candidates were able to describe the correct location of the stabilising circuit.

Question 4 (c) (ii)

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

....

....

.... **[2]**

Few candidates were able to gain marks here. Misconceptions mainly focused on load regulation as either a way of maintaining a constant load on a circuit or in some way protecting the circuit from a high current.

OCR support

Candidates should be directed to the specification for the course where it clearly states that the purpose of load regulation is to "maintain a constant voltage or current level on the output of a power supply regardless of changes in the supply load".

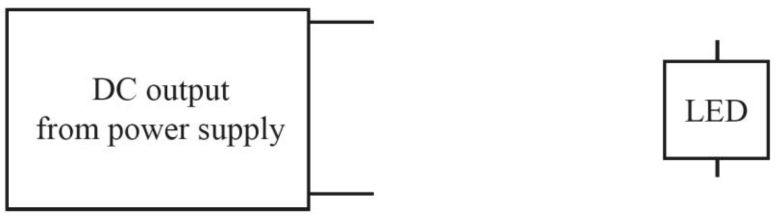
Question 4 (d)

(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]

Most candidates were able to correctly draw a resistor in series, while a few drew the resistor in parallel which was incorrect.

Question 5 (a)

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.

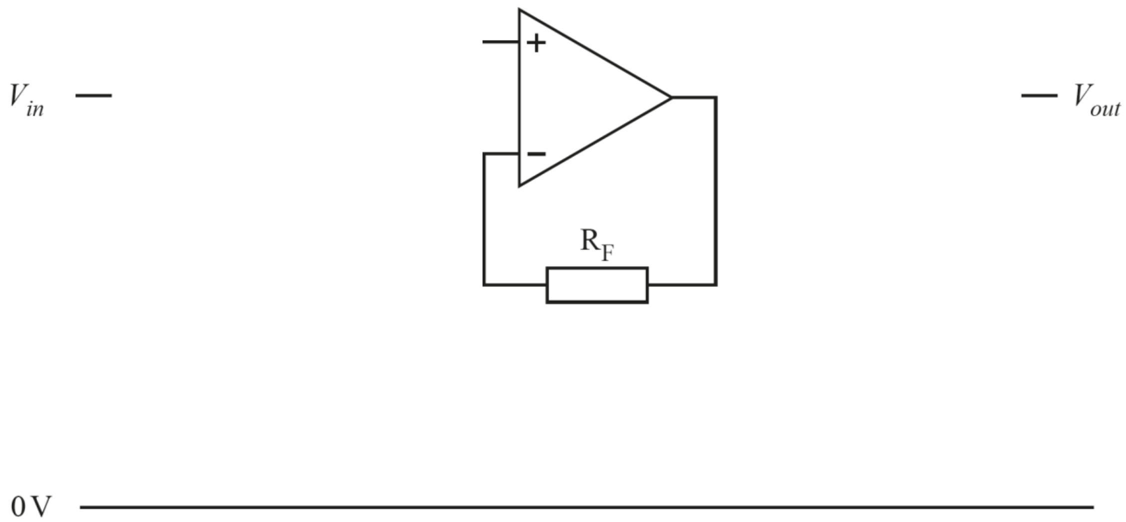
Calculate the output voltage of the amplifier.

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

Most candidates answered this well.

Question 5 (b)

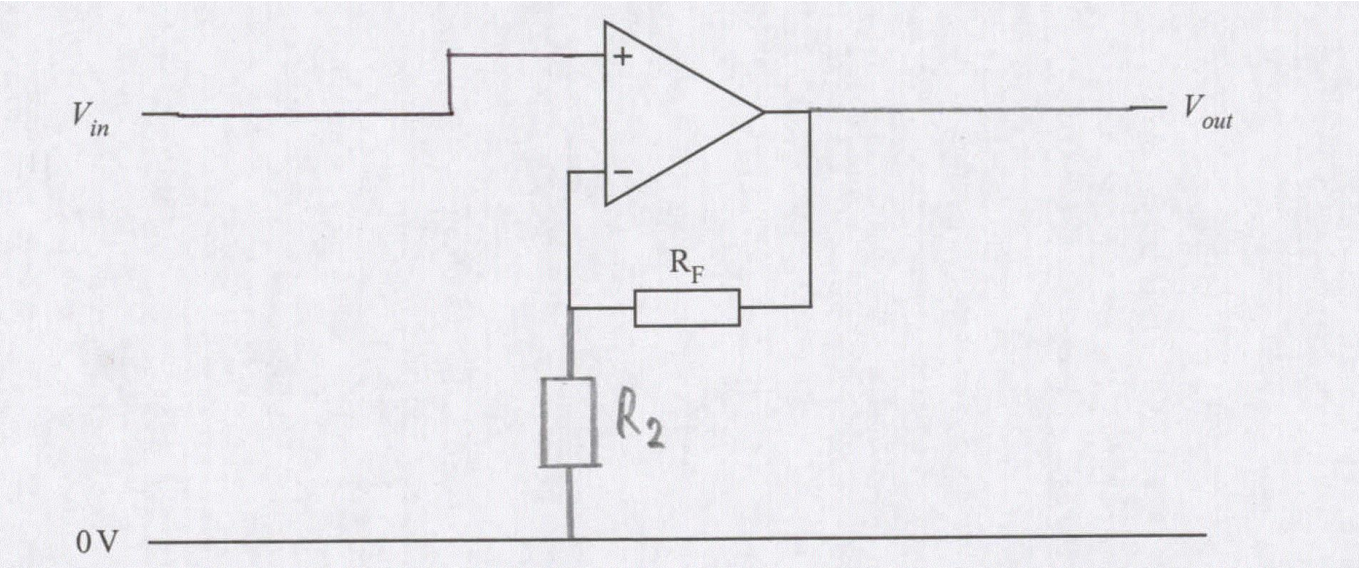
(b) Complete the diagram below to show the circuit of a non-inverting op-amp.



[3]

In general, candidates did not answer this question well, with many differing incorrect responses given. The most common errors included the inclusion of a positive feedback loop, the connection of the non-inverting input to 0V as well as V_{in} and the resistor omitted on the connection from 0V. The circuit diagrams for inverting, non-inverting and summing op-amps should be familiar enough to draw from a partial diagram such as this.

Exemplar 2



As in the exemplar, candidates should be completing circuit diagrams clearly with the use of a ruler.

Question 5 (c)

(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]

Few candidates were successful in this question. The most common incorrect answer selected was 'Infinite open-loop gain'.

Question 5 (d)

(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.

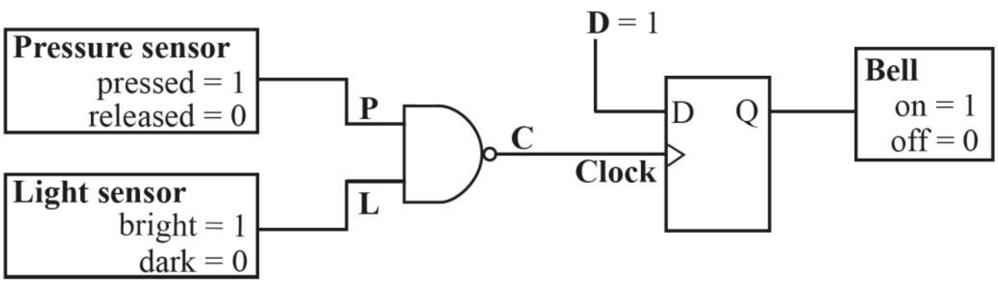
R_F = ... Ω

R_2 = ... Ω
[2]

Many candidates were able to successfully calculate the required ratio. Some candidates did not get full marks by not clearly reading the question which stated that the resistors were required to have values greater than 1 Kiloohm.

Question 6 (a)

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]**

Most candidates were able to identify the NAND gate.

Question 6 (b)

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

P	L	C

[2]

Most candidates were able to get the first mark for all of the input combinations, but some did not get full marks due to repeating combinations. Overall, more candidates were also able to get the second mark than not.

Exemplar 3

P	L	C
0	0	1
1	0	1
0	1	1
1	1	0

Although many did well on this question, candidates should take care when completing logic tables as when overwriting a 1 with a 0 or vice versa it can be difficult to tell which is their final answer. Ideally, if a response is to be changed the incorrect response should be clearly scored out and the replacement answer placed clearly to one side. This exemplar shows an instance where a student has crossed out answers but made their intention clear however if the correct responses were all relocated to the right or left it would make this even clearer.

Question 6 (c)

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

....

.... **[1]**

Most candidates were able to give the correct conditions.

Question 6 (d)

(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]

Few candidates were given full marks on this question with a range of incorrect responses given.

Question 6 (e)

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

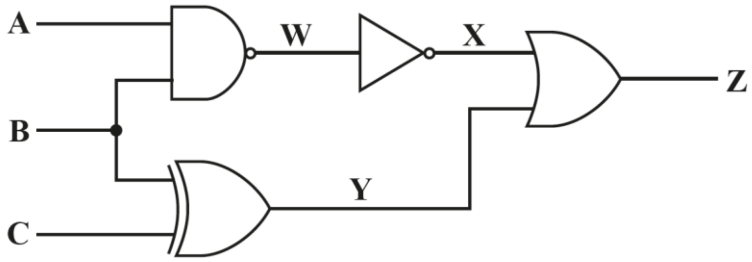
....

.... **[1]**

The reasons given by candidates suggested few understood the purpose of a flip flop as a latch in a circuit.

Question 6 (f)

(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				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

[4]

Most candidates got marks on this question with the NOT then OR gates being the most successful and candidates typically did not do as well with the XOR and NAND gate.

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The introductory module, Building your Confidence in Internal Assessment, is designed for all teachers who are involved in internal assessment for our qualifications. It covers the following topics:

- the purpose and benefits of internal assessment
- the roles and responsibilities of teachers, assessors, internal verifiers and moderators
- the principles and methods of standardisation
- the best practices for collecting, storing and submitting evidence
- the common issues and challenges in internal assessment and how to avoid them.

The subject-specific courses are tailored for each qualification that has non-exam assessment (NEA) units, except for AS Level and Entry Level. They cover the following topics:

- the structure and content of the NEA units
- the assessment objectives and marking criteria for the NEA units
- examples of student work with commentary and feedback for the NEA units
- interactive marking practice and feedback for the NEA units.

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