G.C.E. O/L Grade 10 ICT · Lesson 4

4.1 Logic Gates, Boolean Operators and Truth Tables

Inside every computer, calculator and phone there are millions of tiny switches called **logic gates**. A gate takes one or more inputs that are **1 (true / ON)** or **0 (false / OFF)** and gives one output. In this note you will learn the Boolean operators **AND, OR and NOT**, the gates **AND, OR, NOT, NAND and NOR**, their **standard (ANSI) symbols**, how to write them in **Boolean notation (A.B, A+B, A')**, and how to build **truth tables** with up to three inputs.

1. Boolean logic – only two values

Boolean logic is named after the English mathematician **George Boole** (1815–1864). In Boolean logic a statement is either **true (1)** or **false (0)** – nothing in between. Computers use this because a circuit can easily be **ON (1)** or **OFF (0)**.

Meaning	Value 1	Value 0
Logic	True	False
Switch / lamp	ON	OFF
Voltage	High (about 5 V)	Low (about 0 V)
Answer to a question	Yes	No

A **logic gate** is an electronic circuit that performs one Boolean operation. Inputs are usually named **A, B, C** and the output **X** (or Q / F).

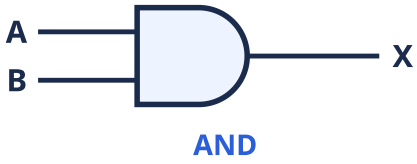
2. The three basic Boolean operators

Operator	Boolean notation	Read as	Output is 1 when…
AND	X = A.B	A and B	all inputs are 1
OR	X = A+B	A or B	at least one input is 1
NOT	X = A' (or Ā)	not A / A bar	the input is 0

💡 In Boolean notation **.** means AND and **+** means OR – they are NOT normal multiplication and addition. 1 + 1 = 1 in Boolean OR (not 2!). The bar over a letter (Ā) and the dash after it (A') both mean NOT.

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3. AND gate



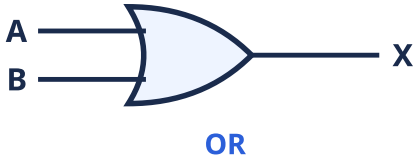
ANSI symbol of the AND gate: flat back, round front. X = A.B

The output of an AND gate is **1 only when all inputs are 1**. If any input is 0, the output is 0. Think of two switches **in series**: the lamp lights only when both switches are ON.

A	B	X = A.B
0	0	0
0	1	0
1	0	0
1	1	1

> 💡 Example: you can enter the exam hall only if you have your **admission card AND** your **identity card**.

4. OR gate



ANSI symbol of the OR gate: curved back, pointed front. X = A+B

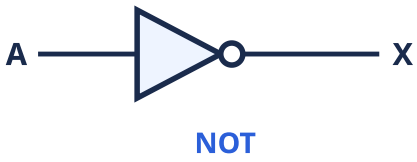
The output of an OR gate is **1 when at least one input is 1**. It is 0 only when all inputs are 0. Think of two switches **in parallel**: either switch can light the lamp.

A	B	X = A+B
0	0	0
0	1	1
1	0	1
1	1	1

> 💡 Example: a house doorbell rings if the **front button OR** the **back button** is pressed.

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5. NOT gate (inverter)

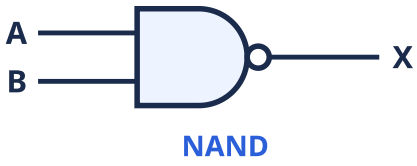


ANSI symbol of the NOT gate: a triangle with a small circle (bubble). X = A'

A NOT gate has **only one input**. It **inverts** (reverses) the input: 1 becomes 0 and 0 becomes 1. The small circle (**bubble**) on a symbol always means NOT.

A	X = A'
0	1
1	0

6. NAND gate (NOT AND)

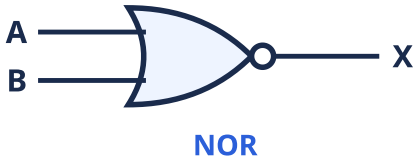


NAND = AND symbol + bubble. X = (A.B)'

NAND is an AND gate followed by a NOT gate. Its output is the **opposite of AND**: it is **0 only when all inputs are 1**.

A	B	A.B	X = (A.B)'
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

7. NOR gate (NOT OR)



NOR = OR symbol + bubble. X = (A+B)'

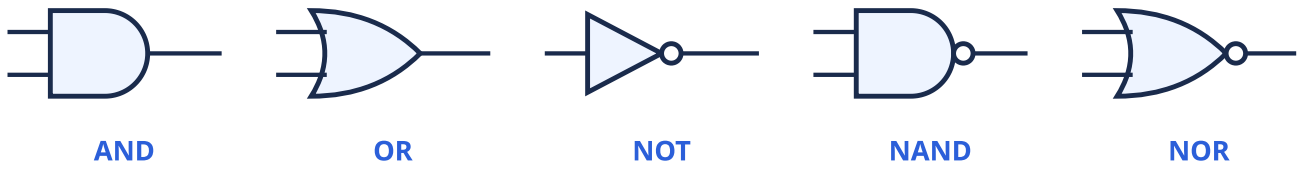
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NOR is an OR gate followed by a NOT gate. Its output is the **opposite of OR**: it is **1 only when all inputs are 0**.

A	B	A+B	X = (A+B)'
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

💡 NAND and NOR are called **universal gates** – any other gate can be built using only NAND gates (or only NOR gates). This is why chip makers like them.

8. All five gates together



Standard ANSI symbols: AND, OR, NOT, NAND, NOR

A	B	AND A.B	OR A+B	NAND (A.B)'	NOR (A+B)'	NOT A A'
0	0	0	0	1	1	1
0	1	0	1	1	0	1
1	0	0	1	1	0	0
1	1	1	1	0	0	0

AND
1 only if ALL inputs are 1

OR
1 if ANY input is 1

NOT
Reverses the single input

NAND
0 only if ALL inputs are 1

NOR
1 only if ALL inputs are 0

9. Truth tables with three inputs

A truth table lists **every possible input combination** and the output for each. With n inputs there are **2^n rows**: 1 input → 2 rows, 2 inputs → 4 rows, 3 inputs → 8 rows. Write the inputs in **binary**

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counting order (000, 001, 010 … 111) so you never miss a row.

> 💡 Quick fill trick for 3 inputs: column C alternates 0,1,0,1…; column B goes 0,0,1,1…; column A has four 0s then four 1s.

A	B	C	X = A.B.C
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

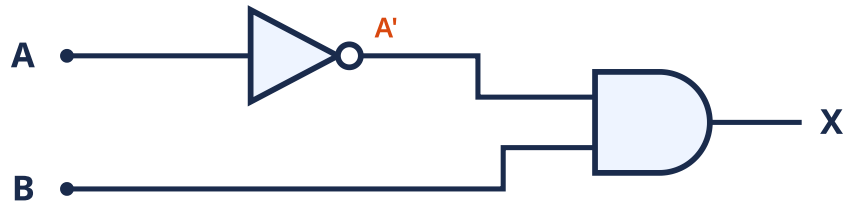
A	B	C	X = A+B+C
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

A 3-input AND gives 1 in only **one** row (1,1,1). A 3-input OR gives 0 in only **one** row (0,0,0).

10. Circuits with two or three gates

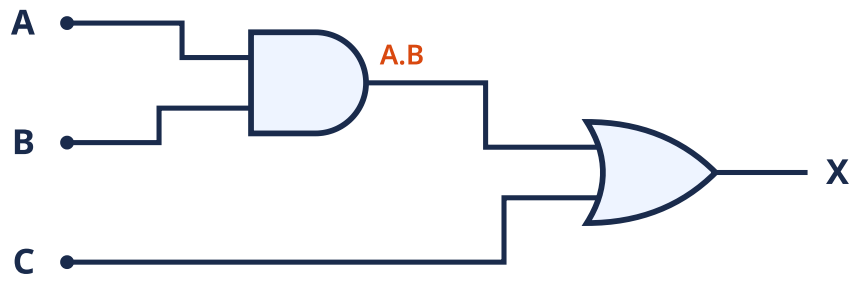
Gates can be joined: the output of one gate becomes the input of the next. To find the output, work **from left to right** and write the expression at each gate.

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Example 1: X = A'.B (NOT then AND)

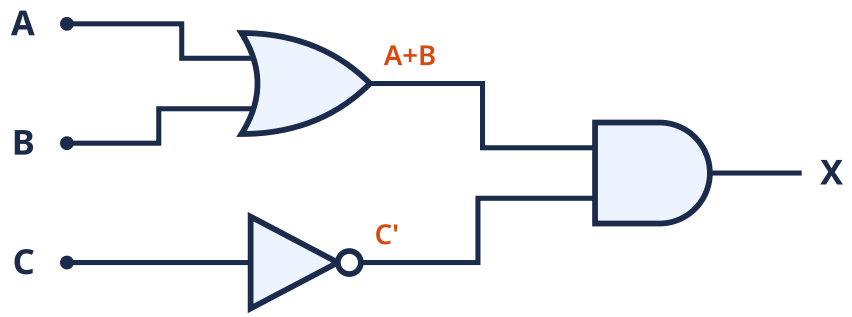
A	B	A'	X = A'.B
0	0	1	0
0	1	1	1
1	0	0	0
1	1	0	0



Example 2: X = A.B + C (AND then OR)

A	B	C	A.B	X = A.B+C
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	0	1
1	0	0	0	0
1	0	1	0	1
1	1	0	1	1
1	1	1	1	1

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Example 3: X = (A+B).C' (three gates)

A	B	C	A+B	C'	X = (A+B).C'
0	0	0	0	1	0
0	0	1	0	0	0
0	1	0	1	1	1
0	1	1	1	0	0
1	0	0	1	1	1
1	0	1	1	0	0
1	1	0	1	1	1
1	1	1	1	0	0

💡 Add a column for every middle (intermediate) output such as A.B or C'. It makes the last column easy and earns working marks.

Brackets matter: **(A.B)'** (NAND – NOT of the whole AND) is different from **A'.B'** (NOT A AND NOT B). Check one row: A=1, B=0 gives (A.B)' = 1 but A'.B' = 0.

NEW 2026 Extra – beyond the O/L syllabus: the **XOR** (exclusive OR) gate gives 1 when the inputs are **different** (A=0,B=1 or A=1,B=0). You do not need it for the O/L exam.

Key Words

Boolean logic – Logic with only two values: true (1) and false (0).

Logic gate – An electronic circuit that performs one Boolean operation on its inputs.

AND gate – Output is 1 only when all inputs are 1 (X = A.B).

OR gate – Output is 1 when at least one input is 1 (X = A+B).

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NOT gate – One input; the output is the opposite of the input (X = A').

NAND gate – AND followed by NOT; output is 0 only when all inputs are 1.

NOR gate – OR followed by NOT; output is 1 only when all inputs are 0.

Truth table – A table showing the output for every possible combination of inputs.

Boolean expression – A formula using A, B, C with . (AND), + (OR) and ' (NOT), e.g. X = A.B + C.

Inverter – Another name for the NOT gate.

Bubble – The small circle on a gate symbol that means NOT (inversion).

Universal gate – NAND or NOR – any other gate can be made using only that gate.

Sample Q&A

1. What is a logic gate?

> **Answer:** An electronic circuit that takes one or more binary inputs (1 or 0) and gives one output according to a Boolean operation.

2. Write the Boolean expressions for AND, OR and NOT.

> **Answer:** AND: X = A.B; OR: X = A+B; NOT: X = A' (or Ā).

3. How many rows does a truth table with three inputs have?

> **Answer:** 2^3 = 8 rows (000 to 111).

4. What is the difference between an AND gate and a NAND gate?

> **Answer:** NAND gives the opposite output of AND: AND is 1 only when all inputs are 1; NAND is 0 only when all inputs are 1. The NAND symbol has a bubble.

5. For which input combination does a NOR gate give 1?

> **Answer:** Only when all inputs are 0 (A = 0, B = 0).

6. Find X = A.B + C when A = 0, B = 1, C = 1.

> **Answer:** A.B = 0.1 = 0; X = 0 + 1 = 1.

MCQ

1. Boolean logic uses how many values?

A. 2 (1 and 0)
B. 10 (0 – 9)
C. 16 (0 – F)
D. 3 (0, 1, 2)

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2. In the Sri Lankan O/L notation, A.B means:

A. NOT A
B. A times B in decimal
C. A AND B
D. A OR B

3. Which expression represents a NOT gate?

A. X = A.B
B. X = A+B
C. X = A'
D. X = (A+B)'

4. An AND gate has inputs A = 1 and B = 0. The output is:

A. 0
B. 2
C. 10
D. 1

5. An OR gate has inputs A = 0 and B = 1. The output is:

A. 0
B. 1
C. 01
D. 2

6. Which gate gives output 0 ONLY when all inputs are 1?

A. OR
B. AND
C. NOR
D. NAND

7. Which gate gives output 1 ONLY when all inputs are 0?

A. OR
B. NAND
C. NOR
D. AND

8. A gate symbol is a triangle with a small circle at the tip. It is:

A. OR gate
B. NOT gate
C. NOR gate
D. AND gate

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9. The small circle (bubble) on a gate symbol means:

A. NOT (inversion)
B. Power supply
C. AND
D. Extra input

10. How many rows are in the truth table of a 3-input gate?

A. 9
B. 6
C. 8
D. 3

11. In the truth table of a 3-input AND gate, how many rows give output 1?

A. 3
B. 8
C. 7
D. 1

12. What is the output of X = (A+B)' when A = 0 and B = 0?

A. 1
B. 00
C. 0
D. 2

13. For X = A.B + C, which input gives X = 0?

A. A=0, B=0, C=1
B. A=1, B=0, C=0
C. A=0, B=1, C=1
D. A=1, B=1, C=0

14. In X = (A+B).C', what is X when A = 1, B = 0, C = 1?

A. 2
B. 1
C. Cannot be found
D. 0

15. Which statement about Boolean OR is correct?

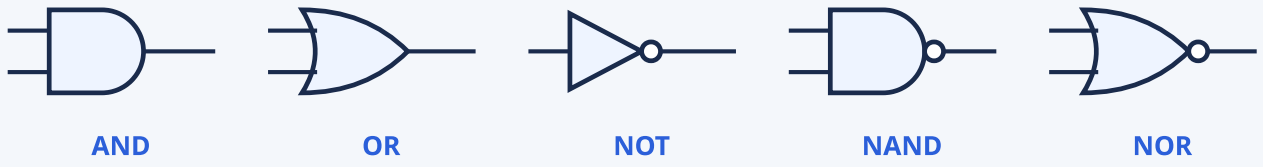
A. 1 + 1 = 2
B. 1 + 1 = 1
C. 1 + 1 = 0
D. 1 + 0 = 0

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Structured Questions

1. (i) Draw the ANSI symbols of the AND, OR and NOT gates. (3 marks)
(ii) Write the Boolean expression for each. (3 marks) *(6 marks)*

(i) AND – flat back, round front; OR – curved back, pointed front; NOT – triangle with a bubble (see symbols below).
(ii) AND X = A.B; OR X = A+B; NOT X = A'.



Model answer: gate symbols

2. Copy and complete the truth table for a 2-input NAND gate and a 2-input NOR gate. (4 marks) *(4 marks)*

1 mark for each correct column pair. NAND: 1,1,1,0; NOR: 1,0,0,0.

A	B	NAND (A.B)'	NOR (A+B)'
0	0	1	1
0	1	1	0
1	0	1	0
1	1	0	0

3. Draw the truth table of a 3-input OR gate (X = A+B+C). (4 marks) *(4 marks)*

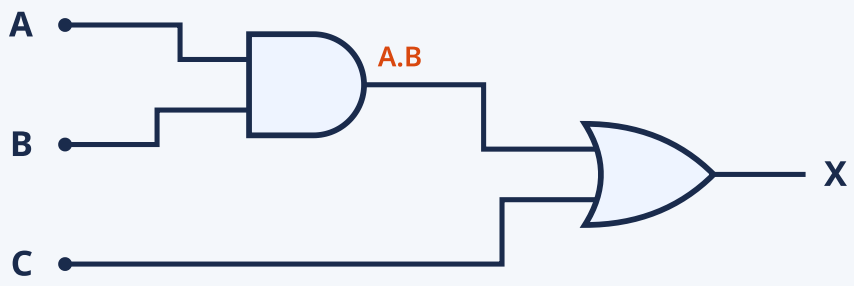
8 rows (1 mark), correct input order (1 mark), output 0 only in row 000 (2 marks).

A	B	C	X = A+B+C
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

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4. For the circuit X = A.B + C: (i) draw the logic circuit (2 marks) (ii) complete the truth table (4 marks). *(6 marks)*

(i) AND gate for A and B, its output and C go into an OR gate. (ii) X = 1 in 5 of the 8 rows.



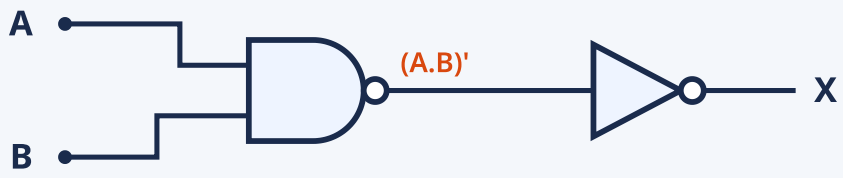
Model circuit

A	B	C	A.B	X = A.B+C
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	0	1
1	0	0	0	0
1	0	1	0	1
1	1	0	1	1
1	1	1	1	1

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5. (i) Explain why NAND is called a universal gate. (2 marks)
(ii) Show that a NAND gate followed by a NOT gate works like an AND gate. (3 marks) *(5 marks)*

(i) Any other gate (AND, OR, NOT…) can be built using only NAND gates. (ii) ((A.B)')' = A.B – the outputs are 0,0,0,1, the same as AND.



NAND + NOT = AND

A	B	(A.B)'	X
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

6. Find the output X of X = (A+B).C' for (i) A=0, B=0, C=0 (ii) A=1, B=1, C=0 (iii) A=0, B=1, C=1. Show working. (3 marks) *(3 marks)*

(i) (0+0).1 = 0.1 = 0 (ii) (1+1).1 = 1.1 = 1 (iii) (0+1).0 = 1.0 = 0

Summary

- Boolean logic has only two values: 1 (true/ON) and 0 (false/OFF).
- Notation: A.B = AND, A+B = OR, A' or $\bar{A}$ = NOT.
- AND → 1 only if all inputs are 1; OR → 1 if any input is 1.
- NOT has one input and reverses it.
- NAND = NOT AND; NOR = NOT OR. A bubble on a symbol means NOT.
- n inputs → 2^n truth-table rows (3 inputs → 8 rows), written in binary order.
- For circuits, work left to right and add a column for each middle output.
- NAND and NOR are universal gates.

MCQ answer key – 4.1

1. **A** – Only true (1) and false (0).

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2. **C** – The dot means AND.
3. **C** – A' (or Ā) is NOT A.
4. **A** – AND needs all inputs 1.
5. **B** – One input is 1, so OR gives 1.
6. **D** – NAND = NOT AND.
7. **C** – NOR = NOT OR.
8. **B** – Triangle + bubble = NOT (inverter).
9. **A** – A bubble inverts the output.
10. **C** – $2^3 = 8$.
11. **D** – Only 1,1,1 gives 1.
12. **A** – A+B = 0, NOT 0 = 1.
13. **B** – A.B = 0 and C = 0 → X = 0.
14. **D** – C' = 0, so the AND output is 0.
15. **B** – OR gives 1 if any input is 1.

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