OCR
Oxford Cambridge and RSA

Wednesday 22 May 2019 – Morning

LEVEL 3 CAMBRIDGE TECHNICAL IN ENGINEERING

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

C304 – 1906

Time allowed: 1 hour 30 minutes
C304/1906

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- 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 may use an HB pencil for graphs and diagrams.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

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	/9
3	/9
4	/10
5	/10
6	/10
Total	**/60**

Answer **all** the questions.

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.

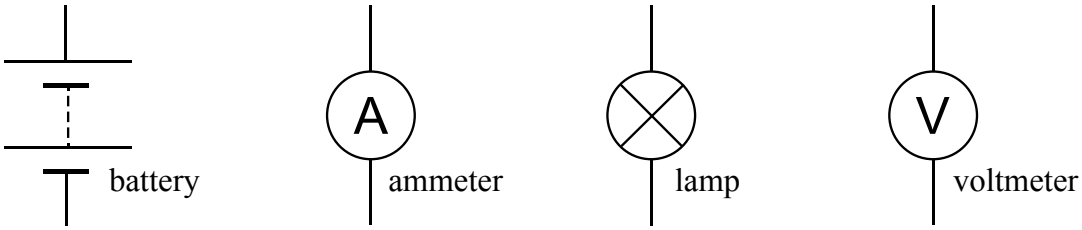


Fig. 1

[3]

(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]**

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

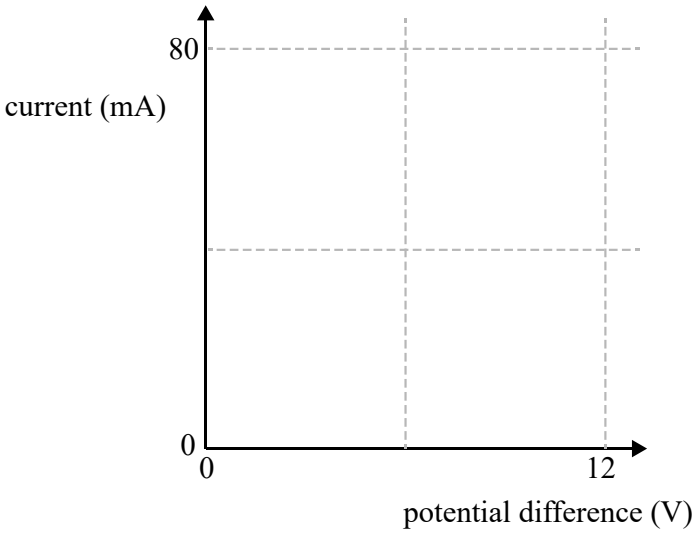


Fig. 2

[2]

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

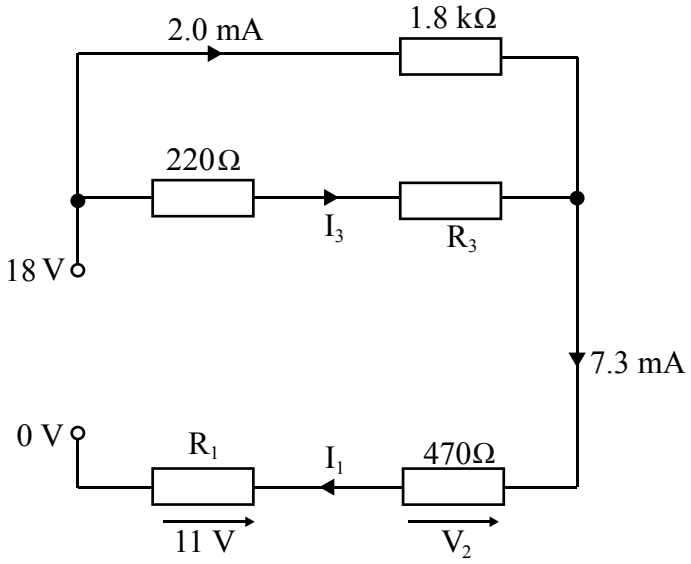


Fig. 3

(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]**

(v) Calculate the value of R_3.

R_3 = ... Ω **[2]**

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

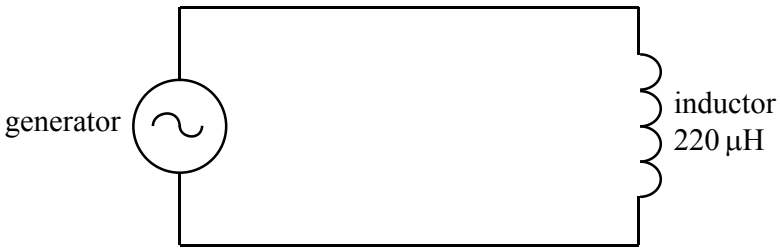


Fig. 4

(a) State the function of a simple generator.

.....

.....

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

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

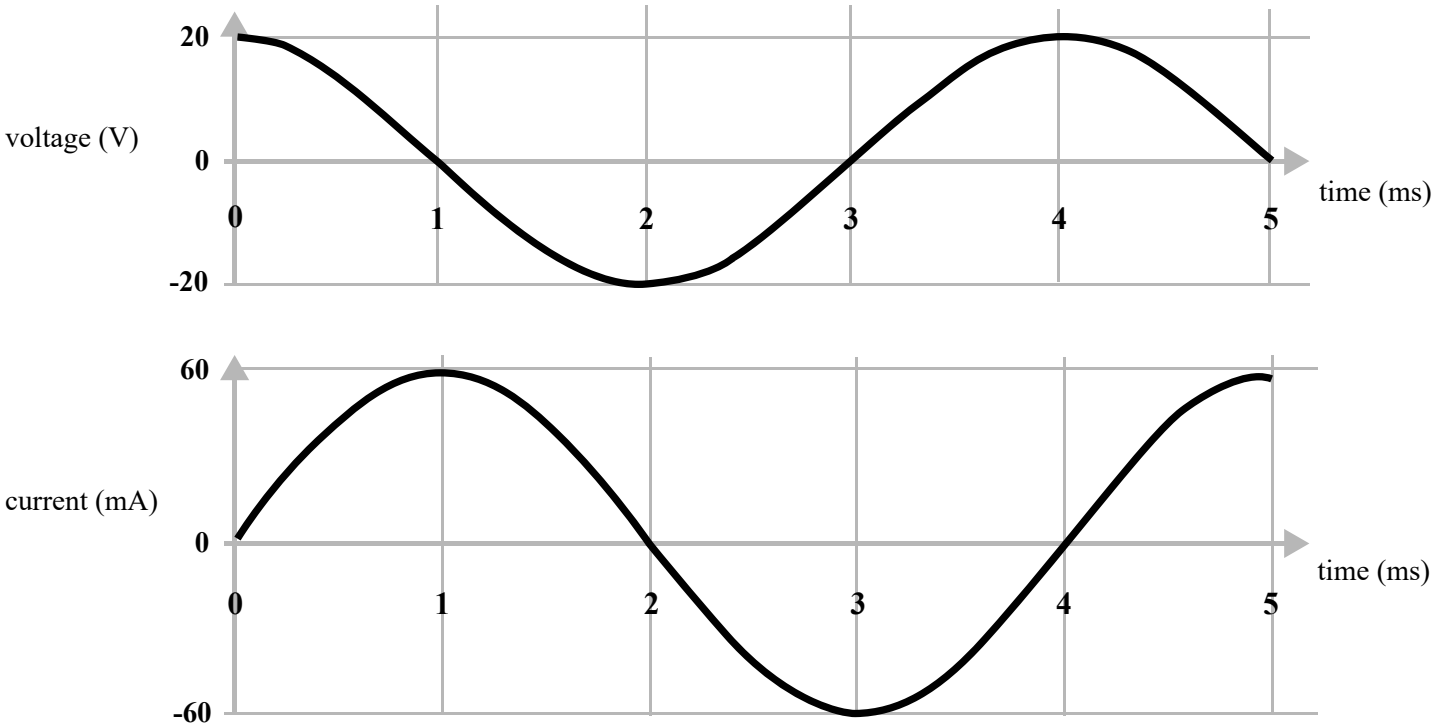


Fig. 5

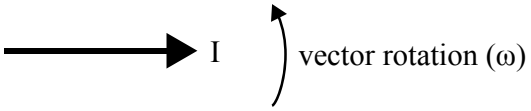
(i) Use the graphs in Fig. 5 to find the frequency of the current in the inductor.

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

(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]**

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]**

(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.

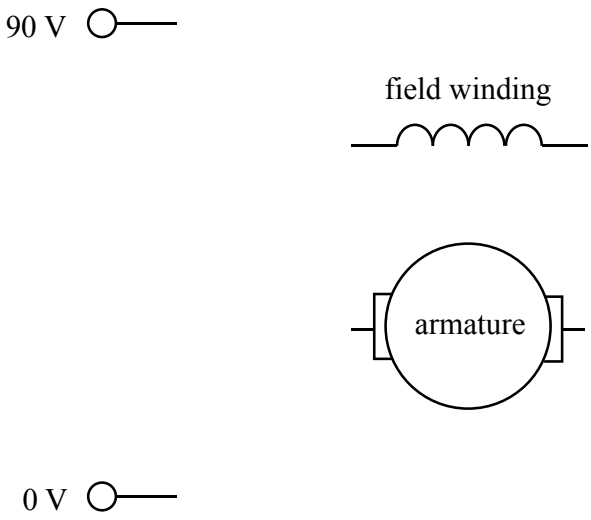


Fig. 8

[2]

(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]**

(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]**

(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]**

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]**

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

phase difference = ... ° **[1]**

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

.....

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

(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]**

(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**

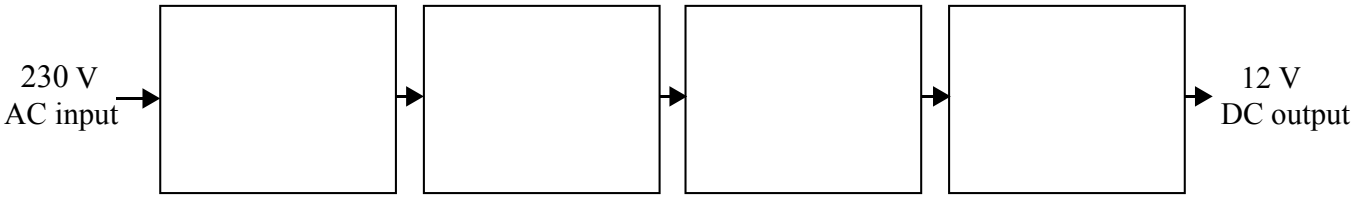


Fig. 9

[4]

Turn over for the next question

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]

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

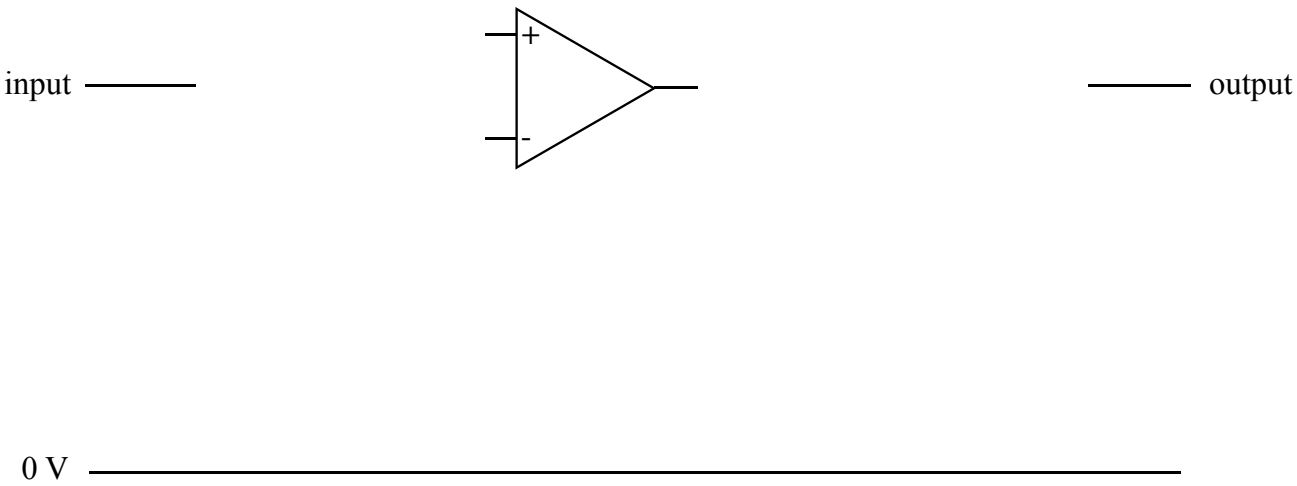


Fig. 10

[4]

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

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

R_F = ... Ω

R_2 = ... Ω

[1]

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

[1]

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

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

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.

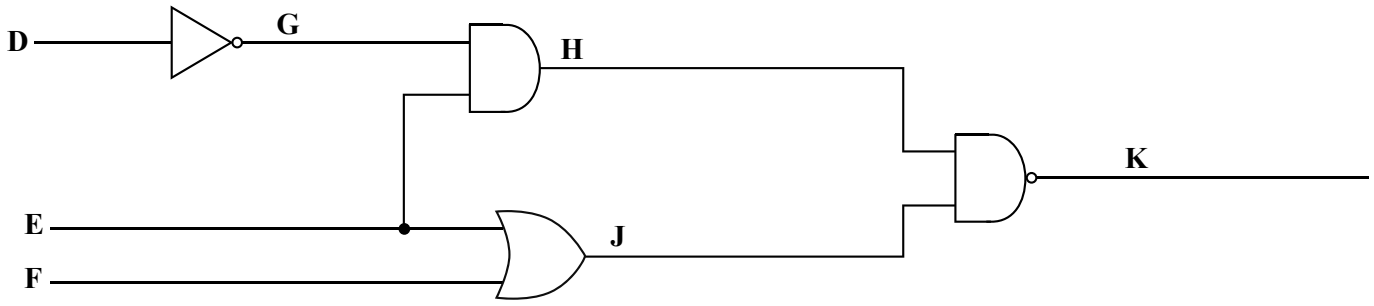


Fig. 11

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.

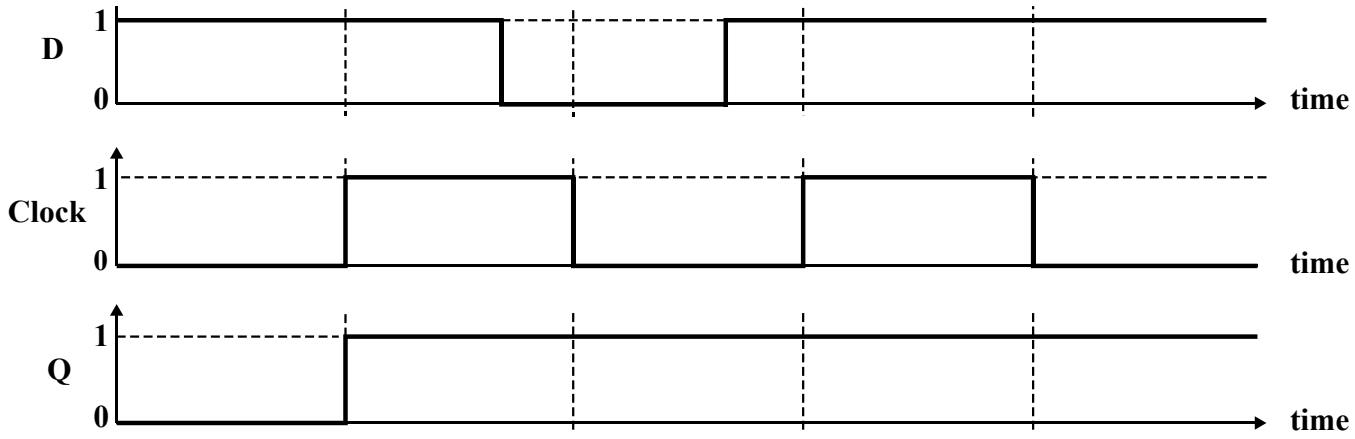


Fig. 12

[2]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown – for example 2(a) or 3(a).