OCR
Oxford Cambridge and RSA

Monday 18 January 2021 – Afternoon

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873 Unit 4: Principles of electrical and electronic engineering

Time allowed: 1 hour 30 minutes
C304/2101

C304 – 2101

You must have:
- the Formula Booklet for Level 3 Cambridge Technical in Engineering (inside this document)
- a ruler (cm/mm)
- a scientific calculator

Please write clearly in black ink.

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working.
- Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/10
2	/11
3	/10
4	/10
5	/11
6	/8
Total	**/60**

Answer **all** the questions.

1 The circuit diagram of a torch designed by a student is shown in Fig. 1.

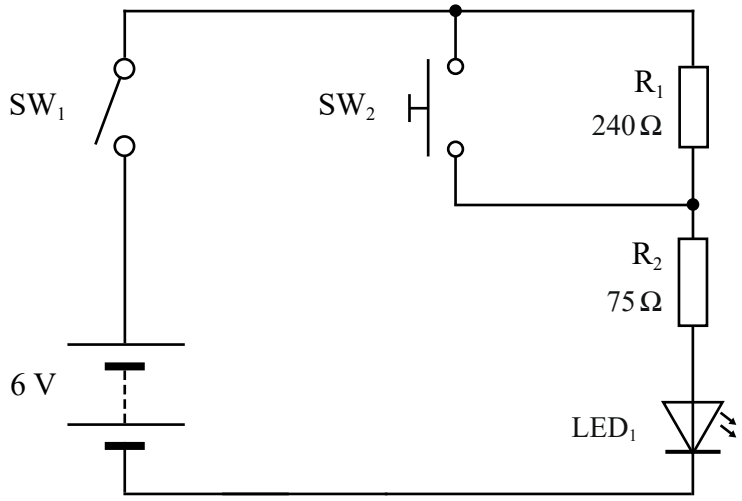

Fig. 1

(a) An ohmmeter is used to measure the resistance of R_1.

(i) Draw **on** Fig. 1 to show an ohmmeter connected to measure the resistance of R_1. **[1]**

(ii) A multimeter is used as an ohmmeter to measure the value of R_1.

Fig. 2a shows a multimeter with the dial in the off position.

Draw an arrow **on** Fig. 2b showing the correct position of the dial to measure the resistance of R_1 precisely.

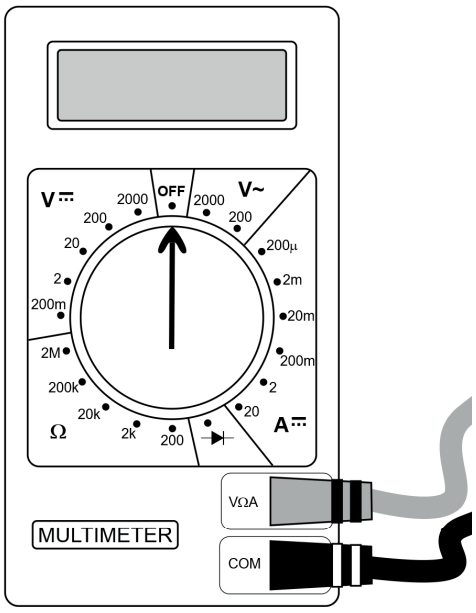

Fig. 2a

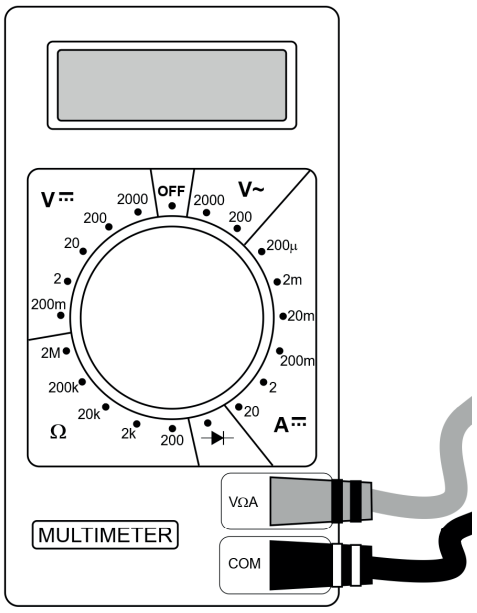

Fig. 2b

[1]

(iii) Explain why switch SW_1 must be in the off position and switch SW_2 should not be pressed when the ohmmeter is being used to measure the resistance of R_1.

.....

.....

.....

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

(b) LED_1 in Fig. 1 has a voltage of 3.6 V across it when it is glowing.

You can assume that the battery has negligible internal resistance.

(i) Calculate the voltage across the two resistors R_1 and R_2 when switch SW_1 is turned on and SW_2 is **not** pressed.

voltage across R_1 and R_2 = ... V **[1]**

(ii) Calculate the current through LED_1 when switch SW_1 is turned on and SW_2 is **not** pressed.

current through LED_1 = ... A **[2]**

(iii) Calculate the current through the LED_1 when switch SW_1 is turned on and SW_2 **is** pressed.

current through LED_1 with SW_2 pressed = ... A **[1]**

(iv) Calculate the power dissipated in resistor R_2 when SW_1 is turned on and SW_2 is pressed.
Give the units for your answer.

power dissipated in R_2 = ... **[2]**

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Turn over for the next question

2 **(a)** State what is meant by 'alternating current (AC)'.

.....

.....

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

(b) An alternating current (AC) signal is a sine wave of frequency 250 kHz and amplitude 20 V.

A graph of the alternating current signal is shown in Fig. 3.

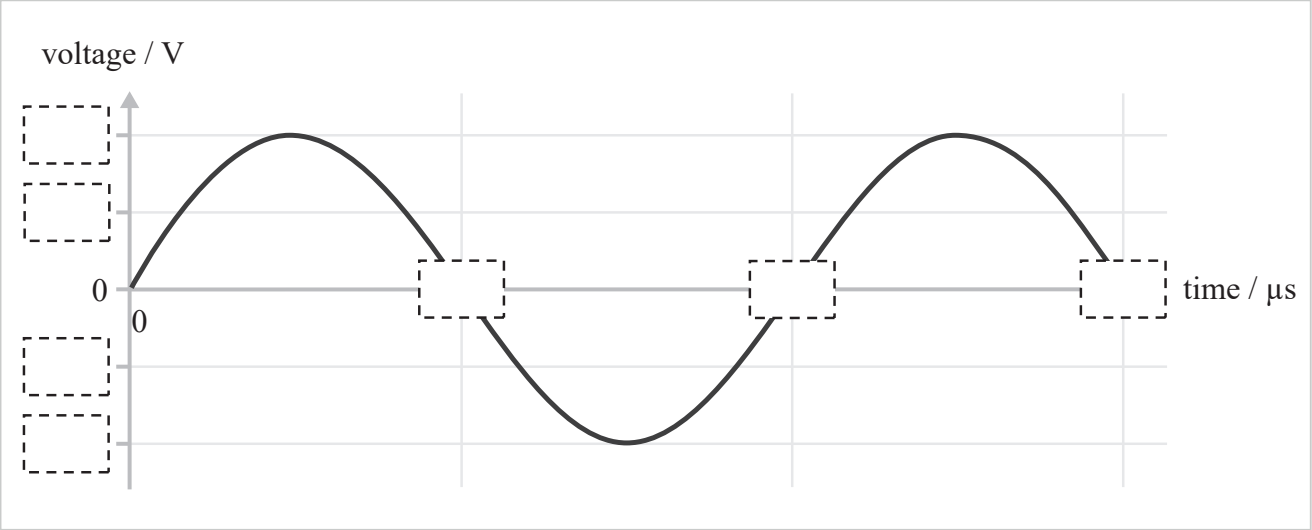

Fig. 3

(i) Calculate the period of the sine wave.

T = ... µs **[2]**

(ii) Complete the labelling of the axes **on** Fig. 3 by filling the boxes ☐ with the correct times and voltages.

[4]

(iii) Calculate the angular frequency, ω, using the formula $\omega = 2\pi f$.

ω = ... rad s^{-1} **[2]**

(iv) The sine wave has an amplitude $V = 20$ V.

Calculate the voltage, v, of the sine wave at $t = 2.2\,\mu$s using the formula $v = V \sin \omega t$.

v = ... V **[2]**

3 **(a)** Describe the difference between a motor and a generator.

.....

.....

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

(b) A shunt-wound self-excited DC generator is used to charge a battery.

(i) Draw a diagram of a shunt-wound self-excited DC generator.
Label all the parts and the output terminals.

[4]

(ii) The shunt-wound self-excited DC generator has a field winding resistance of $R_f = 18\,\Omega$ and armature resistance of $R_a = 0.12\,\Omega$.

Calculate the current (I_f) in the field winding when the generator is producing an output voltage of $V = 16\,V$.

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

(iii) Calculate the current in the armature, I_a, when the DC generator is producing an output voltage, V, of 16.0 V and an EMF, E, of 18.8 V.

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

(iv) State why the output current from the generator is less than the armature current.

.....

.....

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

4 **(a)** Fig. 4 shows a three phase 4-wire power supply.

Add labels **on** Fig. 4 to identify the three phase wires and the neutral wire.

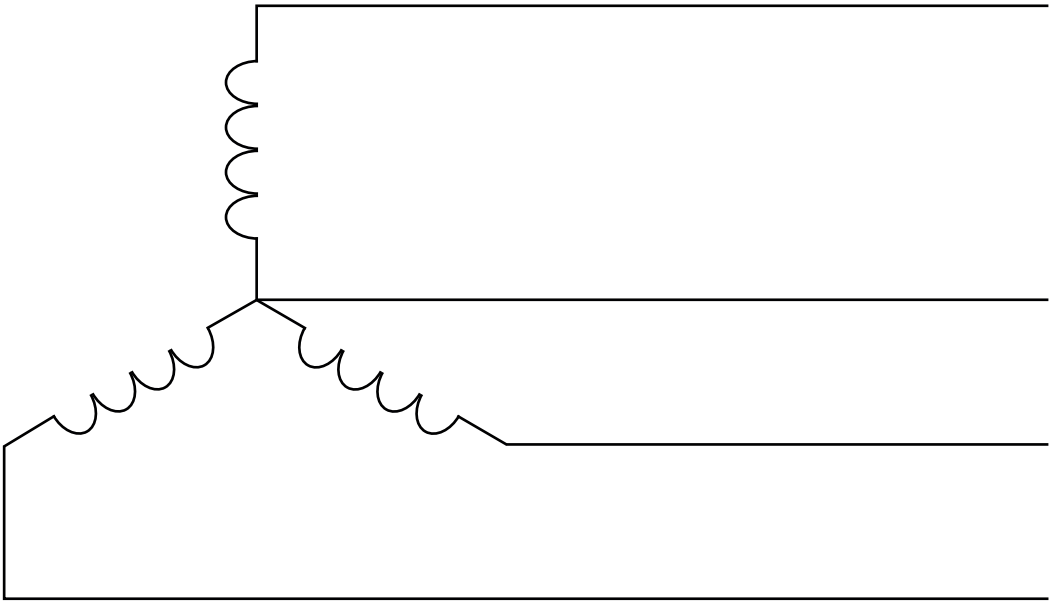

Fig. 4

[2]

(b) 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.

delta **line** **phase** **single** **star** **three**

Most local electricity supplies in the UK use a three phase 4-wire system with three phase wires and a neutral wire. A three phase 4-wire supply is called a ..... connected system. The voltage between one of the phase wires and the neutral wire is called the ..... voltage. The voltage between two phase wires is called the ..... voltage.

[3]

(c) Most electronic equipment requires a low voltage direct current supply.

(i) A transformer can produce a low voltage AC from the high voltage AC input.

Complete Fig. 5 to show how a high voltage AC supply can be converted to a low voltage rectified output using four diodes to make a full wave bridge rectifier.

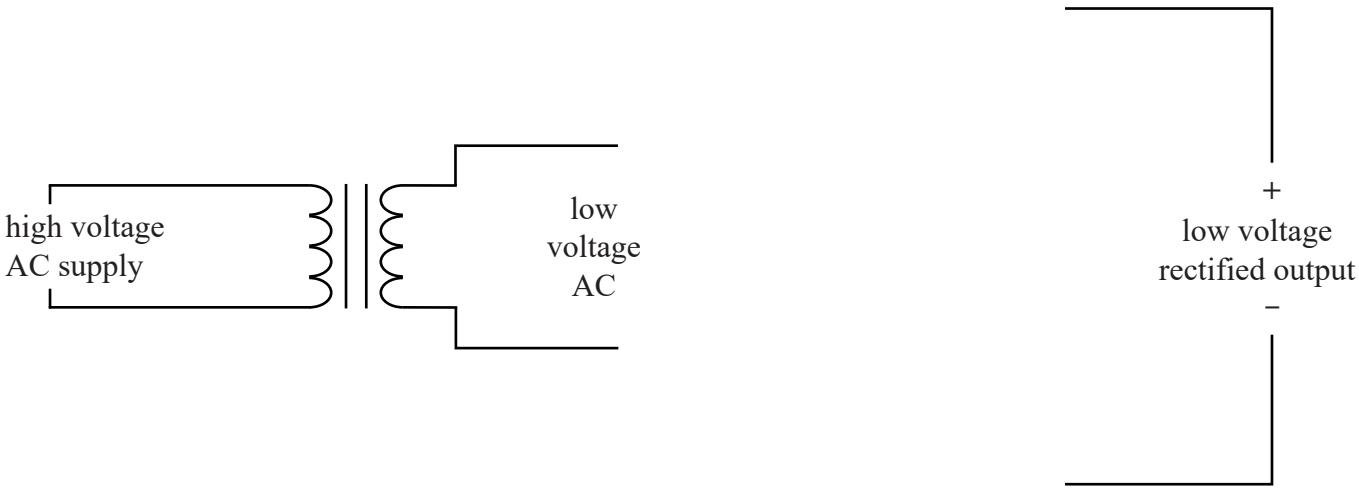

Fig. 5

[3]

Question 4 (c)(ii) begins on page 12

(ii) Fig. 6a shows the low voltage AC signal from the transformer.

Show how the full wave bridge rectifier operates by drawing the low voltage rectified output **on** the axes in Fig. 6b.

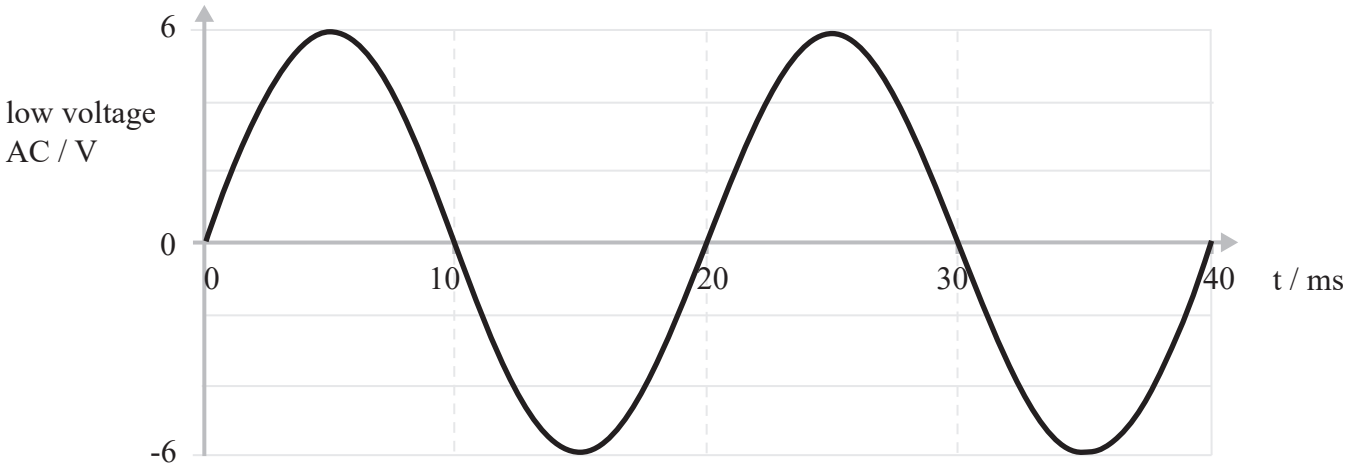

Fig. 6a

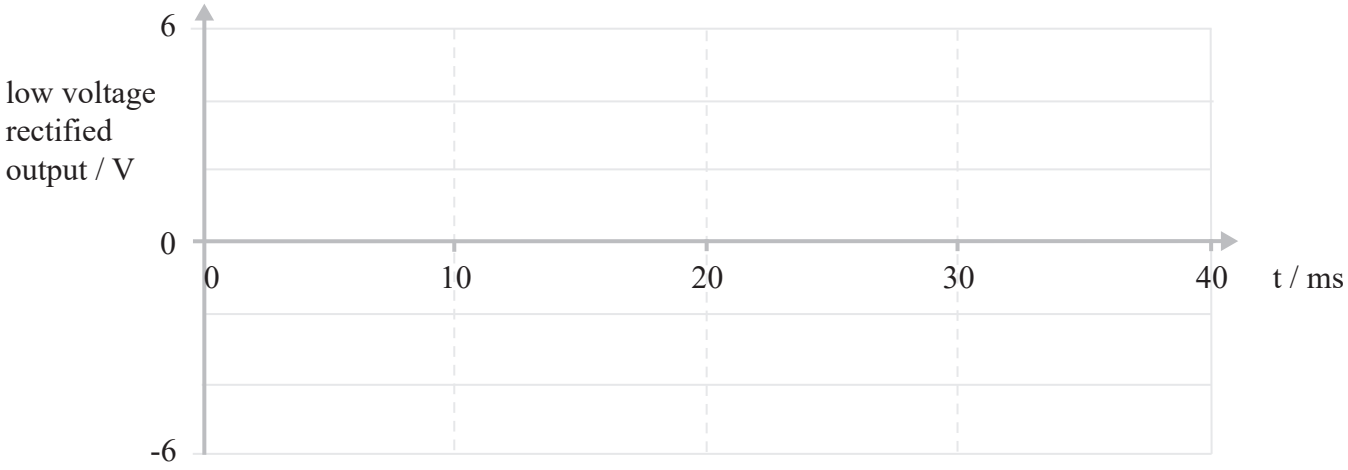

Fig. 6b

[2]

5 **(a)** An operational amplifier (op amp) of Voltage Gain = −12 is used to amplify the voltage from a sensor attached to the input of the amplifier, producing an input voltage, V_{in} = 0.3 V.

Calculate the output voltage V_{out}.

Use the formula: Voltage Gain = $\frac{V_{out}}{V_{in}}$

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

(b) An inverting op-amp amplifier is used to amplify the signal.

Calculate suitable values for the input resistor R_{in} and the feedback resistor R_F to provide a Voltage Gain = −12.

Use the formula: Voltage Gain = $-\frac{R_F}{R_{in}}$

R_F = ... Ω

R_{in} = ... Ω
[2]

(c) Complete the circuit diagram in Fig. 7 of an op-amp inverting amplifier.

Label the resistors $\mathbf{R_F}$ and $\mathbf{R_{in}}$ and the **input** and **output** of the amplifier.

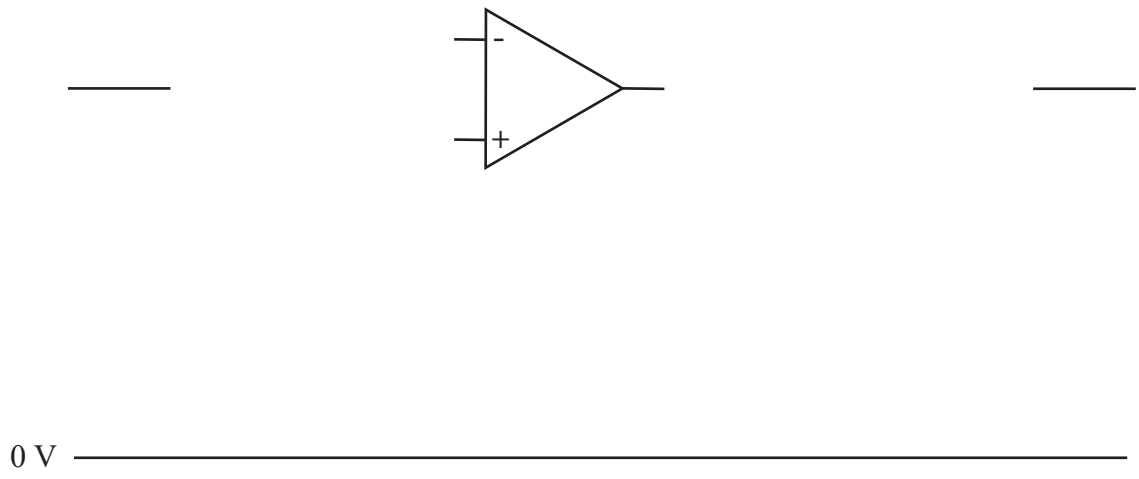

Fig. 7

[7]

6 **(a)** Draw the circuit symbol for a NAND gate.

Label the inputs **A** and **B** and label the output **Q**.

[1]

(b) Complete the truth table for a NAND gate.

A	**B**	**Q**

[2]

(c) Put a ring around the correct Boolean expression for a NAND 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]

(d) Fig. 8 shows a logic gate circuit.

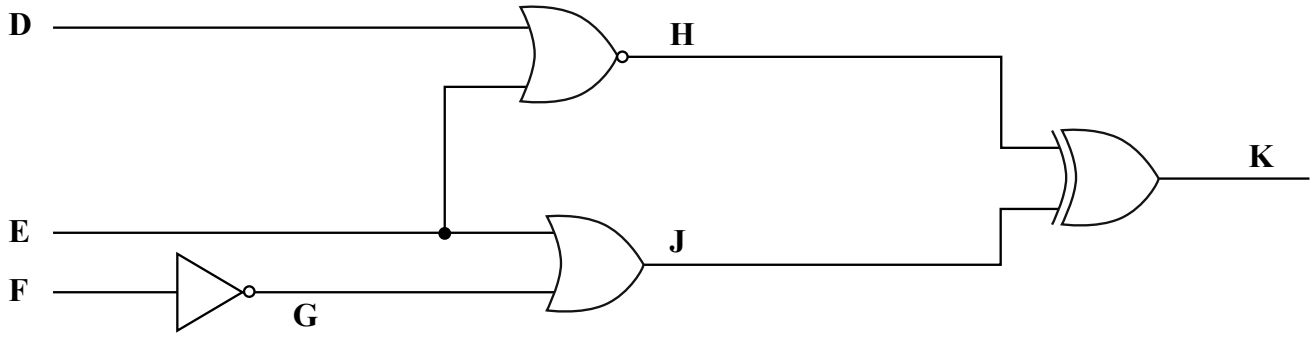

Fig. 8

Complete the truth table for the circuit in Fig. 8.

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]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 1(b)(ii) or 3(a).

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