CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 4 Summer 2019 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 can be downloaded from OCR.

Note to Centres

There were a number of centres who had selected an invalid combination of units or had claimed the wrong units for a candidate that prevented overall qualifications results being issued. Please note that it is the responsibility of the centre to check that correct units have been entered for certification claims. OCR cannot guarantee that the issuing of results in these circumstances will meet deadlines for UCAS confirmation.

Sector Update

Two key changes have occurred in relation to the Level 3 Technicals qualifications, both in relation to the examined units; firstly, an additional re-sit has been allowed, so candidates can have two further attempts at an examined unit if they wish to improve their result from the first attempt made. And secondly, a 'near pass' R grade has been introduced, which enables candidates who do not pass but achieve sufficient marks to gain some points for their examined unit outcome, which may mean that it is not necessary to re-sit the exam.

Paper Unit 4 series overview

This paper assesses understanding of the principles of electrical engineering and digital and analogue electronic control systems. There was a continuation of the improvement in performance first noted in this examination in January 2019, evidenced, not least, by confidence in the use of the correct equations and formulae to deduce the right answers to calculations. There are some specific exceptions to this that are noted below.

Most successful topics	***Least successful topics***
• Candidates are demonstrating a greater confidence with scientific units. In general these are indicated in the answer line, or highlighted in the question text if candidates need to provide them. • The best results were only possible by a combination of careful calculation and a sound grounding in the principles involved. • Questions on digital electronics, Question 6, for instance, continue to be answered well, with a good knowledge of logic gates input/output, Boolean algebra and truth tables.	• The questions that required additional thought were the more descriptive ones for example, 3a, 4ai, and 4aiii. • Operational amplifier circuits and motors, Questions 3 and 5, exemplifying simple systems rather than fundamental principles were not handled so well. • Question 5 was the least successful overall, rescued by a couple of simple formula substitutions. • Unit prefixes, ms, μF, kΩ, etc. still pose challenges for some. • There was some increase in No Response and more candidates had not attempted some questions. Candidates should be encouraged to attempt all questions where time permits.

Question 1 (a) (i)

1 **(a)** A student constructs a circuit with a battery, ammeter, voltmeter and filament lamp to measure the resistance of the lamp when the lamp is glowing.

(i) Draw the connections on Fig. 1 to make the lamp light and to measure the current and potential difference so that the resistance of the lamp can be calculated.

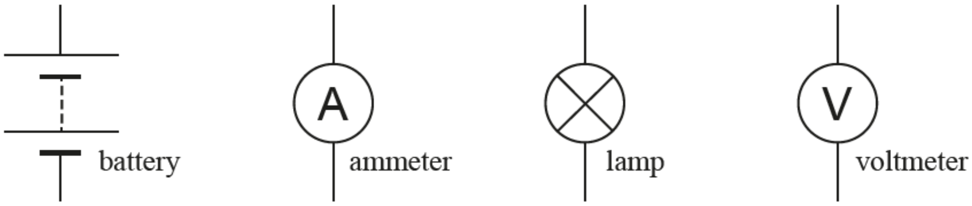


Fig. 1

[3]

For this question, half the entry had the ammeter wired in parallel, rather than in series, with the lamp, thereby losing 1 mark.

Question 1 (a) (ii)

(ii) Calculate the resistance of the lamp when the voltmeter shows a reading of 12 V and the ammeter shows a reading of 80 mA.

resistance of lamp = ... Ω **[1]**

This question was mostly answered well except when the quality milli in mA was misinterpreted.

Question 1 (a) (iii)

(iii) Sketch a graph on the axes of Fig. 2 to show how the current in the lamp filament varies with potential difference.

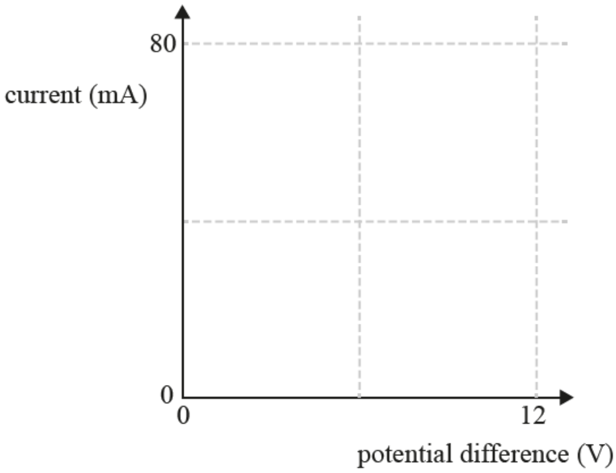


Fig. 2

[2]

While the graphs usually went correctly through the point (12,80) for one mark, a significant number also went through (6,40) rather than 'north' of it for the second mark.

Question 1 (b) (i), (ii), (iii) and (iv)

(b) A network of resistors is shown in Fig. 3.

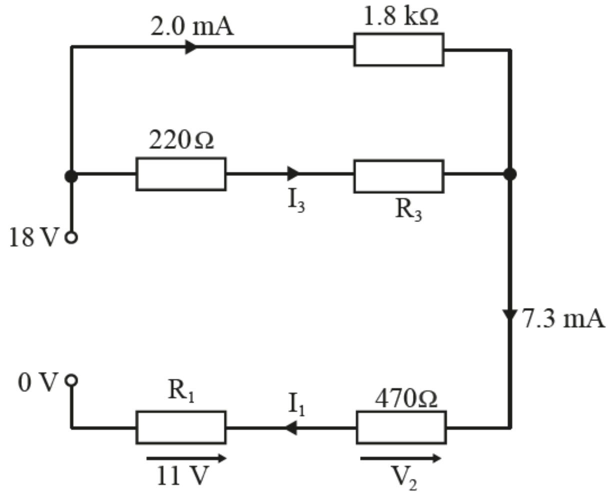


Fig. 3

(i) State the value of I_1.

I_1 = ... mA **[1]**

(ii) Calculate the value of I_3.

I_3 = ... mA **[1]**

(iii) Calculate the value of V_2.

V_2 = ... V **[1]**

(iv) Calculate the value of R_1.

R_1 = ... Ω **[1]**

Questions 1 (b) (i-iv) were answered well demonstrating a good basic understanding of Kirchhoff's Law.

Question 1 (b) (v)

(v) Calculate the value of R_3.

R_3 = ... Ω **[2]**

This was the least successful question on the paper, contrasting sharply with what had preceded it. This revealed a generally poor familiarity with correct sequencing of calculations.

Question 2 (a)

2 A simple generator connected to an inductor is shown in Fig. 4.

Fig. 4

(a) State the function of a simple generator.

....

....

.... **[2]**

This question was generally well attempted.

Question 2 (b) (i)

(b) The graphs of the voltage across the inductor and the current through the inductor are shown in Fig. 5.

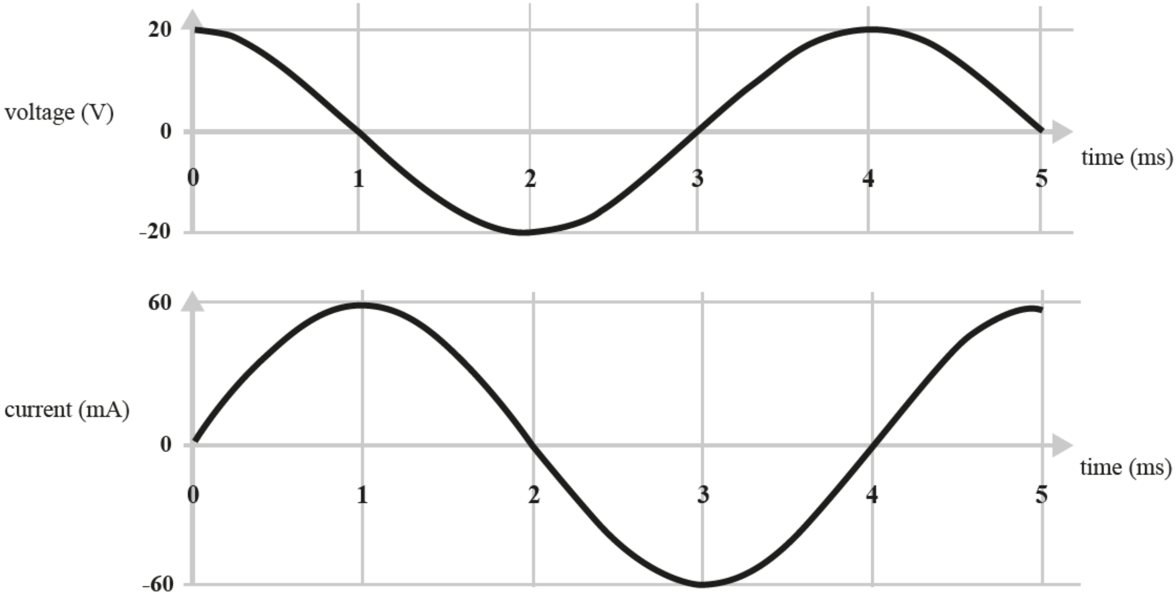


Fig. 5

(i) Use the graphs in Fig. 5 to find the frequency of the current in the inductor.

frequency = ... Hz **[1]**

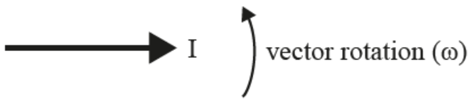
There was a strong correlation between performance in this question and that for the paper overall. It seemed that many of the weaker candidates were unfamiliar with sinusoid theory.

Question 2 (b) (ii), (iii) and (iv)

(ii) Use the graphs in Fig. 5 to find the phase difference (in degrees) between the voltage across the inductor and the current in the inductor.

phase difference = ... ° **[1]**

(iii) Complete the phasor diagram in Fig. 6 by adding the voltage vector to show the phase relationship between the voltage (V) and current (I) for the inductor in Fig. 4.
Label the voltage vector V.



[2]

Fig. 6

(iv) Calculate the reactance, X_L, of the inductor in Fig. 4.
Give the units for your answer.

X_L = ... **[3]**

In contrast to Question 2(b)(i), Questions 2(b)(ii-iv) were often answered more successfully.

Question 3 (a)

3 Fig. 7 shows a workshop pillar drill that uses a shunt-wound DC motor.

Fig. 7

(a) Suggest why the pillar drill uses a shunt-wound DC motor rather than a series-wound DC motor.

....

....

.... **[2]**

The majority of candidates did not identify that better control of speed/torque is available with a shunt wound motor. Among those who did, less than half associated this as advantageous when performing drilling operations, thereby only being awarded one mark for this question.

Question 3 (b)

(b) Draw on Fig. 8 to show how the field winding and armature should be connected to a 90 V power supply in a shunt-wound DC motor.

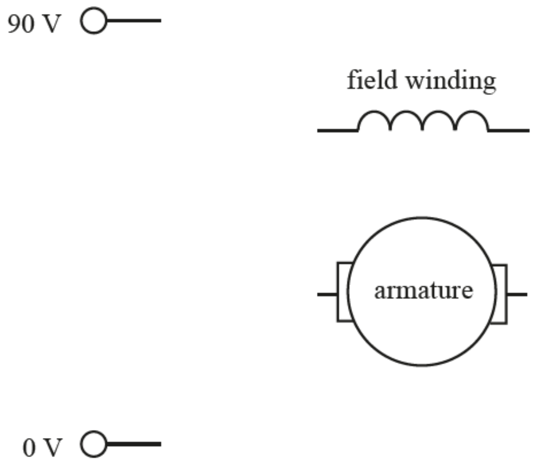


Fig. 8

[2]

For part (b) of Question 3, the majority of candidates were aware that the armature and the field winding were connected in parallel in a shunt-wound motor.

Question 3 (c) (i)

(c) The shunt-wound motor has a field winding resistance (R_f) of 333 Ω and an armature winding resistance (R_a) of 2.55 Ω.

(i) Calculate the resistance of the motor.

resistance of motor = ... Ω **[2]**

Few candidates were able to recognise that the total resistance of the motor should be calculated from the parallel combination of the armature resistance with the field resistance.

Question 3 (c) (ii)

(ii) Calculate the current in the field windings (I_f) when the motor is operated from a power supply of 90 V.

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

Part (c)(ii) was nevertheless well answered despite candidates failing to understand fully the earlier parts of Question 3.

Question 3 (c) (iii)

(iii) The drill operates from a 90 V power supply (V).When the drill is running at high speed the armature current (I_a) is 0.606 A.

Calculate the EMF (E) produced by the motor.

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

A substantial number of candidates made the same error regarding the choice of formula and chose V=E-IaRa instead of V=E+IaRa. In several cases the formula for Rt was also used. Irrespective of the formula chosen (correct or incorrect), there was evidence of being unable to rearrange the formula correctly.

Question 4 (a) (i)

4 This question is about power supplies.

(a) Most homes in the UK are supplied with electricity using a single-phase supply. Many factories and commercial properties have a three-phase supply.

(i) Give **one** advantage for three-phase power distribution.

....

.... **[1]**

This was one of the least successfully answered questions on the paper, with a majority offering no response at all to this question.

Question 4 (a) (ii)

(ii) State the phase difference in degrees between any two phases of a three-phase system.

phase difference = ... ° **[1]**

This question was attempted with mixed success, with approximately half of candidates presenting the correct answer.

Question 4 (a) (iii)

(iii) Give **one** advantage for single-phase power distribution.

....

.... **[1]**

This question also proved challenging and was out of the reach of the majority of candidates.

Question 4 (a) (iv)

(iv) Most homes are fitted with circuit breakers to protect the power supply and electrical components in the home.

Explain how a circuit breaker protects the power supply and electrical components.

....

....

....

....

....

.... **[3]**

Most candidates were able to supply at least two essential points relating to how circuit breakers provide protection of the power supply and associated components.

Question 4 (b)

(b) Complete the block diagram of a stabilised power supply shown in Fig. 9.
Choose from the terms below.

rectifier **smoothing circuit** **stabilising circuit** **transformer** **T-type flip-flop**

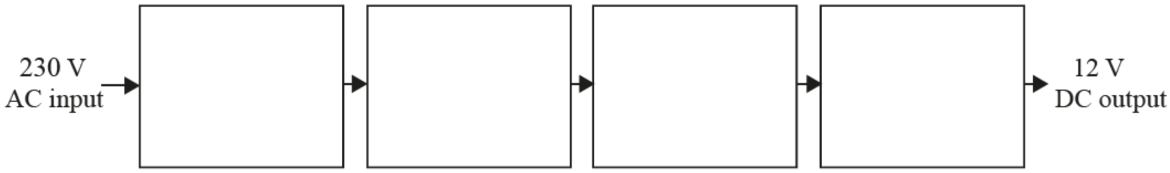


Fig. 9

[4]

This question was one of the most successfully attempted on the paper, and would have been more so were it not for a sizeable group that incorrectly interchanged the smoothing circuit and the stabilising circuit.

Question 5 (a)

5 This question is about operational amplifiers.

(a) Complete the paragraph 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.

D-type **high** **low** **series-wound** **single-ended**

An operational amplifier (op-amp) is a DC-coupled voltage amplifier with a .... open loop gain. Op-amps have a .... input impedance. Op-amps have a .... output impedance.

[3]

Approximately one-third of candidates were able to secure all three correct responses to this question.

Question 5 (b)

(b) Complete the circuit diagram of a non-inverting amplifier by adding resistors and connections to Fig. 10.

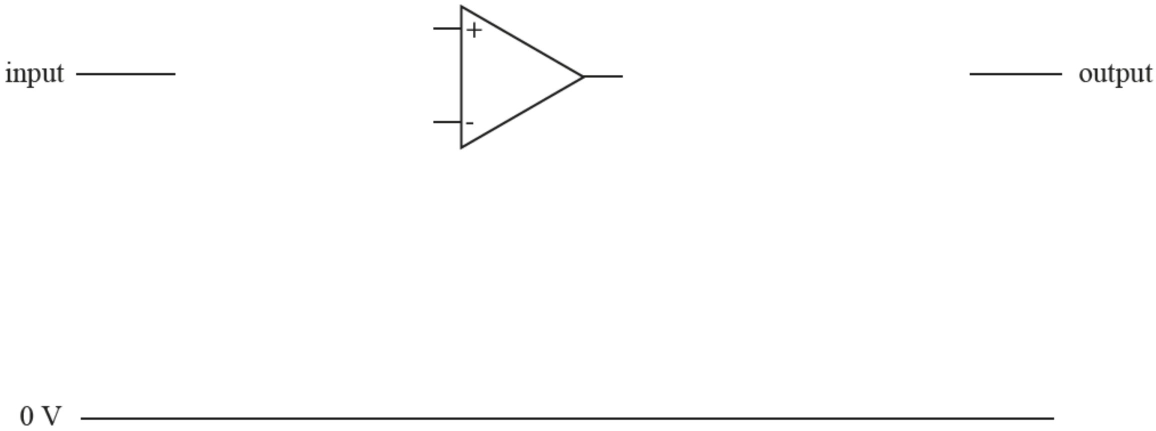


Fig. 10

[4]

Unfortunately, only a one-quarter of candidates scored 3 or 4 marks for this question. Two marks could be earned without correctly characterising the amplifier circuit diagram as non-inverting.

Question 5 (c)

(c) Calculate the values of the resistors needed to produce a voltage gain of +4.

Use the equation $$\text{Voltage Gain} = \frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_2}$$

R_F = ... Ω

R_2 = ... Ω

[1]

This question required a simple formula substitution to correctly determine the two resistor values.

Question 5 (d)

(d) Write the values of R_F and R_2 next to the correct resistors you have drawn on Fig. 10.

[1]

Success in this question partly relied on the circuit presented in Question 5 (b) resembling a non-inverting amplified circuit.

Question 5 (e)

(e) Calculate the input voltage of the circuit in Fig. 10 when the output voltage is 10 V.

input voltage = ... V **[1]**

This question was generally answered well and required candidates to have an understanding of the term 'gain'.

Question 6

6 This question is about digital electronics.

(a) Draw the circuit symbol for a NOR gate. Label the inputs **A** and **B** and label the output **Q**.

[1]

(b) Complete the truth table for a NOR gate.

A	B	Q

[2]

(c) Put a (ring) around the correct Boolean expression for a NOR gate.

$Q = A + B$ $\quad Q = \overline{A + B}$ $\quad Q = A \cdot B$ $\quad Q = \overline{A \cdot B}$ $\quad Q = A \oplus B$

[1]

(d) Fig. 11 shows a logic gate circuit.

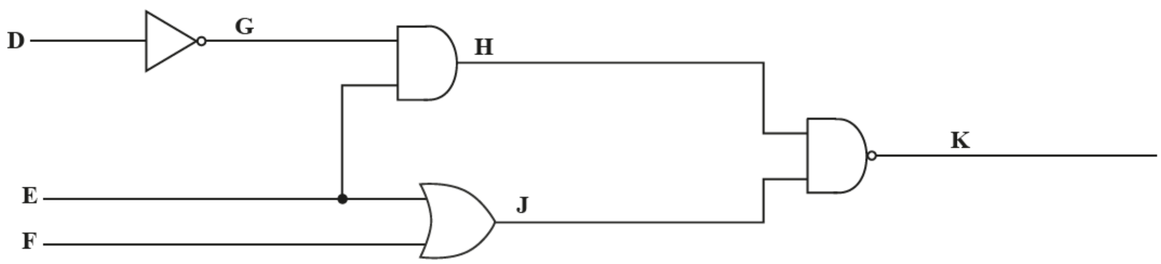


Fig. 11

Complete the truth table for the circuit in Fig. 11.

D	E	F	G	H	J	K
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]

(e) The timing diagram for a rising edge triggered D-type flip-flop is shown in Fig. 12.

Draw a (ring) around each of the rising edges of the clock in Fig. 12.

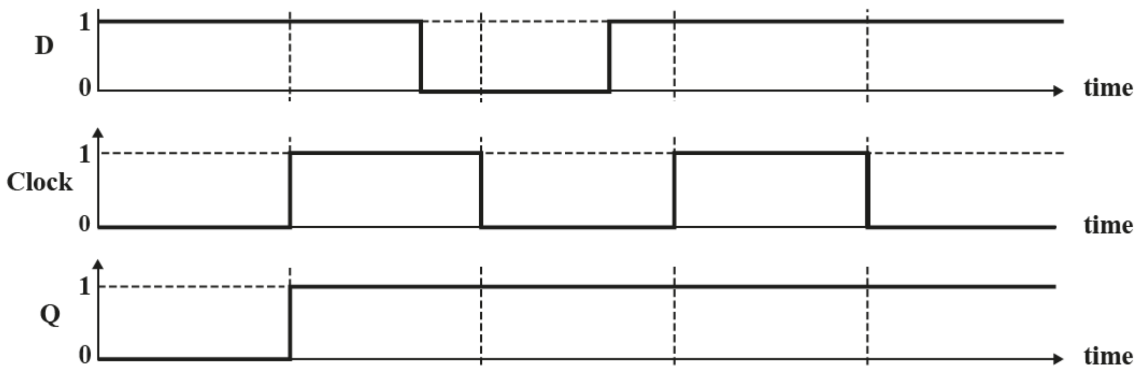


Fig. 12

[2]

Question 6 was perhaps the most successfully answered question on the exam paper, with candidates demonstrating good understanding of digital logic circuits, Boolean algebra, truth tables and timing diagrams.

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