

## Wednesday 16 January 2019 – Afternoon

### LEVEL 3 CAMBRIDGE TECHNICAL IN ENGINEERING

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

**Duration: 1 hour 30 minutes**  
**C304/1901**



**You must have:**

- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a scientific calculator

First Name						Last Name				
Centre Number						Candidate Number				
Date of Birth	D	D	M	M	Y	Y	Y	Y		

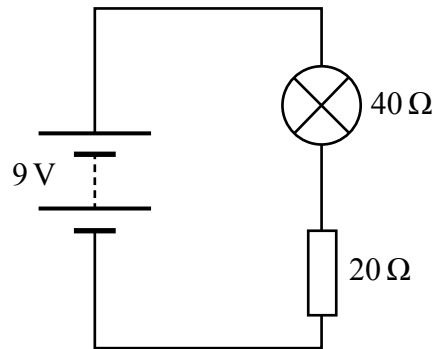
- INSTRUCTIONS**
- Use black ink. You may use an HB pencil for graphs and diagrams.
  - Complete the boxes above with your name, centre number, candidate number and date of birth.
  - Answer **all** the questions.
  - Write your answer to each question in the space provided. Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).

- INFORMATION**
- The total mark for this paper is **60**.
  - The marks for each question are shown in brackets [ ].
  - Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
  - An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
  - Final answers should be given to a degree of accuracy appropriate to the context.
  - This document consists of **16** pages.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/12
2	/12
3	/9
4	/11
5	/8
6	/8
<b>Total</b>	<b>/60</b>

Answer **all** the questions.

- 1 (a) Fig. 1 shows a filament lamp with a resistance when lit of  $40\ \Omega$  in series with a  $20\ \Omega$  resistor, connected to a  $9.0\ \text{V}$  battery with negligible internal resistance.



**Fig. 1**

- (i) Calculate the total resistance in the circuit.

total resistance = .....  $\Omega$  [1]

- (ii) Calculate the current in the circuit. Give the units for your answer.

current = ..... [2]

- (iii) Calculate the voltage across the lamp.

voltage across lamp = ..... V [1]

(iv) Calculate the power dissipated by the lamp.

power = ..... W [1]

(b) The power supply on a boat operates at about 24 VDC.

(i) 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 accurately measure the voltage of the power supply on the boat.

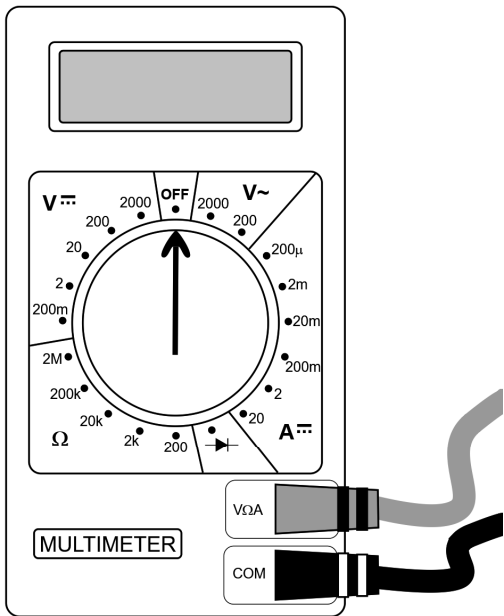


Fig. 2a

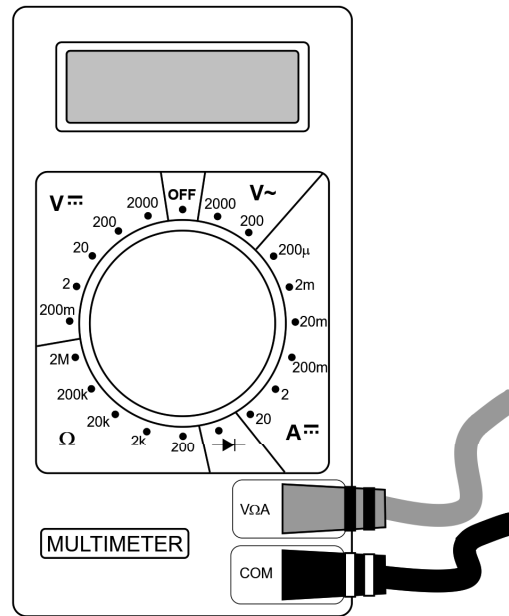


Fig. 2b

[1]

(ii) State why the dial position you have chosen for your answer will produce the most accurate measurement.

.....

..... [1]

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

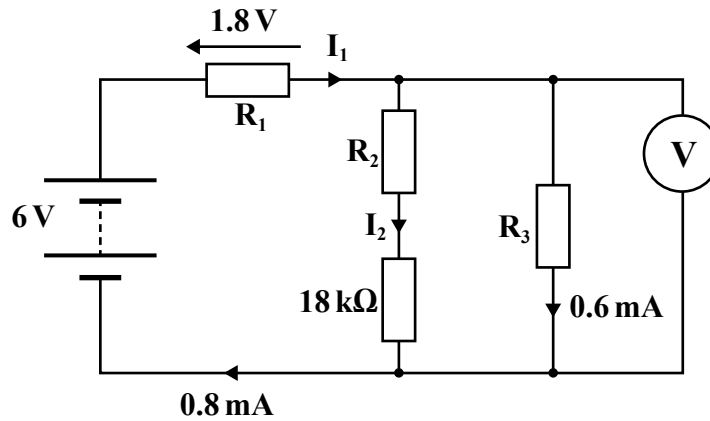


Fig. 3

(i) Calculate the voltage shown on the voltmeter.

$$V = \dots\dots\dots \text{ V [1]}$$

(ii) State the value of  $I_1$ .

$$I_1 = \dots\dots\dots \text{ mA [1]}$$

(iii) Calculate the value of  $I_2$ .

$$I_2 = \dots\dots\dots \text{ mA [1]}$$

(iv) Calculate the value of  $R_1$ .

$$R_1 = \dots\dots\dots \Omega [1]$$

(v) Calculate the value of  $R_2$ .

$$R_2 = \dots\dots\dots \Omega [1]$$

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**Turn over for the next question**

- 2 (a) A sine wave is shown in Fig. 4.

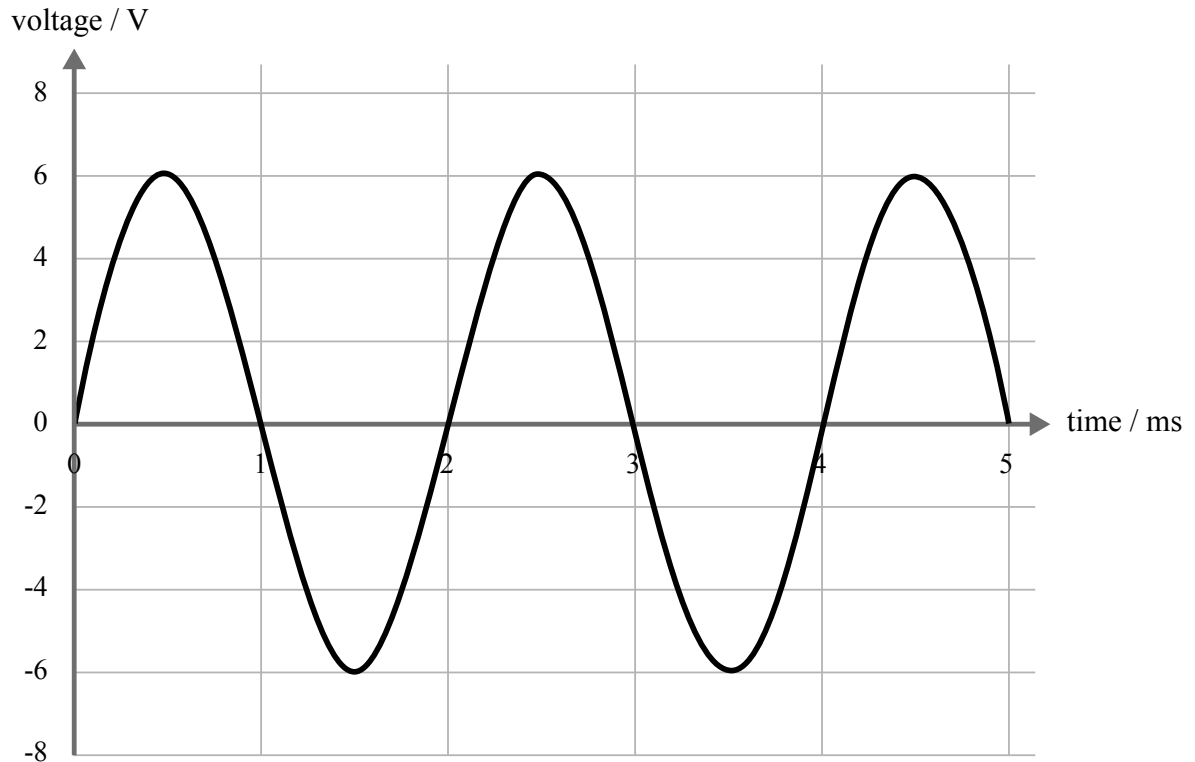


Fig. 4

- (i) State the amplitude of the signal in Fig. 4.

amplitude = ..... V [1]

- (ii) State the period of the signal in Fig. 4.

period = ..... ms [1]

- (iii) State the peak to peak voltage of the signal in Fig. 4.

peak to peak voltage = ..... V [1]

- (iv) Calculate the frequency of the signal in Fig. 4.  
Show your working. Give the units for your answer.

frequency = ..... [3]

- (b) An AC supply of frequency (f) 600 Hz is connected to a  $3.3 \mu\text{F}$  capacitor (C) in series with a  $64 \Omega$  resistor (R).
- (i) Draw a circuit diagram of the system.

[2]

- (ii) Calculate the reactance ( $X_c$ ) of the capacitor.

Use the equation for reactance  $X_c = \frac{1}{2\pi fC}$

Give the units for your answer.

$X_c = \dots\dots\dots$  [3]

- (iii) Calculate the impedance (Z) of the circuit.

$Z = \dots\dots\dots \Omega$  [1]

3 This question is about series-wound DC motors.

(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.

**high**

**infinite**

**low**

**slow**

**zero**

A series-wound DC motor is used to start a car engine. When a voltage is first applied to the motor it is not turning and so the EMF generated by the motor is ..... and the torque provided by the motor is ..... . After a short time the motor has reached high speed and so the EMF generated by the motor is ..... and the torque provided by the motor is .....

[4]

(b) Complete the diagram in Fig. 5 to show how the armature and the field winding are connected to a battery in a series-wound DC motor.

Label the field winding and armature.

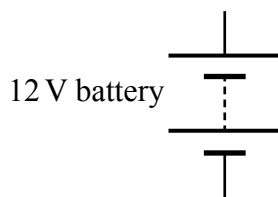


Fig. 5

[1]



- (c) In a series-wound DC motor the resistance of the armature ( $R_a$ ) is  $0.16\ \Omega$  and the resistance of the field windings ( $R_f$ ) is  $0.04\ \Omega$ .
- (i) Calculate the total resistance ( $R_t$ ) of the series-wound DC motor.

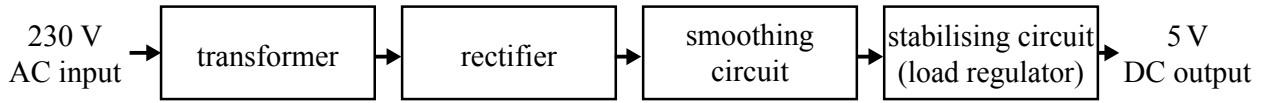
$$R_t = \dots\dots\dots \Omega \quad [1]$$

- (ii) The motor is used with a supply voltage ( $V$ ) of  $12\ \text{V}$ .  
When the motor is turning quickly the current in the armature ( $I_a$ ) is  $20\ \text{A}$ .  
Calculate the EMF ( $E$ ) generated by the motor.  
Give the units for your answer.

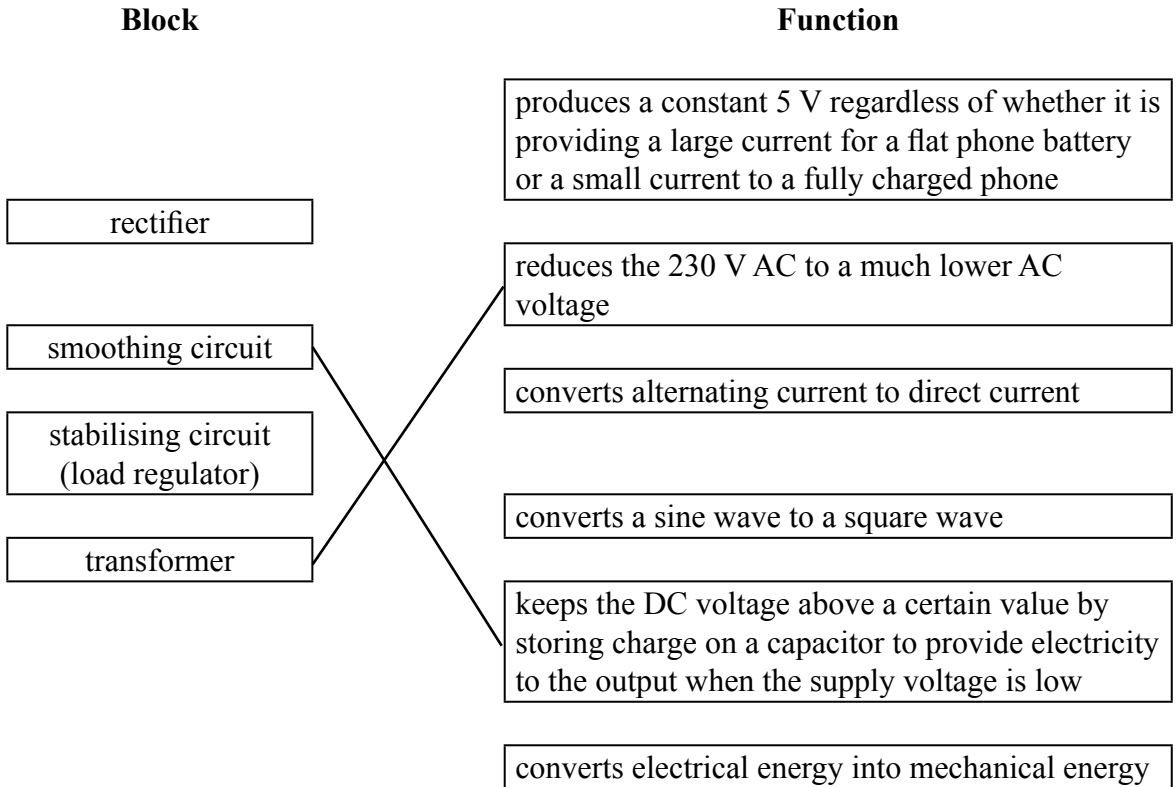
$$E = \dots\dots\dots [3]$$

4 This question is about a stabilised power supply being used as a phone charger.

(a) A phone charger uses a stabilised power supply to produce 5 V DC from 230 V AC.



Draw a line to join the name of each block to its function, two have been done for you. There will be some functions without a connecting line.



[2]

(b) Draw on Fig. 6 to show how alternating current (AC) can be converted to half-wave direct current (DC) of the correct polarity using a **single** diode.



Fig. 6

[3]

(c) State the meanings of the terms *direct current* and *alternating current*.

direct current: .....

.....

alternating current: .....

.....

[2]

(d) The DC output of the power supply is protected with a 2 A fuse.

(i) Draw the wires on Fig. 7 to show how all the parts should be connected.

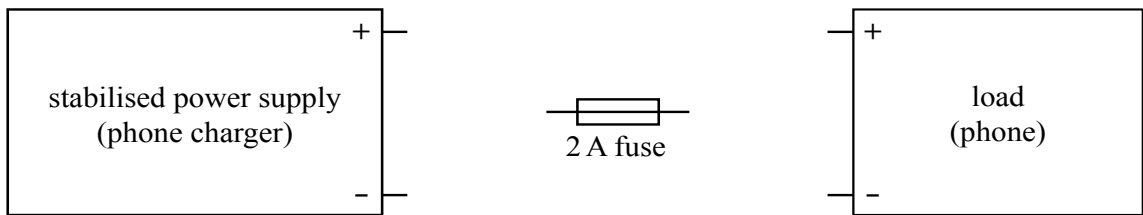


Fig. 7

[1]

(ii) Explain how the fuse works to protect the output of the power supply.

.....

.....

.....

.....

.....

..... [3]

5 (a) Fig. 8 shows the circuit diagram for an amplifier.

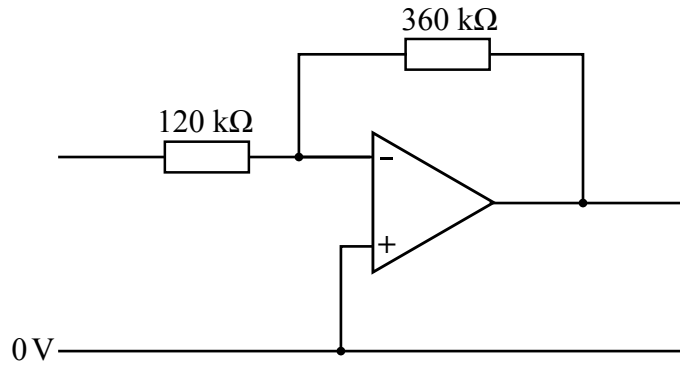


Fig. 8

(i) Put a ring around the name of the amplifier circuit shown in Fig 8.

- |                   |                     |                         |                          |
|-------------------|---------------------|-------------------------|--------------------------|
| class A amplifier | inverting amplifier | non-inverting amplifier | transimpedance amplifier |
|-------------------|---------------------|-------------------------|--------------------------|

[1]

(ii) Label the *input* and the *output* of the amplifier on Fig 8.

[1]

(iii) Calculate the voltage gain of the amplifier in Fig. 8 using the formula

$$\text{Voltage Gain} = \frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_f}{R_{\text{in}}}$$

Voltage Gain = ..... [2]

(iv) The input voltage of the amplifier,  $V_{\text{in}}$ , is 1.5 V. Calculate the output voltage,  $V_{\text{out}}$ .

$V_{\text{out}} = \dots\dots\dots$  V [1]

- (b) A summing amplifier circuit is used to combine two different signals,  
 $V_1 = 1.2 \text{ V}$  and  $V_2 = -2.5 \text{ V}$

The feedback resistor of the summing amplifier ( $R_f$ ) has a value of  $220 \text{ k}\Omega$  and the input resistors ( $R_{in}$ ) both have a value of  $110 \text{ k}\Omega$ .

- (i) Draw the circuit diagram for the summing amplifier.

Label all the resistors and inputs with their values.

[2]

- (ii) Calculate the output voltage of the summing amplifier.

Use the formula  $V_{out} = -\frac{R_f}{R_{in}}(V_1 + V_2)$

$V_{out} = \dots\dots\dots \text{ V [1]}$

6 Fig. 9 shows a logic gate.

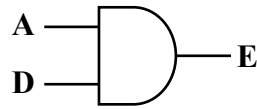


Fig. 9

(a) Name the logic gate in Fig. 9. .... [1]

(b) Complete the truth table for the logic gate in Fig. 9.

A	D	E

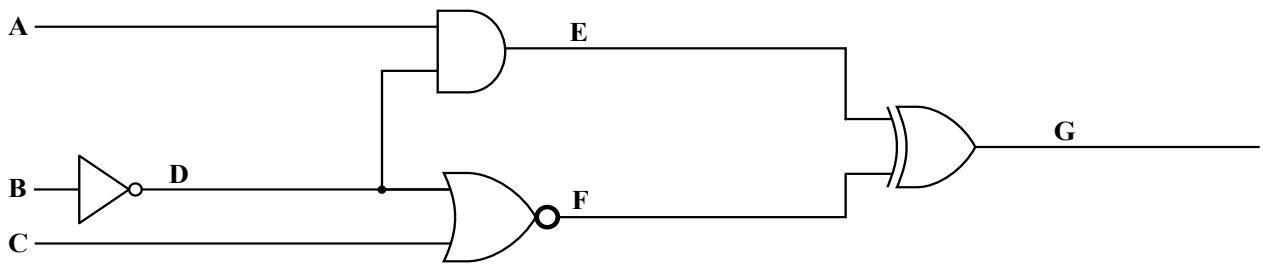
[2]

(c) Put a ring around the correct Boolean expression for the logic gate in Fig 9.

$$\mathbf{E = A + D} \quad \mathbf{E = \overline{A + D}} \quad \mathbf{E = A \cdot D} \quad \mathbf{E = \overline{A \cdot D}} \quad \mathbf{E = A \oplus D} \quad \mathbf{E = \overline{A}}$$

[1]

(d) Fig. 10 shows the logic gate in a larger circuit.



**Fig. 10**

Complete the truth table for the circuit in Fig. 10.

A	B	C	D	E	F	G
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**

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