SECONDARY 4
PRELIMINARY EXAMINATION

ELECTRONICS

6063/1

25 August 2021 (Wednesday) **2 hours**

CANDIDATE NAME	
CLASS	
INDEX NUMBER	

READ THESE INSTRUCTIONS FIRST
Do not turn over the page until you are told to do so.
Write your name, class, and index number in the spaces provided above.
Write in dark blue or black ink pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, and glue or correction fluid/tape.

Sections A and B
Answer **all** the questions.
Write your answers in the spaces provided on the question paper.

Approved electronic calculators are allowed for use in this paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

The total marks for this paper is **100**.

FOR EXAMINERS' USE	
Section A	**/ 38**
Section B	**/ 57**
TOTAL	**/ 95**

This document consists of **26** printed pages including the cover page

Resistor Colour Code

1st Colour Band 1st Digit	2nd Colour Band 2nd Digit	3rd Colour Band Multiplier	4th Colour Band Tolerance
Black 0	Black 0	Black 0	Gold ± 5 %
Brown 1	Brown 1	Brown 1	Red ± 2 %
Red 2	Red 2	Red 2	
Orange 3	Orange 3	Orange 3	
Yellow 4	Yellow 4	Yellow 4	
Green 5	Green 5	Green 5	
Blue 6	Blue 6	Blue 6	
Violet 7	Violet 7	Violet 7	
Grey 8	Grey 8	Silver 0.01	
White 9	White 9	Gold 0.1	

Preferred values for resistors (E24 SERIES)

1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0 3.3
3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1 and multiples of ten.

FORMULAE

Astable and monostable generators using 555 timers

Monostable mode — Period $T = 1.1RC$

Astable mode frequency ($t_1 + t_2$) — Period $T = \dfrac{(R_1 + 2R_2)C}{1.44}$

Bipolar Junction Transistor (BJT)

Current gain — $\beta = \dfrac{\text{Collector current}}{\text{Base current}}$

Voltage gain (for voltage-divider biased CE amplifier, emitter resistor unbypassed)

$$\cong -\frac{R_C}{R_E}$$

Table on Boolean algebra

Single variable theorems	Laws of Complementation	• $\overline{0} = 1$ • $\overline{1} = 0$ • $\overline{\overline{A}} = A$
	AND Laws	• $A \cdot 0 = 0$ • $A \cdot 1 = A$ • $A \cdot A = A$ • $A \cdot \overline{A} = 0$
	OR Laws	• $A + 0 = A$ • $A + 1 = 1$ • $A + A = A$ • $A + \overline{A} = 1$
Multivariable theorems	Commutative Laws	• $A + B = B + A$ • $A \cdot B = B \cdot A$
	Associative Laws	• $A + (B + C) = (A + B) + C = A + B + C$ • $A(B \cdot C) = (A \cdot B) \cdot C = A \cdot B \cdot C$
	Distributive Laws	• $A \cdot (B + C) = A \cdot B + A \cdot C$ • $(A + B) \cdot (C + D) = A \cdot C + B \cdot C + A \cdot D + B \cdot D$
	Absorptive Laws	• $A + A \cdot B = A$ • $A \cdot (A + B) = A$ • $A + \overline{A} \cdot B = A + B$ • $A \cdot (\overline{A} + B) = A \cdot B$
	DeMorgan's Theorems	• $(\overline{A + B}) = \overline{A} \cdot \overline{B}$ • $(\overline{A \cdot B}) = \overline{A} + \overline{B}$

Section A

Answer **all** questions.

Write your answers in the spaces provided.

1 Pulse Width Modulation (PWM) can be used to transmit data in telecommunications. Fig. 1.1 shows how the message signal (X) is modulated with carrier signal (Y) to produce PWM signal (Z).

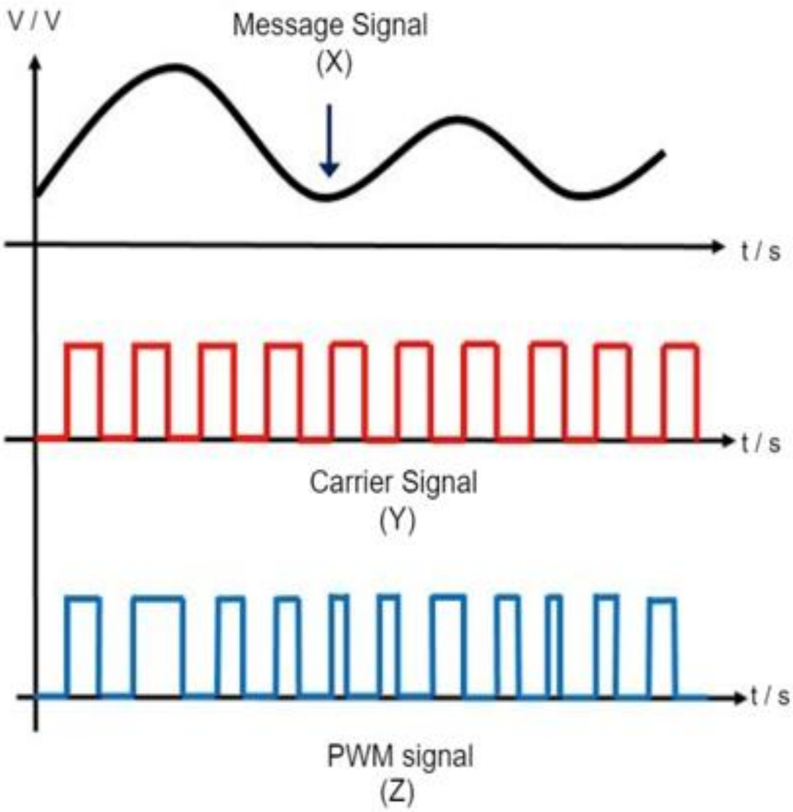


Fig 1.1

(a) State the type of signal shown in Fig. 1.1 in the table below. [2]

Signal	Type of signal
X	
Z	

(b) State the difference between carrier signal (Y) and PWM signal (Z). [1]

....

....

[Total: 3 marks]

2 Fig 2.1 shows a common emitter amplifier that is commonly used to amplify signal from sources such as microphone or photodiode sensor.

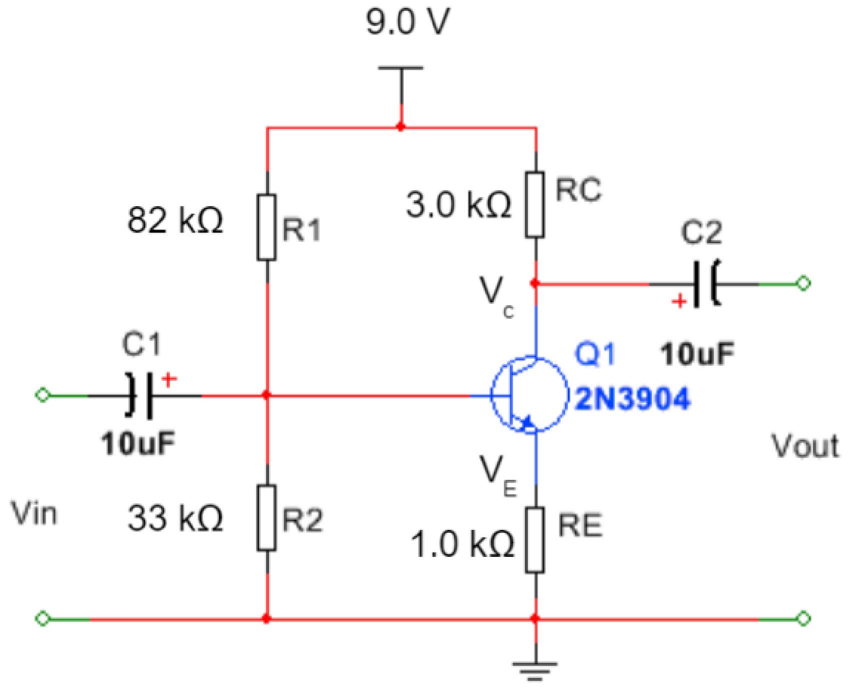


Fig. 2.1

(a) **(i)** Deduce the output KVL equation. [1]

(ii) Calculate V_C if I_E = 1.5 mA. [1]

V_c =..................................

(b) Determine the base current I_B. [1]

....

(c) Determine the gain of the amplifier. [1]

gain =..................................

(d) Fig. 2.2 shows the output waveform measured across V_{out}.
On Fig. 2.2, draw the input waveform V_{in} and label the value of V_{peak}. [2]

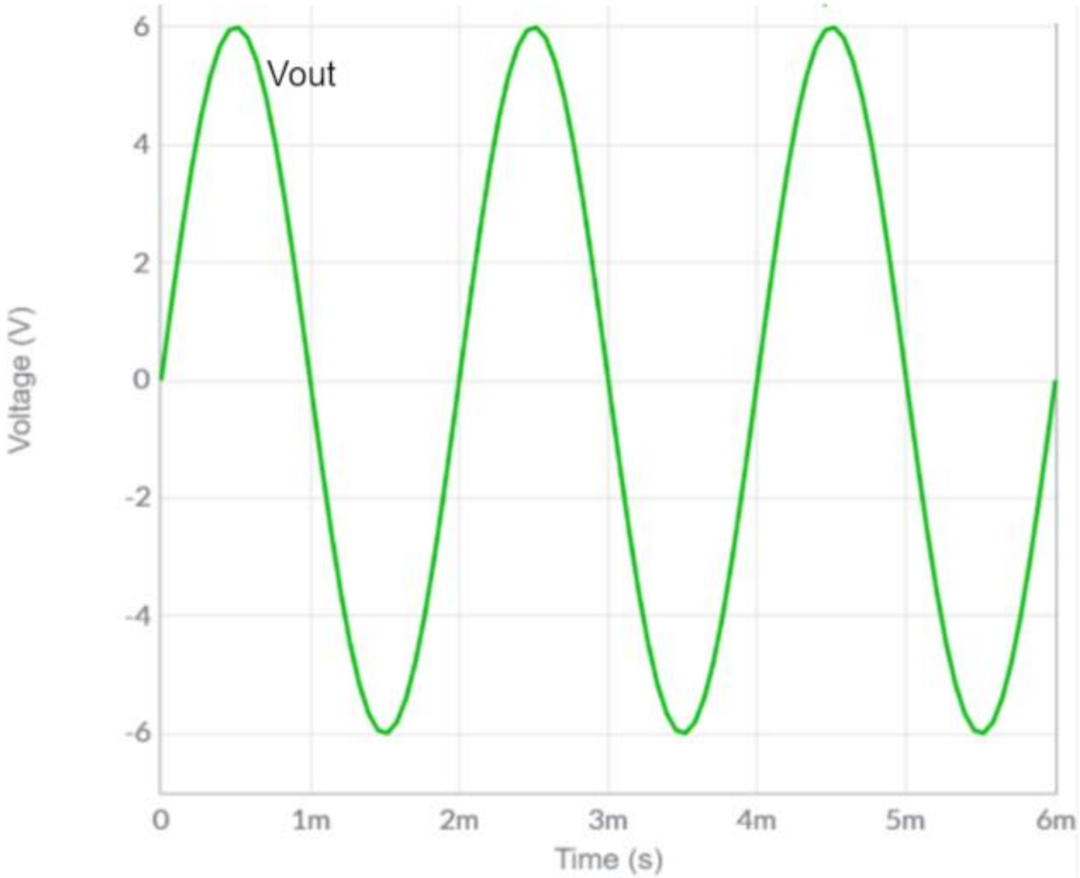


Fig. 2.2

[Total: 6 marks]

3 Fig. 3.1 shows the I*V* graph of three different components.

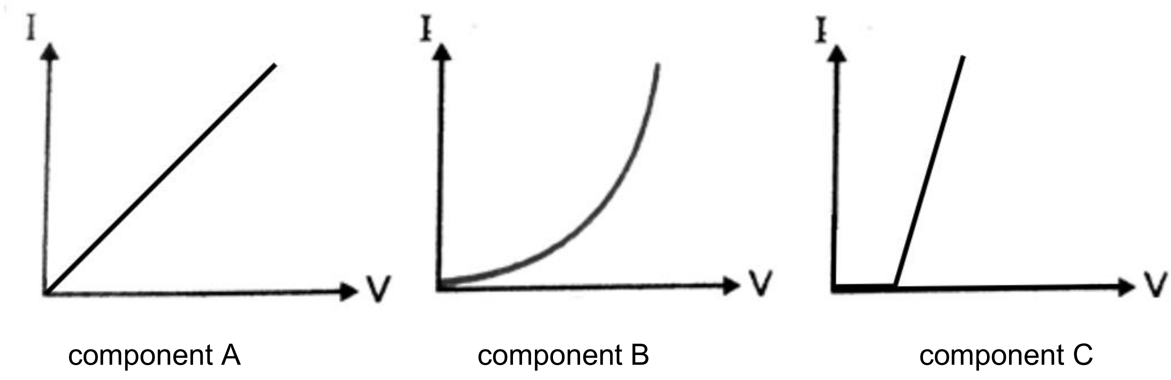


Fig. 3.1

(a) State and explain which conductor/s is/are non ohmic. [2]

....

....

....

(b) Component A is 1.8 m long and has a total resistance of 0.046 Ω.
The table below shows some information on component A.

American Wire Gauge Table

AWG number	Diameter	Cross-sectional area
17	1.2×10^{-3} m	1.1×10^{-6} m^2

Resistivity of some conducting materials

Material	Resistivity / Ωm
copper	1.7×10^{-8}
aluminum	2.8×10^{-8}
tungsten	5.6×10^{-8}

(i) Calculate the resistivity of component A. [1]

resistivity =.......................................

(ii) Hence, determine the material that is used to make component A. [1]

....

(c) Component X has a resistance of 2.0×10^{-3} Ω.
Component Y has the same cross-sectional area and resistivity as component X but twice its length.
Determine the resistance of component Y. [1]

resistance of component Y =……………………………..………

[Total: 5 marks]

4 Fig. 4.1 shows a combinational logic circuit.

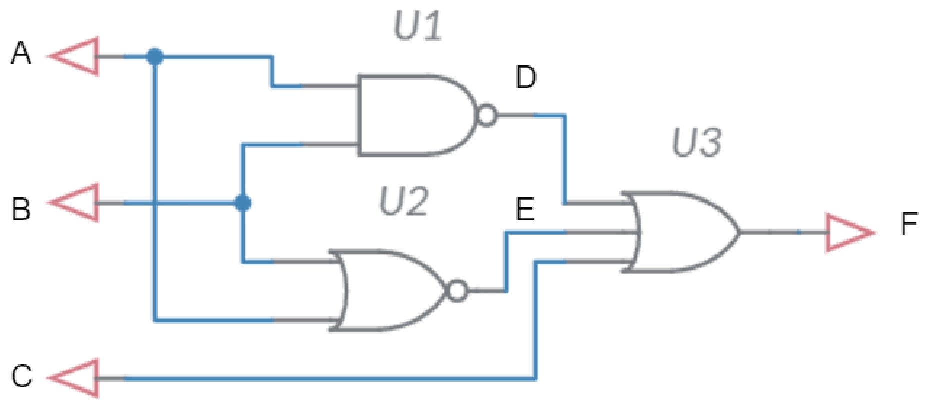


Fig. 4.1

(a) Fig. 4.2 shows a timing diagram of the circuit. Complete the timing diagram of the circuit. [3]

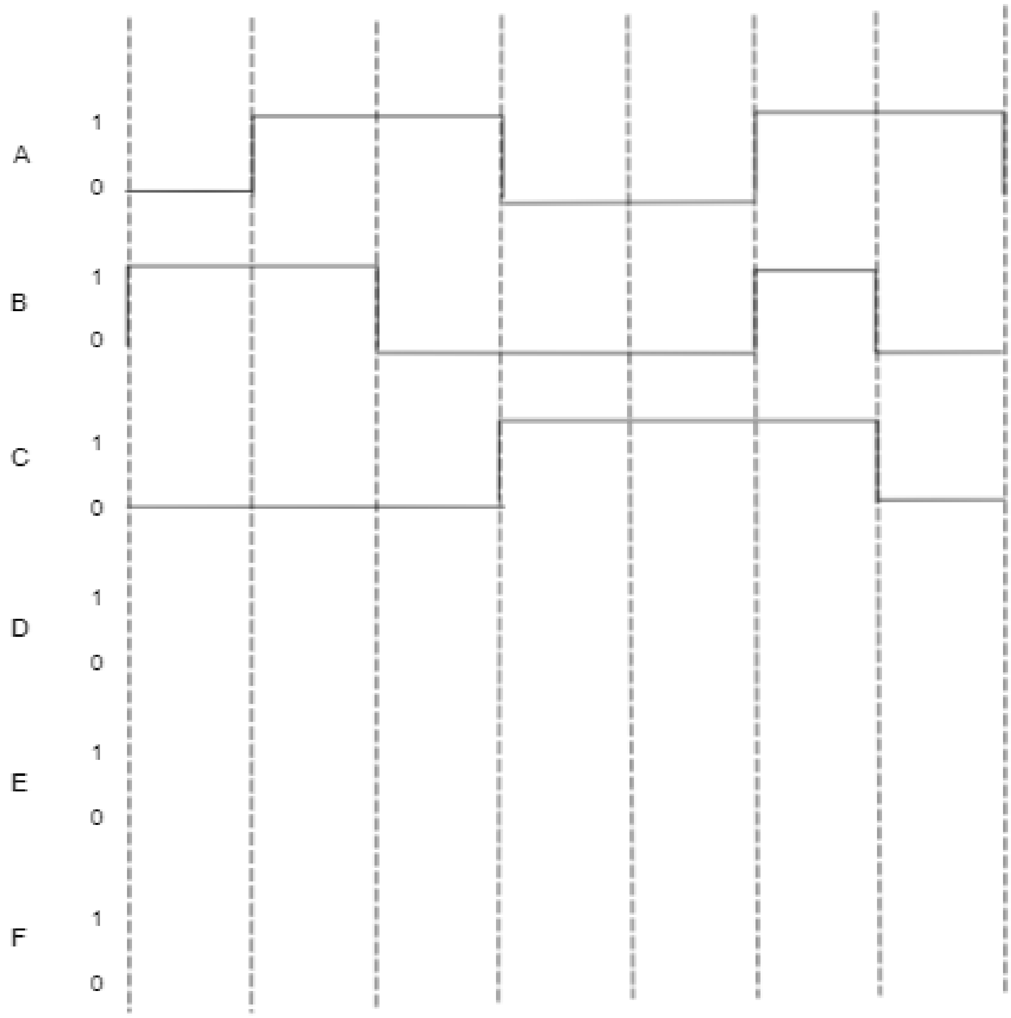


Fig. 4.2

(b) Write the Boolean expressions for D, E and F. [3]

D =...

E =...

F =...

(c) Universal gates can be used to represent any other logic gates.
Draw in the space below to show how a two input OR gate can be represented by universal gates. [2]

[Total: 8 marks]

5 Fig. 5.1 shows an astable multivibrator circuit.

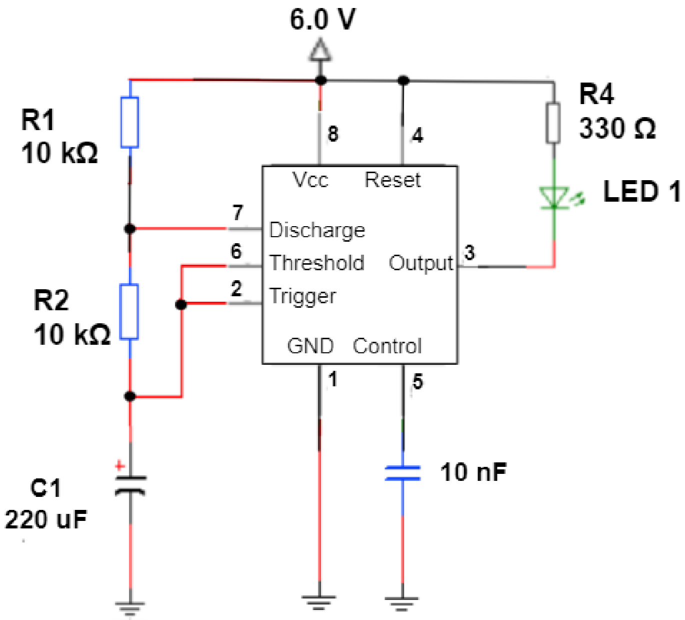


Fig. 5.1

(a) Determine the frequency at which LED 1 flashes. [2]

frequency =……………………………………

(b) Explain why it is impossible for the circuit in Fig. 5.1 to achieve 50% duty cycle.[2]

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

(c) A diode is added in parallel to R2 as shown in Fig. 5.2.

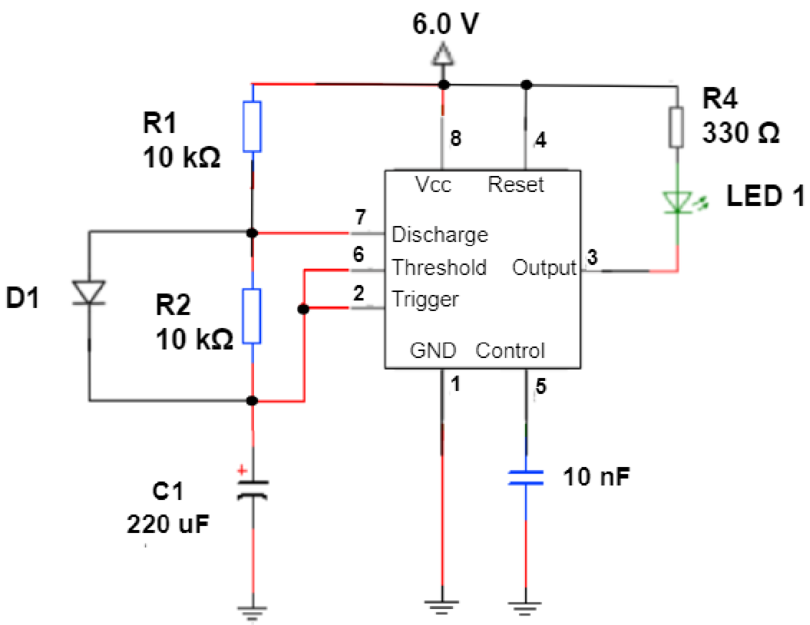


Fig. 5.2

Explain why with the addition of diode D1, it is now possible to achieve a 50% duty cycle. [2]

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

[Total: 6 marks]

6 **(a)** Table 6.1 shows numbers in a range of number systems.
Complete the table by adding the missing numbers. [2]

Binary	BCD	Decimal
01101110		
	1001 0011	

Table 6.1.

(b) Circle the largest decimal value for a 4-bit binary system. [1]

16 8 15 10 32

(c) Give one example of a number in 4-bit binary that cannot be converted to BCD. [1]

……………………………………………………………………………………………

[Total: 4 marks]

7 Fig. 7.1 shows a circuit used to detect AC signals.

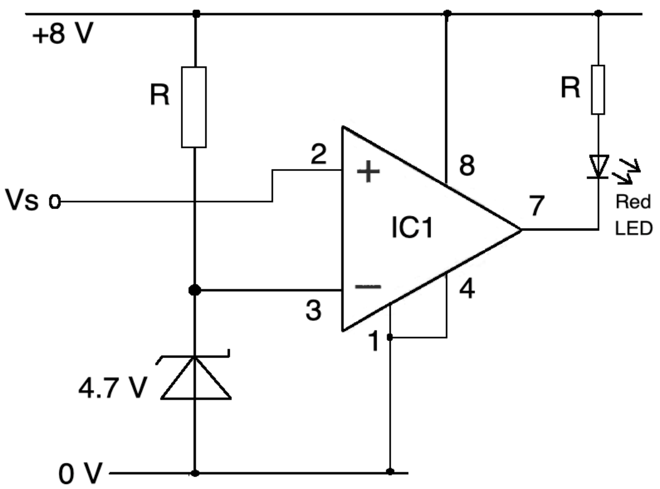


Fig. 7.1

(a) Name the component IC1 used in Fig. 7.1. [1]

……………………………………………………………………………………

(b) **(i)** The reference voltage at pin 3 is set to 4.7 V. An input waveform Vs is applied at pin 2. Draw and label the voltage signal at pin 7 and the reference voltage on Fig. 7.2. [3]

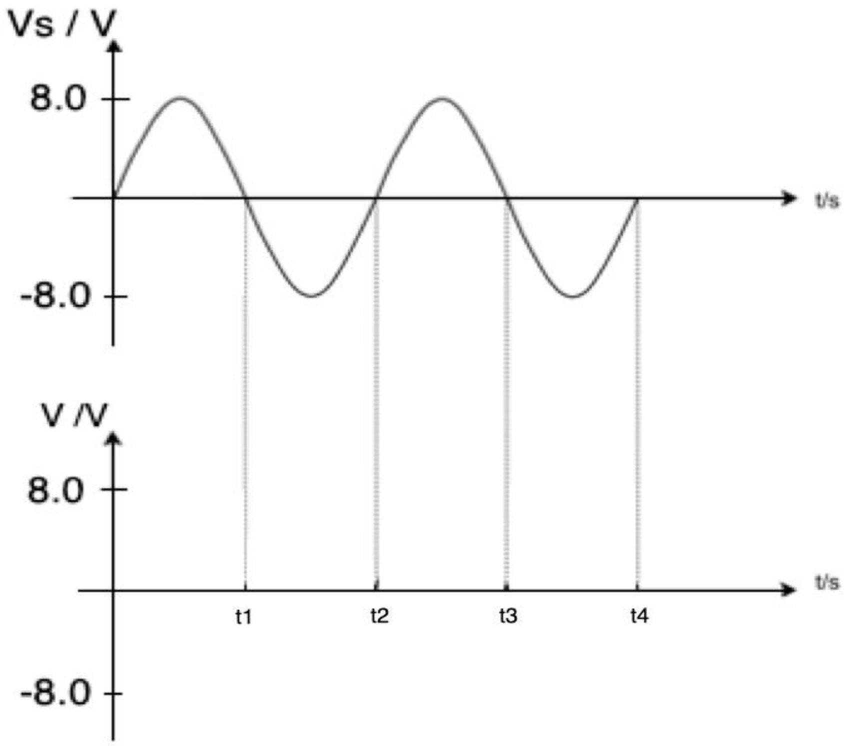


Fig. 7.2

(ii) Explain how the component IC1 in Fig. 7.1 causes the red LED to light up. [2]

……..………………………………………………………………………………

……..………………………………………………………………………………

……..………………………………………………………………………………

[Total: 6 marks]

Section B

Answer **all** questions.
Write your answers in the spaces provided.

8 Fig. 8.1 shows a circuit that is connected to a 12 V battery.

(a) The maximum resistance of R2 is 10 kΩ.

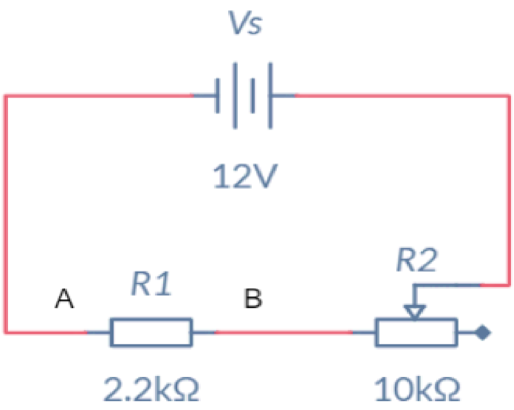


Fig. 8.1

(i) Determine the maximum and the minimum current passing through the circuit. [2]

maximum current =…………….……………...

minimum current =…………….……………...

(ii) Determine the maximum power dissipated across R1. [2]

power =…………….……………...

(iii) Circle the suitable power rating for R1. Explain your answer. [2]

0.125 W 0.25 W 0.5 W 1.0 W 2.0 W

……….......……………………………………………………………………………

……….......……………………………………………………………………………

(b) R2 in Fig. 8.1 is replaced by a thermistor. Fig. 8.2 shows the characteristic graph of the thermistor.

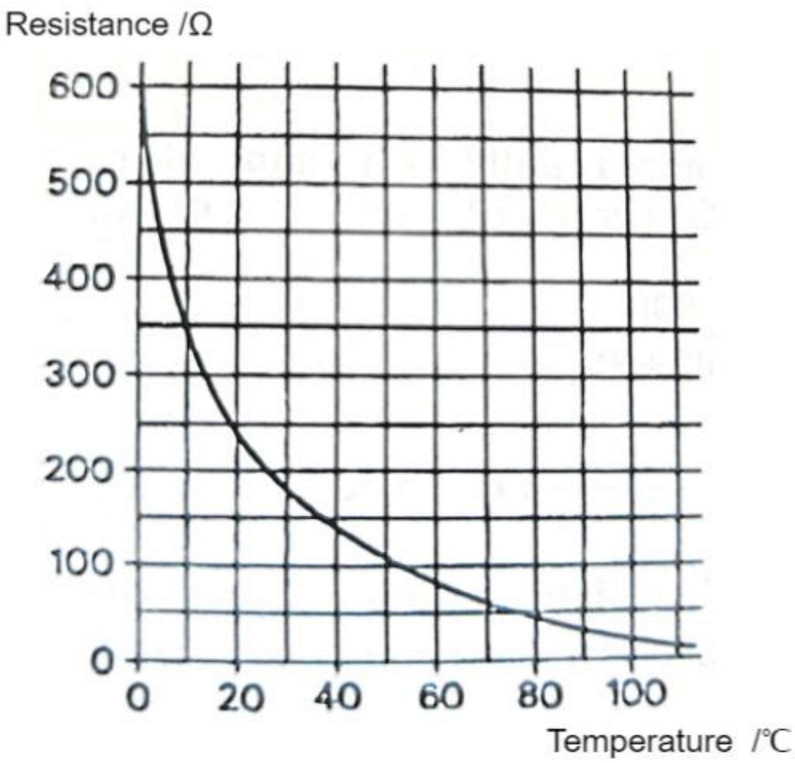


Fig. 8.2

The thermistor is placed in pure melting ice and then subsequently in steam.

(i) Using Fig. 8.2 state the resistance of the thermistor in the following conditions. [1]

Condition	**Temperature /°C**	**Resistance /Ω**
Melting ice	0	
Steam	100	

(ii) State the type of thermistor used in part **(b).** Explain your answer. [2]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(iii) Using Fig. 8.2, compare how the resistance of the thermistor varies with temperature when temperature is between 0°C to 50°C and 50°C to 100°C. [1]

……………………………………………………………………………………………

……………………………………………………………………………………………

(iv) Determine the change of voltage across the thermistor when it is placed in melting ice and subsequently in steam. [2]

change of voltage =…………….…………

[Total: 12 marks]

9 Fig. 9.1 shows a photovoltaics (PV) system that converts sunlight into electricity using a solar panel. The PV system includes a super capacitor bank to store the electrical energy and a regulator circuit. The forward voltage of diode is 0.70 V.

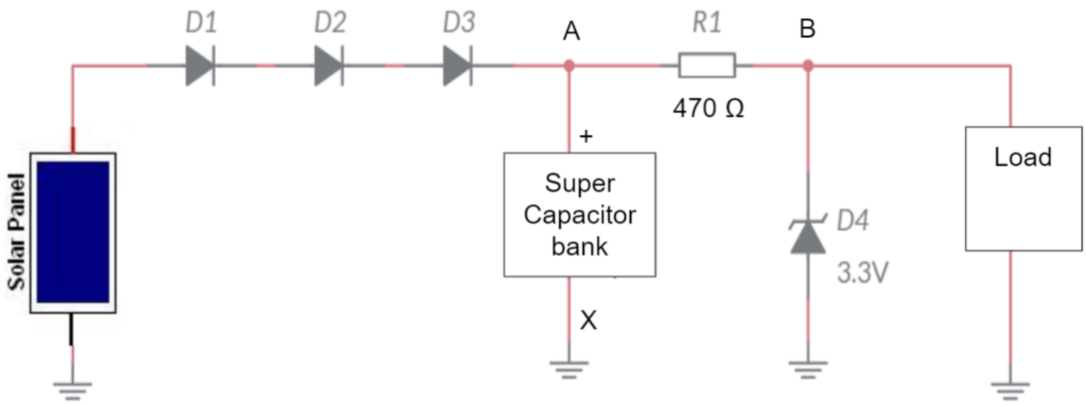


Fig 9.1

(a) When the capacitor bank is fully charged, the voltage at point A is 4.9 V.

(i) Determine the potential difference across the solar panel. [1]

potential difference =…………….………...

(ii) State the two purposes of these diodes in this circuit. [2]

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

(b) The super capacitor bank has an equivalent capacitance of 4.5 F and is made up of three capacitors connected in a circuit. Fig. 9.2 shows three different configurations of the capacitors.

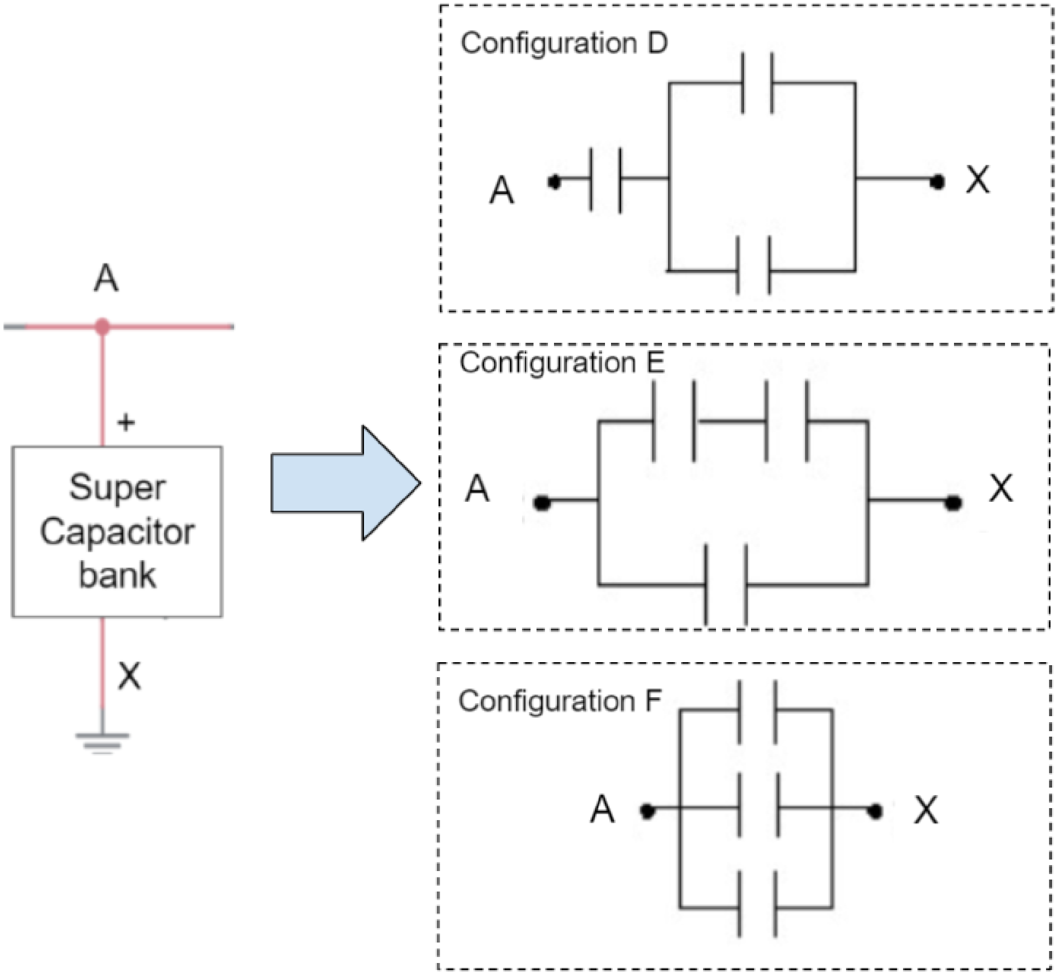


Fig 9.2

(i) If each capacitor is 3.0 F, state which configuration D, E and F is used in the super capacitor bank. Show your workings. [3]

………………………………………………………………………………………………

(ii) When the capacitor bank is fully charged, determine the amount of charge stored in the capacitor bank. [2]

charge =………………………….

(c) Fig. 9.3 shows a voltage regulation circuit using a 3.3 V Zener diode D4.
The load resistance varies from 390 Ω to 1.2 kΩ

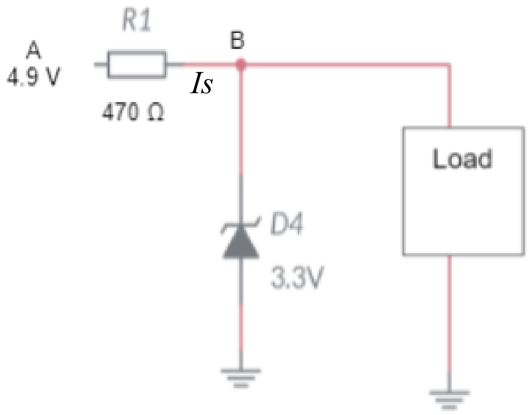


Fig. 9.3

(i) When the load resistance is at 390 Ω,

(1) State and verify if the load potential difference is regulated. [2]

……………………………………………………………………………………

……………………………………………………………………………………

(2) State the amount of the current passing through the Zener diode. [1]

……………………………………………………………………………………

(ii) When the load is at 1.2 kΩ, determine the amount of current *Is* that passes through R1. [2]

current *Is* = ………………………….

(d) Fig. 9.4 shows that the Zener diode is being inverted.

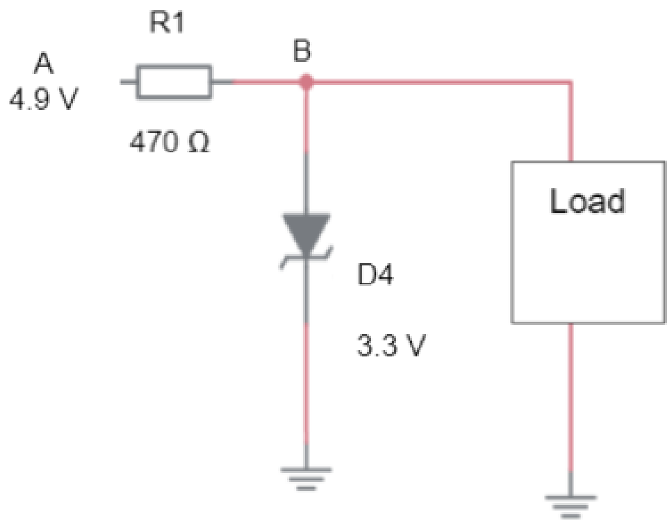


Fig. 9.4

State and explain what happens to the potential difference across the load when the load resistance varies from 390 Ω to 1.2 kΩ. [2]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

[Total: 15 marks]

10 A scenario that can be described in logic terms is given below:

To unlock the door to the computer room requires two keys.

The software engineer and a department manager each hold an identical key.
The security officer has a different key.

To unlock the door, the security officer and either the software engineer or department manager must be present to use their keys.

An output of ‘1’ represents the door is unlocked and ‘0’ represents lock.

Security Officer (**S**)	Software Engineer (**E**)	Department Manager (**D**)	Output **X**
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Table 10.1

(a) **(i)** Complete the truth table in Table 10.1 to show when the door is locked or unlocked. [3]

(ii) Write down the Boolean expression of **X**. [2]

X =...

(b) **(i)** Complete the Karnaugh map in Table 10.2 using the information from the truth table in Table 10.1. [2]

S \ E D	Karnaugh map			
	00	01	11	10
0				
1				

Table 10.2

(ii) State the simplified Boolean output expression from the Karnaugh map in Table 10.2.

X = ... [1]

(c) Using logic gates with 2-inputs, draw on Fig. 10.1, the logic circuit that would implement the simplified Boolean expression from part **(b)(ii)**. [3]

Fig. 10.1

(d) **(i)** The logic output **X** is fed into a circuit that consists of the components shown in Table 10.3. When the output **X** is '1' the relay coil is energised, the green LED is turned on and the door is unlocked. Complete the circuit on Fig.10.2 to show how it works. [3]

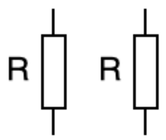
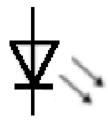
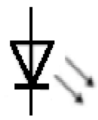
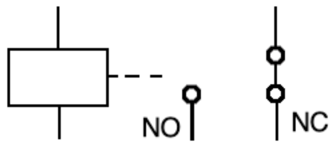
			
2 resistors	Green LED	RED LED	electromechanical relay

Table 10.3

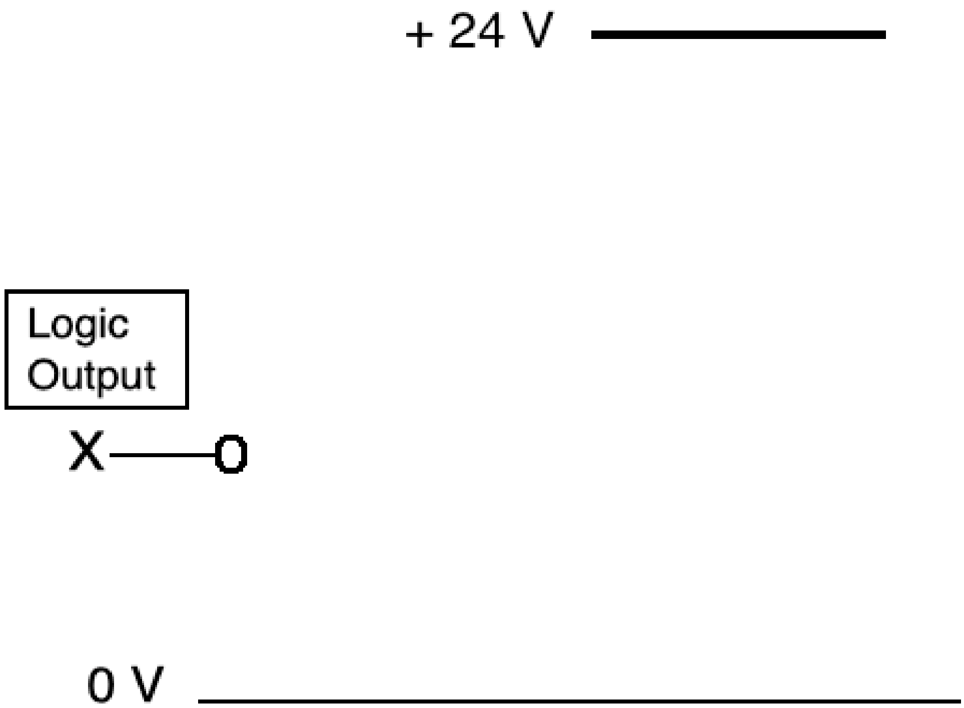


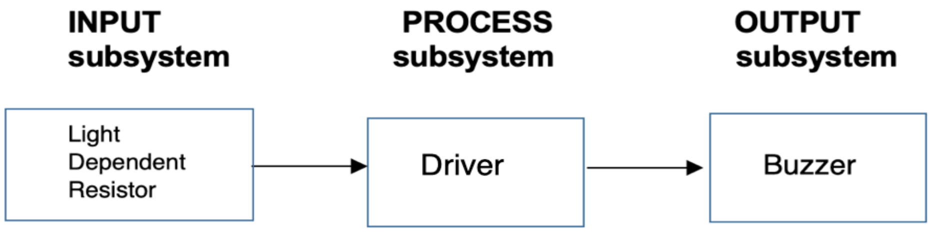
Fig. 10.2

(ii) Name the type of electromechanical relay used. [1]

……………………………………………………………………………………………

[Total: 15 marks]

11 Fig. 11.1 shows a part of a light dependent resistance sensor circuit using a bipolar junction transistor.



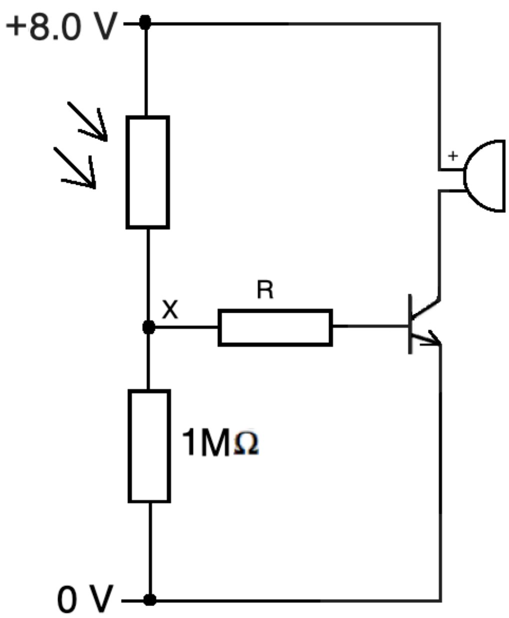


Fig. 11.1

(a) **(i)** Name the transistor used in Fig.11.1. [1]

....

(ii) The buzzer is a polarised component. [1]
State what is meant by polarised.

....

....

(iii) State the light condition either bright or dark that will turn on the buzzer.
Explain your answer. [3]

....

....

....

....

(b) The transistor has a voltage $V_{CE(sat)}$ of 0.2 V. Calculate the voltage across the buzzer when the transistor is fully saturated. [1]

voltage = ……………………

(c) To drive the buzzer in part **(b)**, the collector current is 0.15 A with a base current of 750 μA is required.
Calculate the current gain of the transistor. [1]

current gain = ……………………

(d) **(i)** Select a transistor in Table 11.1 that would be suitable for use in the circuit in Fig. 11.1. [1]

Transistor	Typical Gain at ambient condition	Maximum I_c (A)	Suitable (Tick)
2N1976	15	0.20	
2N3904	220	0.15	
2N1350	40	0.10	
2N5601	160	0.15	

Table 11.1

(ii) State a reason for your choice of transistor. [1]

……………………………………………………………………………………

(e) The transistor in Fig. 11.1 saturates with a base voltage V_{BE} = 0.7 V. The voltage at **X** is 4.9 V.

(i) Using the transistor selected in **(d)(i)**, calculate the resistance R. [3]

resistance R = ………………………………

(ii) Circle the most suitable resistor R from the following E24 standard values. Explain your selection. [2]

5.1 kΩ 5.6 kΩ 6.8 kΩ 7.5 kΩ

....

....

(f) State one modification to the circuit in Fig. 11.1 to amplify the buzzer sound. [1]

....

[Total: 15 marks]

END OF PAPER