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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

Cambridge TECHNICALS

ENGINEERING

05822–05825, 05873

Unit 4 January 2020 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.

You can now find the results awarded in 2018/19 for your Cambridge Technical subject area

As a centre approved to offer our Cambridge Technicals qualifications, we wanted to let you know we have now published the results awarded for 2018/19 Level 2 and 3 Cambridge Technicals (2016 suite). This information is helpful in allowing you to compare your centre achievements alongside national outcomes.

To browse to the document, log in to Interchange, click on 'Resources and materials>Past papers and mark schemes' in the left-hand menu and select 'Cambridge Technicals (2016) Results Awarded 2018/2019' from the drop down list.

ExamBuilder

Remember to keep your eye on ExamBuilder as we continue to update the bank of questions post exam series in line with our past paper policy. Therefore, you can be assured that new assessment material will continually be fed into ExamBuilder on an annual basis.

Online post series external feedback

Keep an eye out for updates on our post series feedback on Exams for Cambridge Technicals Webinars available in the autumn term.

Paper Unit 4 series overview

This Level 3 paper appeared accessible with the majority of candidates attempting all questions. In numerical questions most candidates showed working out, but a large number were not converting into standard units before performing calculations. Questions where candidates had to apply their knowledge to a situation or offer an explanation were handled less well with few clearly structured answers containing appropriately used engineering terminology.

Candidates who performed well tended to:	*Candidates who did less well tended to:*
• be able to apply knowledge to new contexts • talk through a process logically explaining what is happening at each stage and why • apply Kirchhoff's Voltage Law to simple circuits successfully • have confident recall of circuit symbols and logic gates • convert prefixes to standard form and recall units	• find it difficult to apply what they had learnt to different scenarios particularly in the motors and generators question • have difficulty in the application of Kirchhoff's Laws and Ohm's Law to simple circuits • not have confident recall of key definitions • not have confident recall of circuit symbols • not change numbers into standard form before using them in calculations

	AfL	Formula booklet. Candidates should become familiar with the formula booklet prior to sitting the examination. This way they will be able to locate, and use required formulae quickly.

Question 1 (a)

1 The circuit diagram in Fig. 1 shows a circuit for operating a lamp at 6.0 V, 200 mA from a 9.0 V battery of negligible internal resistance.

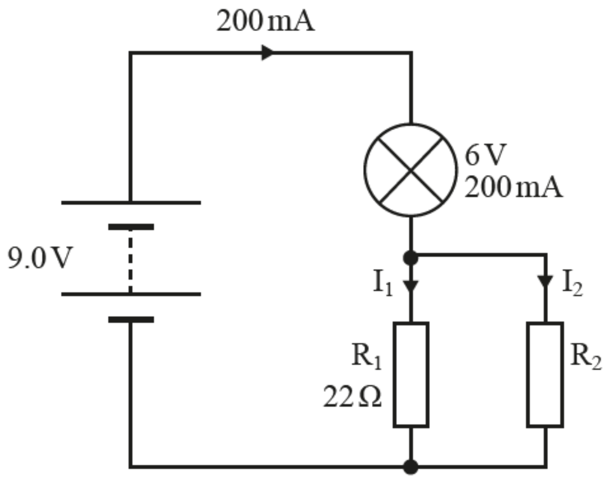

Fig. 1

(a) Calculate the power dissipated by the lamp.

P = ... W **[1]**

Most candidates successfully answered this question. Those that did not tended to incorrectly use current in mA instead of A.

Question 1 (b)

(b) Calculate the energy dissipated by the lamp in 3 minutes.

Give the correct units for your answer.

energy dissipated = ... **[3]**

The majority of candidates successfully converted time into seconds with most then correctly applying the formula to gain an answer in J (with the correct unit being required for the third mark). Alternative calculations giving an answer in Whr or Wmin were also credited.

A minority of candidates gave an incorrect (usually W although this was given as the unit for power on the previous question) or no response for units.

A small minority had difficulty rearranging the formula resulting in an incorrect response.

	AfL	Rearranging formulae. Candidates should have practice in rearranging formula to make a different letter or quantity in the original equation the subject.

Question 1 (c)

(c) Calculate the voltage across the resistor R_1.

voltage across R_1 = ... V **[1]**

This question concerns Kirchhoff's Voltage Law, which many candidates used successfully.

Many others answered with either 9V (from supply voltage) or 4.4V (using Ohm's Law and the incorrect statement that all the current would flow through R_1).

Question 1 (d)

(d) Calculate the current I_1.

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

Many candidates correctly applied Ohm's Law using their value of the voltage across R_1 from 1(c) however a large number of candidates simply halved the 200mA current between the 2 resistors.

Question 1 (e)

(e) Calculate the value of the resistor R_2.

R_2 = ... Ω **[2]**

This question relied on understanding hoe to correctly apply Kirchhoff's Voltage and Current laws.

Candidates had to be aware that the voltage across R_2 would be the same as across R_1, and also that the current through R_2 would be the difference between 200mA and I_1. They could then use Ohm's Law to determine the value of R_2.

This application of knowledge proved difficult for most candidates although many were able to achieve partial marks.

Question 1 (f)

(f) Calculate the total resistance of R_1 and R_2 in parallel.

total resistance of R_1 and R_2 = ... Ω **[1]**

One mark for this question was achieved by most candidates through application of the parallel resistor formula however many candidates gave a final answer of the inverse of the value of total resistance by not working through the formula fully.

Question 1 (g)

(g) Draw **on** Fig. 1 to show how a voltmeter should be connected to measure the terminal voltage of the battery.

[1]

Most candidates were able to connect the voltmeter correctly with an extremely small minority showing the voltmeter in series or across a wire.

Question 2 (a) (i)

2 A sine wave alternating current (AC) supply with a frequency $f = 250\,\text{kHz}$ is connected in series with a resistor $R = 4.7\,\text{k}\Omega$ and a capacitor $C = 220\,\text{pF}$.

(a) (i) Draw a diagram of the circuit. Label all components with their values.

[3]

This question was successfully attempted by most candidates.

A significant minority lost marks for incorrect symbol for the capacitor (with the inductor symbol being the most common substitution) and/or using the symbol for a cell/battery incorrectly for the AC supply.

	AfL	Candidates should learn appropriate circuit symbols for capacitor, resistor, inductor and AC supply and be able to use these confidently.

Question 2 (a) (ii)

(ii) Calculate the reactance, X_C, of the capacitor C.

X_C = ... Ω **[3]**

Most candidates were able to select the appropriate formula, but the unit prefixes continue to pose a challenge with many candidates either selecting a range of incorrect options for pico or not considering the kilo or pico prefixes.

	AfL	Unit conversions. Candidates should practice converting units using standard scientific notation (e.g. Mega, kilo, milli, nano, pico)

Question 2 (a) (iii)

(iii) Calculate the impedance, Z, of the series resistor and capacitor circuit at 250 kHz.

Z = ... Ω **[2]**

Many candidates were able to use the formula to calculate reactance. The application of the kilo prefix for the resistance, however, was missed by some.

Question 2 (a) (iv)

(iv) Calculate the phase difference, ϕ, in degrees between the voltage signal across the circuit and the current signal through the circuit.

Use the equation $\cos \phi = \frac{R}{Z}$

ϕ = ... ° **[2]**

In responses to this question, the use of inverse cosine to obtain the final answer proved a challenge for candidates.

Question 3 (a)

3 An electric train uses series-wound DC motors.

(a) Complete Fig. 2 to show how the field winding and armature in a series-wound DC motor should be connected to a 315 V power supply. Label all of the parts of the motor.

Fig. 2

[2]

Although successfully attempted by the majority of candidates it is important that candidates can clearly draw the correct symbols for armature and field winding and that parts are clearly labelled as stated in the question. Additional series resistors to show, e.g. armature resistance was allowed but were not necessary.

Question 3 (b)

(b) Suggest why the train uses series-wound DC motors rather than shunt-wound DC motors.

....

....

....

.... **[2]**

This question was not well answered by many candidates.

A confident statement of the differing performance characteristics (torque vs speed) of series as opposed to shunt wound motors was required but many candidates seemed not to realise this and tried to draw on personal experience.

Question 3 (c) (i)

(c) The series-wound motor has a field winding resistance (R_f) of 0.63 Ω and an armature winding resistance (R_a) of 0.42 Ω.

(i) Calculate the resistance (R_t) of the DC series-wound motor.

R_t = ... Ω **[1]**

Candidates had a clear grasp of this question, with addition of resistors in series answered well.

Question 3 (c) (ii)

(ii) The motor operates from a 315 V power supply (V).

When the motor is turning quickly, it produces a back EMF (E) of 141 V.

Calculate the armature current (I_a) in the DC series-wound motor.

I_a = ... A **[2]**

Many candidates started off with the correct formula but were unable to transpose successfully applying knowledge from Unit 1 to reach the correct answer.

	AfL	Rearranging formulae. Candidates should have practice in rearranging formula to make a different letter or quantity in the original equation the subject.

Question 3 (c) (iii)

(iii) When the train starts to climb a small hill, the gradient of the hill makes the train and motor slow down, even though the electrical supply to the motor remains the same.

Explain what happens to the armature current as the train and motor slow down.

....

....

....

....

....

.... **[3]**

This question was not well answered with most candidates, with some drawing on personal experience with trains or attempting to apply prior knowledge of forces to the situation.

Those candidates who read the question carefully and noticed that the motor was slowing down were able to access the question.

The most successful clearly linked motor speed to back EMF and the resulting effect on current.

Question 4 (a) (i)

4 The block diagram of a stabilised power supply is shown in Fig. 3.

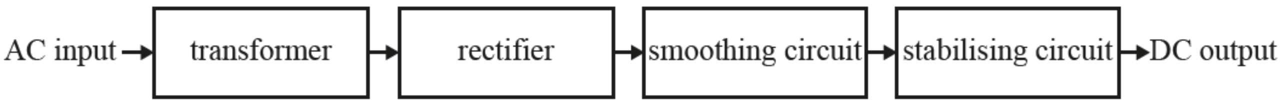

Fig. 3

(a) A rectifier is used as part of the stabilised power supply.

(i) Complete Fig. 4 to show how alternating current (AC) can be converted to half-wave direct current (DC) of the correct polarity using a **single** diode as a half-wave rectifier.

Fig. 4

[3]

Most candidates were able to successfully draw the diode symbol. A significant minority drew it incorrectly positioned or showing the AC and/or the DC supply shorted out.

Inclusion of a transformer/load resistor was not required in the response to this question.

Question 4 (a) (ii)

(ii) Explain how the half-wave rectifier works.

....

....

....

.... **[2]**

This question was not well answered by many candidates.

A clear explanation of rectification including diode conductivity and voltage polarity/direction of current flow had not been learnt by candidates resulting in a complicated unstructured response by many.

Question 4 (b)

(b) The stabilising circuit in Fig. 3 provides good load regulation.

Explain what load regulation means.

....

....

....

.... **[2]**

This question was not well answered by many candidates.

Successful candidates were likely to correctly state the capability of load regulation to maintain a constant voltage or current level on the output of a power supply regardless of changes in the supply load.

Question 4 (c)

(c) 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.

high **low** **series** **no** **parallel** **phase**

Fuses are used to protect power supplies and electrical devices. A fuse is connected

in .... with the power supply and the electrical device.

If a fault occurs in the electrical device and it draws too much power then

.... current flows through the fuse causing it to get very hot

and melt. After the fuse has melted .... current is supplied to

the electrical device and it stops operating.

[3]

For this question, most candidates secured full marks by correctly inserting the missing words in the statement.

Question 5 (a)

5 (a) The table below compares the characteristics of an ideal operational amplifier (op-amp) with a real op-amp.

Complete the table 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.

differential **high** **infinite** **low** **zero**

Characteristic	Ideal op-amp	Real op-amp
open-loop gain		very high
input impedance		
output impedance	zero	

[4]

Candidates who read the question carefully were successful. There were a minority of cases where candidates crossed off responses as they assumed that each response could only be used once. Some candidates also had difficulty distinguishing between high/infinite and low/zero when applied to ideal or real op-amp.

Question 5 (b) (i)

(b) The circuit diagram of an op-amp amplifier is shown in Fig. 5.

(i) Label the **input** and **output** of the amplifier.

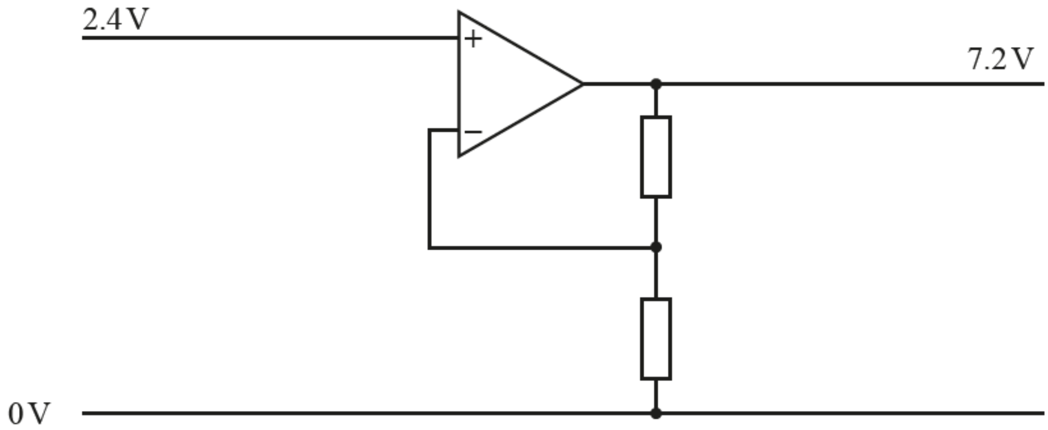

Fig. 5

[1]

Almost all candidates that attempted this question achieved the mark however many did not attempt this question completely.

Question 5 (b) (ii)

(ii) Put a (ring) around the name of the amplifier circuit in Fig. 5.

class C amplifier	**inverting amplifier**	**non-inverting amplifier**	**RF amplifier**

[1]

Most candidates successfully selected the corrected response to this question.

Question 5 (b) (iii)

(iii) Calculate the voltage gain of the circuit in Fig. 5.

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

voltage gain = ... **[1]**

Most candidates were successful at using the voltage gain equation with a minority trying to use the entire 3 parts of the formula thereby struggling to find resistor values that were no provided in the question. These therefore failed to achieve a final answer.

Question 5 (b) (iv)

(iv) Calculate suitable values for the resistors in the amplifier and label them **on** Fig. 5 with their values **and** units.

[3]

Many candidates were able to achieve partial marks on this question, however, obtaining the correct resistor ratio using the required formula proved a challenge to some.

Of those that calculated the correct ratio not all achieved full marks due to not reading the question carefully and so not labelling the resistors and/or stating units as required of the question.

Question 6 (a)

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

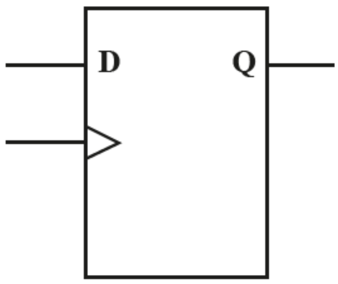

Fig. 6

Draw a line to join the start of each sentence to the most appropriate end of sentence describing the behaviour of a rising-edge triggered D-type flip-flop.

There will be some end of sentences with no connecting line.

Start of sentence	**End of sentence**
	... from **D** to **Q**.
A rising-edge D-type flip-flop is triggered when the clock changes ...	
	... from 0 to 1.
	... from 1 to 0.
When a rising-edge D-type flip-flop is triggered, the information is copied ...	
	... from **Q** to **D**.

[2]

This question was well answered by many candidates, with the correct start and end of sentences being linked.

Question 6 (b)

(b) Draw the circuit symbol for an XOR gate. Label the inputs **A** and **B** and label the output **Q**.

[1]

This question was answered well by most candidates with a minority not labelling inputs and outputs as required in the question.

Question 6 (c)

(c) Complete the truth table for an XOR gate.

A	B	Q

[2]

Almost all candidates were able to correctly complete all input combinations.

Many candidates could then progress to completing the correct output Q for the XOR gate. A minority of candidates, however, seemed unfamiliar with this type of logic gate.

Question 6 (d)

(d) Put a (ring) around the correct Boolean expression for an XOR gate.

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

[1]

Many candidates answered correctly by placing a ring around the required Boolean expression.

Question 6 (e)

(e) Fig. 7 shows a logic gate circuit.

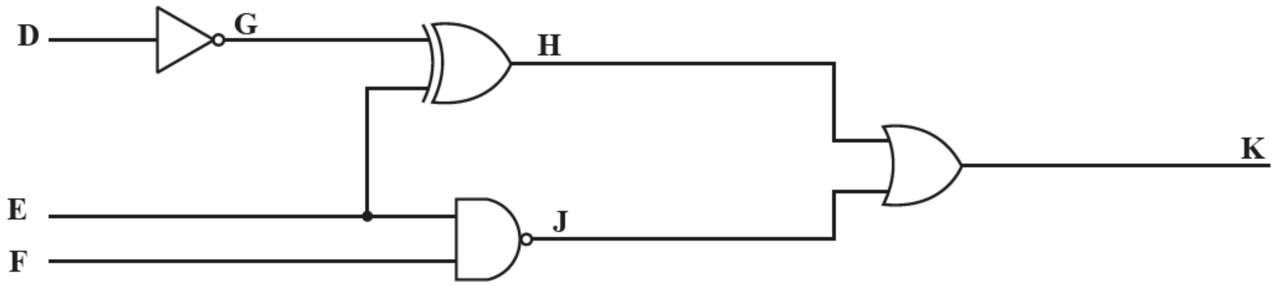

Fig. 7

Complete the truth table for the logic gate circuit in Fig. 7.

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]

Columns G and K in the table received the majority of correct responses with the NOT and OR gates being the best understood.

Candidates that were unsure of the XOR truth table in part 6(c) were unlikely to complete column H and a substantial number of candidates were unable to correctly complete the truth table for the NAND gate (column J).

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