BINDURA UNIVERSITY OF SCIENCE EDUCATION

PHYSICS AND ENGINEERING DEPARTMENT

PH005: BASIC ELECTRONICS

TIME: 3 HOURS

JUN 2025

INSTRUCTIONS

Answer **question one** in Section A and **any three** questions from Section B. Section A carries 40 marks and each question in Section B carries 20 marks.

SECTION A

1 (a) Define the term transducer and give any two examples? [3]

(b) Discuss the use of light dependent resistors, negative temperature coefficient thermistors and metal wire strain gauges in voltage divider circuits to provide analogue signals. [6]

(c) List the four major properties of an ideal op-amp. [4]

(d) Negative feedback reduces the gain of the op-amp. Give two reasons why negative feedback is favourable. [2]

(e) An inverting operational amplifier has a voltage gain of 50 and it is powered by 6 V. A voltage of 200 mA is applied at its inputs. Calculate the output voltage. [3]

(f) Construct a truth table for the EX-NOR gate. [4]

(g) Using NAND gates only, show how you can implement the following logic gates:

(1) NOT gate. [3]

(2) NOR gate. [3]

(h) Prove the following Boolean identities using truth tables:

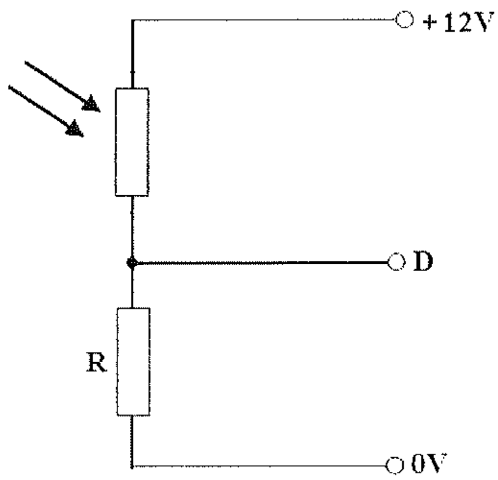
$$(A + B)\bullet(A + C) = A + B\bullet C$$ [5]

(i) Explain why the NAND and NOR gates are said to be universal gates. [2]

(j) Construct a logic circuit for the expression $Q = A\bullet (B + C)$ using NAND gates only. [5]

SECTION B

2 Figure 2.1 shows a light sensor circuit and an LDR's data sheet.



LDR DATA SHEET	
Light level / lux	resistance /kΩ
0	100
10	10
100	3.5

Figure 2.1: Light sensor circuit and the LDR data sheet.

(a) Suppose you find that the lowest resistance of the LDR in bright sunlight is 100Ω. The LDR maximum power dissipation is 100 mW. Calculate:

(i) the maximum current that can flow safely through the LDR in bright sunlight. [3]

(ii) the total resistance of the LDR and fixed resistor R, that would limit the current through the LDR to the value found in part (i). [3]

(iii) the minimum resistance that could safely be used for R, and then choose the lowest appropriate value from the E24 series. [3]

(b) Determine the output voltage of the circuit at point X when the light level is:

(i) 10 lux. [3]

(ii) 0 lux. [3]

(c) State why the value of resistance chosen in part (a) (iii) is a poor choice for measuring low light levels. [2]

(d) How would you change the value of R calculated in part (a) (iii) to improve the situation at low light levels? [1]

(e) The circuit is powered from a 12 V battery of low capacity. State one other advantage of changing the value of R. [2]

3 Figure 3.1 shows part of a comparator circuit.

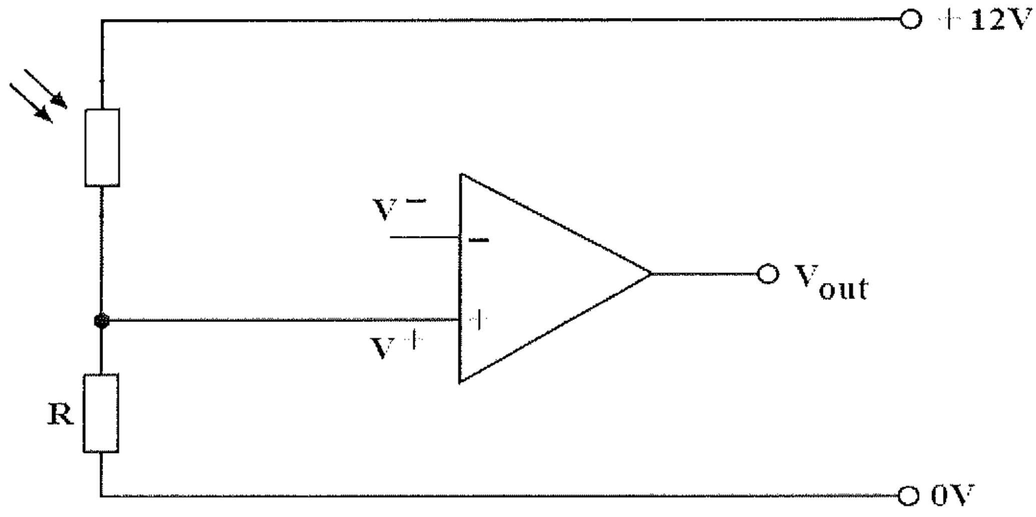


Figure 3.1: Part of a comparator circuit.

(a) The inverting input V^- requires a reference voltage of 4V.

(i) In Figure 3.1 draw two components and their connections to show how this is achieved. [2]

(ii) Select suitable values for these components and mark these in Figure 3.1 next to each component. [6]

(b) The LDR has a maximum power dissipation of 120mW.

(i) Calculate the maximum current that could safely flow through the LDR if it had 12V across it. [3]

(ii) Calculate the combined resistance of the LDR and R that would allow this current to flow. [3]

(iii) The LDR has a minimum resistance of 100Ω in very bright light. Calculate the value of R required if the current calculated in part (b)(i) is not to be exceeded. [2]

(c) Given that the op-amp used in Figure 3.1 is ideal, state its output voltage when:

(i) $V^- > V^+$. [2]

(ii) $V^- < V^+$. [2]

4 (a) A student designs a flood warning system. When the humidity goes above a set level, a signal that operates a siren is produced.
Draw a system diagram by choosing appropriate input, process, and output subsystems from the list below.
Alarm (audible warning device), comparator, humidity sensor. [6]

(b) A student designs a noise warning system to alert the user to the presence of a noise level likely to damage hearing. An LED flashes on and off when the noise level exceeds a safe value.

(i) Draw and label each subsystem in Figure 4.1 to show a possible design for the noise warning system using the following subsystems: comparator, LED and sound sensor. [6]

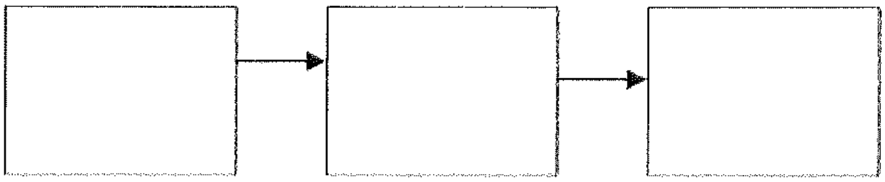


Figure 4.1: A possible design for a noise warning system.

(ii) In which subsystem could an op-amp be used? [1]

(c) The comparator circuit diagram is shown in Figure 4.2.

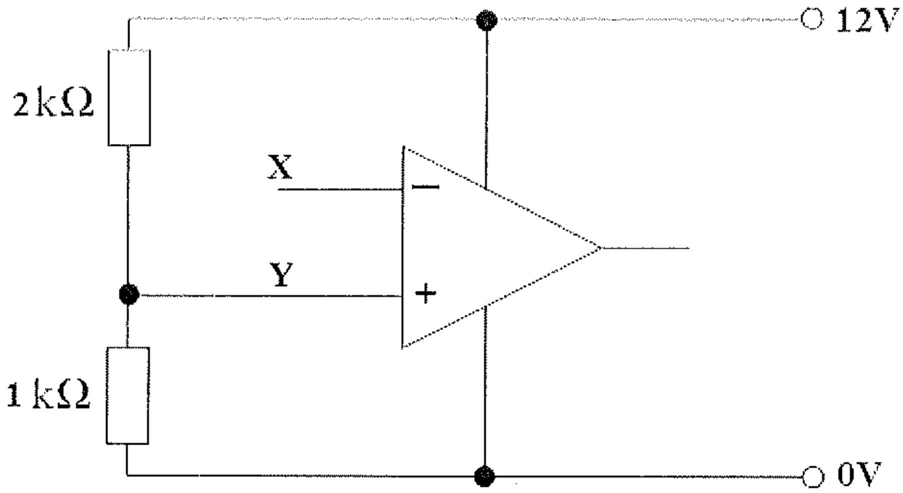


Figure 4.2: The comparator circuit.

(i) Calculate the voltage at point Y in this circuit. [3]

The signal from the sound sensor is connected to point X in the comparator circuit. What voltage would you expect from the output of this circuit when

(ii) the voltage at X is 2V? [2]

(iii) the voltage at X rises to 6V? [2]

5 (a) Figure 5.1 shows a logic circuit.

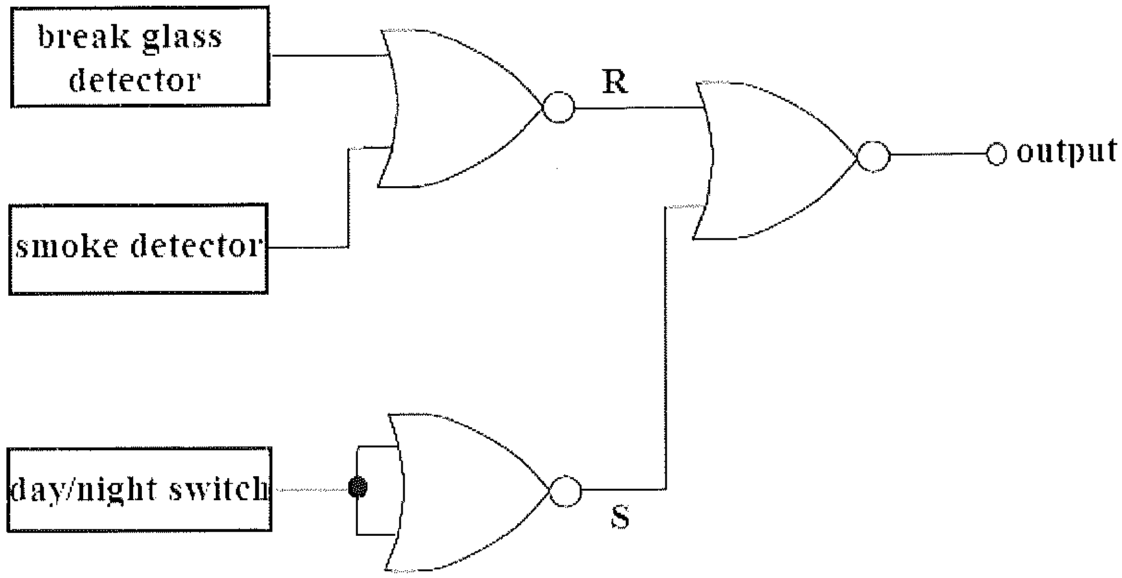


Figure 5.1: Logic circuit.

Copy and complete its truth table shown in Table 5.1. [18]

Table 5.1: Truth table.

Day/night switch	Break glass detector	Smoke detector	R	S	Output to outside siren
0	0	0			
1	0	0			
0	1	0			
1	1	0			
0	0	1			
1	0	1			
0	1	1			
1	1	1			

(b) Explain whether this proposed system would provide the building with an adequate level of protection. [2]

6 A logic circuit with two inputs X and Y and output Q has the following the Boolean equation:

$Q = \left(\overline{X} + \overline{Y}\right) \bullet \left(X + Y\right)$

(a) Copy and complete Table 6.1. [10]

Table 6.1: Truth table.

X	Y	$\overline{X}$	$\overline{Y}$	$\overline{X}+\overline{Y}$	$X+Y$	Q
0	0					
1	0					
0	1					
1	1					

(b) Complete Figure 6.1 to show how a logic circuit can be constructed from two NOT gates, two OR gates and one AND gate to represent the Boolean equation above. [9]

Figure 6.1: Part of a logic circuit.

(c) State which single logic gate has the same function as the complete circuit above. [1]

END OF EXAMINATION