



Oxford Cambridge and RSA

# Friday 9 June 2023 – 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**  
**C304/2306**



**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. **Do not write in the barcodes.**

Centre number      Candidate number

First name(s) \_\_\_\_\_

Last name \_\_\_\_\_

Date of birth 

D	D	M	M	Y	Y	Y	Y
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### 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.

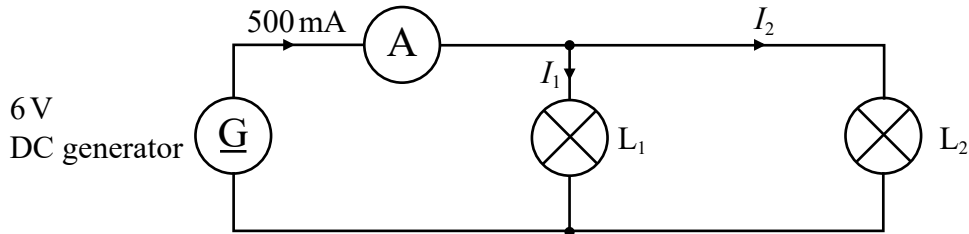
### ADVICE

- Read each question carefully before you start your answer.

- 1 A bicycle has front and back lights powered by a 6 V DC generator of negligible internal resistance.

The front and back lights use filament lamps. A mechanic uses a multimeter to test the circuit while the bicycle wheel is turning the generator. **Fig. 1** shows the circuit diagram of the bicycle lighting system and the multimeter being used as an ammeter.

**Fig. 1**



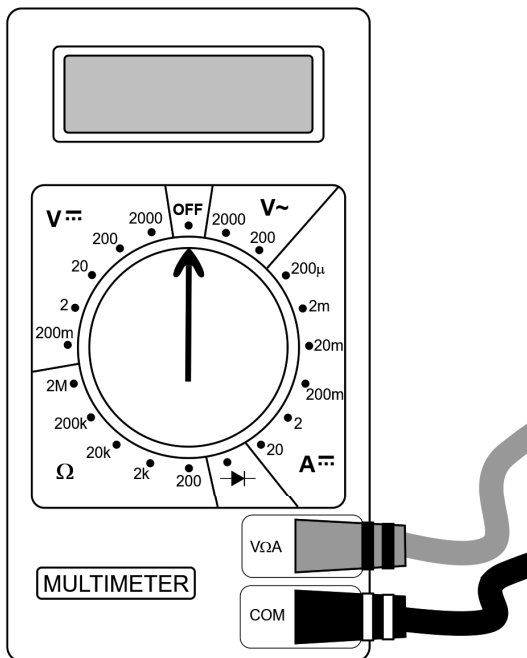
- (a) The multimeter is used as an ammeter to measure the current from the DC generator.

The current from the DC generator is designed to be 500 mA.

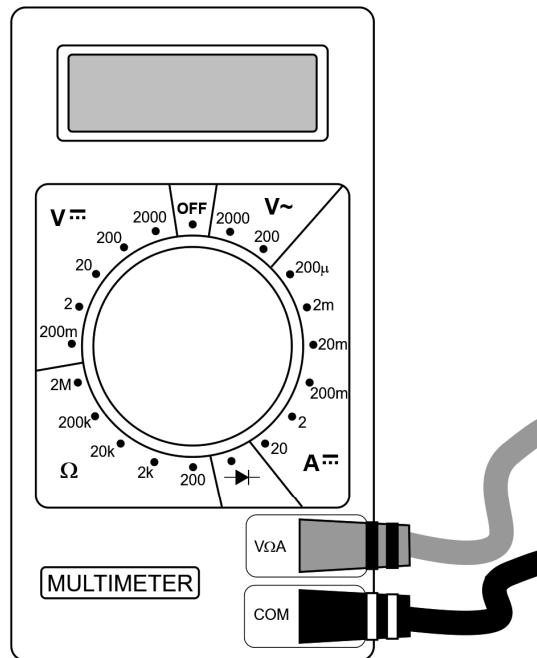
**Fig. 2a** shows a multimeter with the dial in the off position.

Draw an arrow **on Fig. 2b** to show the correct position of the dial to precisely measure the current from the DC generator.

**Fig. 2a**



**Fig. 2b**



[1]

(b) The power dissipated by  $L_1$  is 0.6 W.

(i) Calculate the energy dissipated by  $L_1$  in 5 minutes.

energy dissipated by  $L_1 = \dots\dots\dots$  J [2]

(ii) Calculate the current,  $I_1$ .

current,  $I_1 = \dots\dots\dots$  A [1]

(iii) Calculate the resistance of  $L_1$ .

resistance of  $L_1 = \dots\dots\dots$   $\Omega$  [1]

(c) Calculate the resistance of  $L_2$ .

resistance of  $L_2 = \dots\dots\dots$   $\Omega$  [2]

(d) Calculate the power dissipated by  $L_2$ .

power dissipated by  $L_2 = \dots\dots\dots$  W [1]

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2 An inductor and resistor are connected in series to an alternating current (AC) generator.

(a) Explain what is meant by alternating current.

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

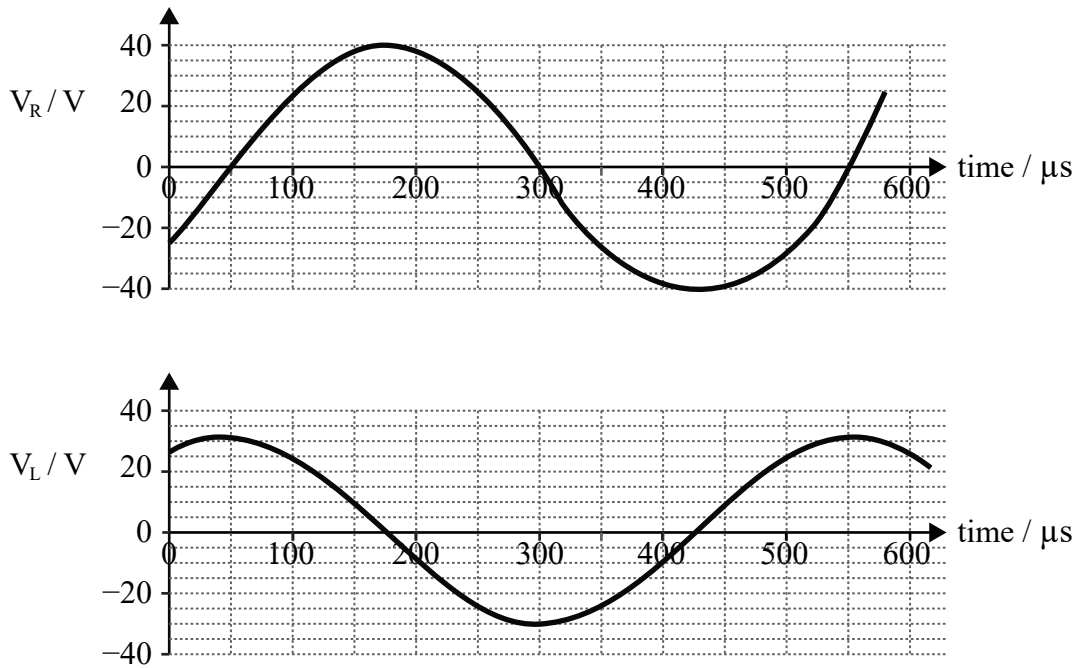
(b) Draw a circuit diagram of the inductor and resistor connected in series to an alternating current (AC) generator.

Label all components.

[2]

- (c) Graphs of voltage against time for the voltage across the resistor  $V_R$  and the voltage across the inductor  $V_L$  are shown in **Fig. 3**.

**Fig. 3**



- (i) Find the amplitude of  $V_R$  from the graph in **Fig. 3**.

amplitude of  $V_R = \dots\dots\dots$  V [1]

- (ii) Find the period of  $V_R$  from the graph in **Fig. 3**.

period of  $V_R = \dots\dots\dots$  μs [1]

- (iii) Calculate the frequency of  $V_R$ .

frequency of  $V_R = \dots\dots\dots$  Hz [2]

- (iv) Calculate the phase difference between  $V_R$  and  $V_L$  in degrees.

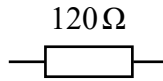
phase difference between  $V_R$  and  $V_L$  = ..... ° [2]

- (v) Calculate the phase difference between  $V_R$  and  $V_L$  in radians.

phase difference between  $V_R$  and  $V_L$  = ..... rad [1]

- 3 An engineer is testing a series-wound self-excited DC generator connected to a  $120\ \Omega$  resistor. The resistance of the armature is  $25\ \Omega$  and the resistance of the field winding is  $18\ \Omega$ .
- (a) Draw the circuit diagram of a series-wound self-excited DC generator **on Fig. 4** and show how it is connected to the resistor.  
Label the field winding and the armature.

**Fig. 4**



[2]

- (b) When the generator is connected to the  $120\ \Omega$  resistor the voltage at the output is  $8.2\ \text{V}$ .
- (i) Calculate the current in the  $120\ \Omega$  resistor.

current in the  $120\ \Omega$  resistor = ..... A [1]

- (ii) Calculate the EMF,  $E$ , in the armature.  
Give the units of your answer.

EMF generated in the armature,  $E =$  ..... [3]



(c) When the  $120\ \Omega$  resistor is replaced by a power supply, the series-wound DC generator works as a series-wound DC motor.

(i) State the difference between a motor and a generator.

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

(ii) When the motor is operating from a supply of 24 V the EMF in the armature is 17 V. Calculate the current in the armature,  $I_a$ .

$I_a = \dots\dots\dots$  A [2]

(iii) The engineer needs a motor to make a conveyer belt move at a fairly constant speed regardless of the load on the conveyer belt. A series-wound self-excited DC motor is not the best choice of motor for this application.

Suggest a better choice of DC motor for the conveyer belt. Explain your answer. Refer to the characteristics of the motor.

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

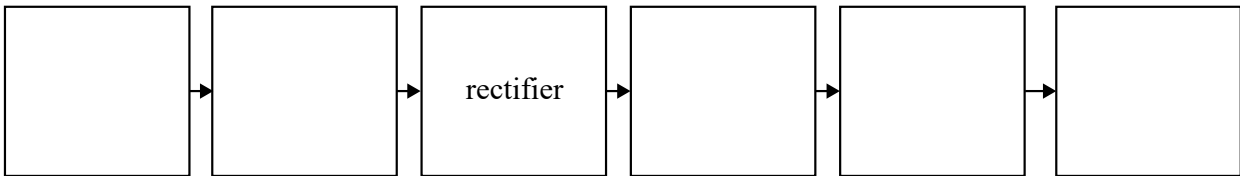
4 A stabilised power supply is used to provide the steady 19 V DC supply for a laptop computer from the 230 V AC mains supply.

(a) Complete the block diagram of a stabilised power supply shown in Fig. 5.

Choose from the terms below.

3-wire Delta      AC input      DC output      smoothing circuit      stabilising circuit      transformer

Fig. 5



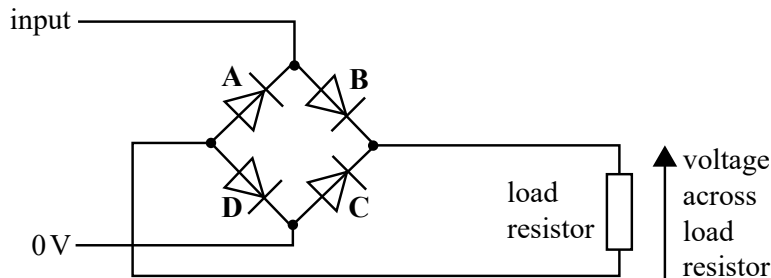
[5]

(b) State the function of the rectifier.

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

(c) A rectifier is shown in Fig. 6.

Fig. 6



(i) Complete the sentences below about the rectifier in Fig. 6 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.

**A and B    A and C    A and D    all    B and C    B and D    C and D    no**

When the voltage at the input is 24 V, ..... diodes are conducting.

When the voltage at the input is 0 V, ..... diodes are conducting.

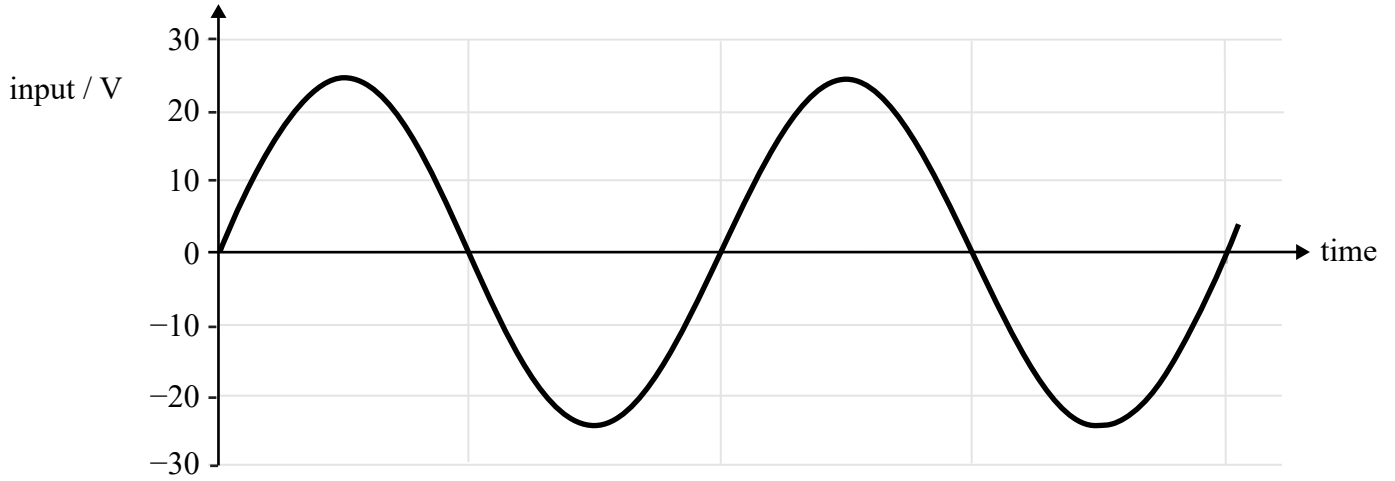
When the voltage at the input is -24 V, ..... diodes are conducting.

[3]

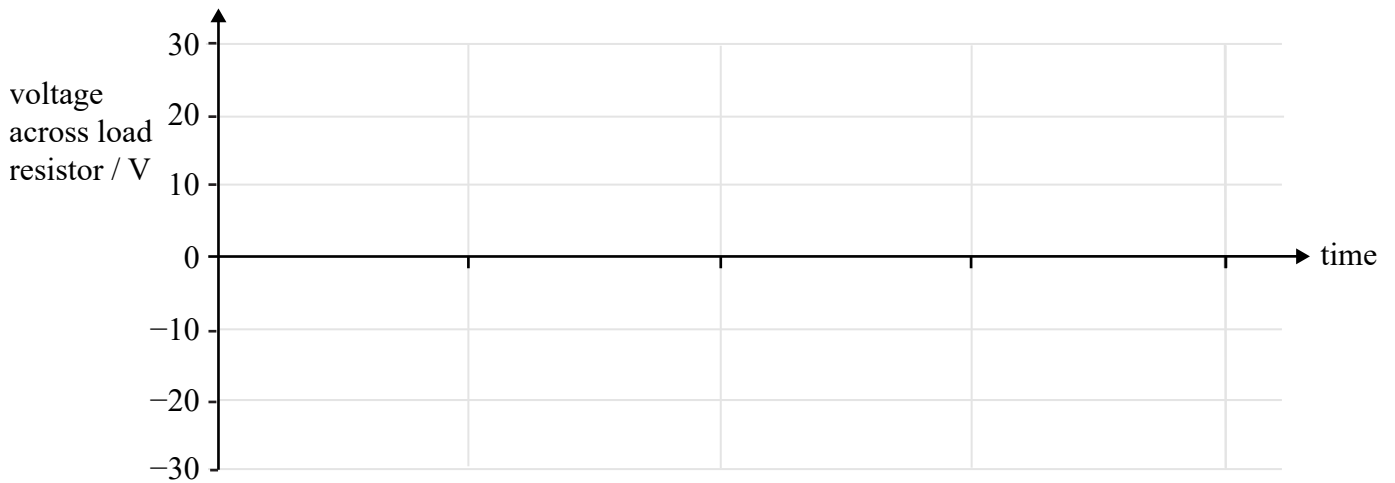
(ii) The input voltage to the rectifier is shown in **Fig. 7a**.

Show how the full wave bridge rectifier operates by drawing the voltage across the load resistor on the grid in **Fig. 7b**.

**Fig. 7a**



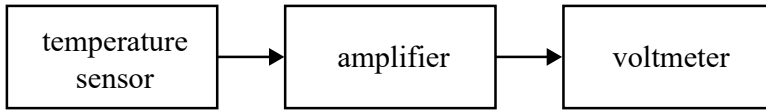
**Fig. 7b**



[2]

5 The block diagram of a system for measuring temperature is shown in **Fig. 8**.

**Fig. 8**



(a) The equation for voltage gain of a non-inverting op-amp amplifier is:

$$\text{Voltage gain} = \frac{V_{\text{out}}}{V_{\text{in}}} = 1 + \frac{R_F}{R_2}$$

- (i) When the voltage from the temperature sensor is 2.2 V the voltmeter reads 5.5 V.  
Calculate the voltage gain of the amplifier.

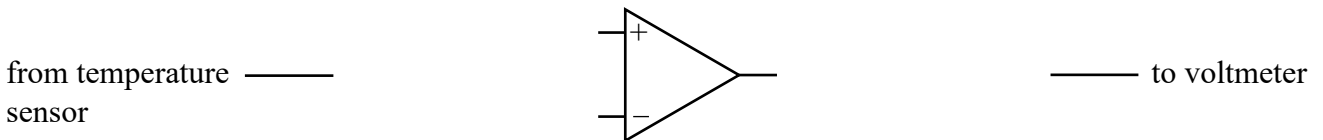
voltage gain of the amplifier = ..... [1]

(ii) The system in **Fig. 8** uses a non-inverting amplifier.

Complete the circuit diagram in **Fig. 9** of a non-inverting amplifier.

Label the components with suitable values.

**Fig. 9**



0V \_\_\_\_\_

[5]

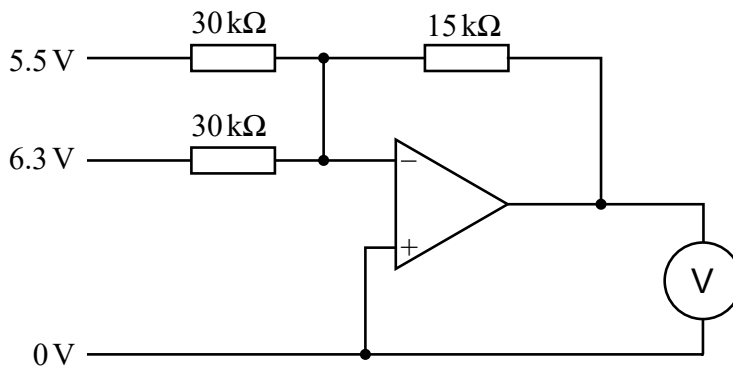
- (b) The current from the temperature sensor must be low to obtain an accurate reading.  
 State the property of an op-amp that ensures the current from the sensor is low.

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

- (c) The circuit in **Fig. 10** shows a summing amplifier being used to combine the signals from two temperature sensors.

Calculate the voltage shown on the voltmeter in **Fig. 10**.

**Fig. 10**



voltage shown on voltmeter = ..... V [3]

6 This question is about digital electronic circuits.

(a) State the meaning of **digital** in the term **digital electronic circuits**.

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

(b) This is the truth table of a logic system with inputs **F** and **G** and output **P**.

<b>F</b>	<b>G</b>	<b>P</b>
0	0	0
0	1	1
1	0	0
1	1	0

Draw a circuit using logic gates to obey this truth table.

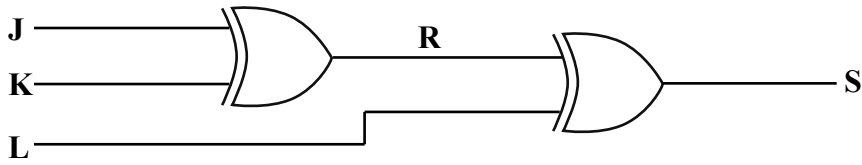
You may use any logic gates in your design.

Label the inputs **F** and **G**. Label the output **P**.

[2]

(c) A logic circuit is shown in **Fig. 11**.

**Fig. 11**



(i) Name the type of logic gate used in **Fig. 11**.

..... [1]

(ii) Put a **ring** around the Boolean expression for the first logic gate in **Fig. 11**.

$R = J + K$       $R = \overline{J + K}$       $R = J \cdot K$       $R = \overline{J \cdot K}$       $R = J \oplus K$

[1]

(iii) Complete the truth table for the logic circuit in **Fig. 11**.

J	K	L	R	S
0	0	0		

[3]

**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, 2(a) or 4(b).

A vertical line on the left side of the page is followed by 25 horizontal dotted lines, providing a ruled area for writing answers.



A series of horizontal dotted lines for writing, spanning the width of the page.

A series of horizontal dotted lines for writing, spanning the width of the page.

A series of horizontal dotted lines for writing, starting below the page number and extending to the bottom of the page. The lines are evenly spaced and cover most of the page width.



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