G.C.E. O/L Grade 10 ICT

Lesson 4: Boolean Logic and Logic Gates

- 4.1 Logic Gates, Boolean Operators and Truth Tables
- 4.2 Solving Real-World Problems with Logic Gates

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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).

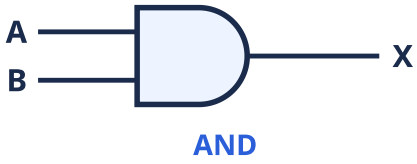
2. The three basic Boolean operators

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



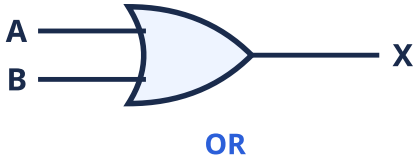
ANSI symbol of the AND gate: flat back, round front. X = A.B

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

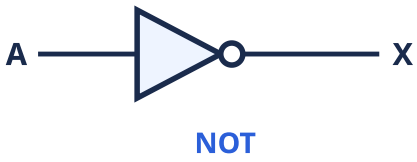
The output of an OR gate is **1 when at least one input is 1**. It is 0 only when all inputs are 0. Think of two switches **in parallel**: either switch can light the lamp.

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)

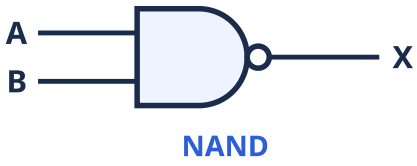


ANSI symbol of the NOT gate: a triangle with a small circle (bubble). X = A'

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)

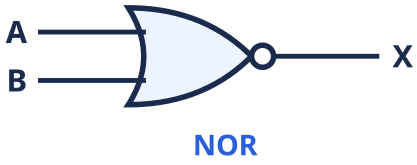


NAND = AND symbol + bubble. X = (A.B)'

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)'

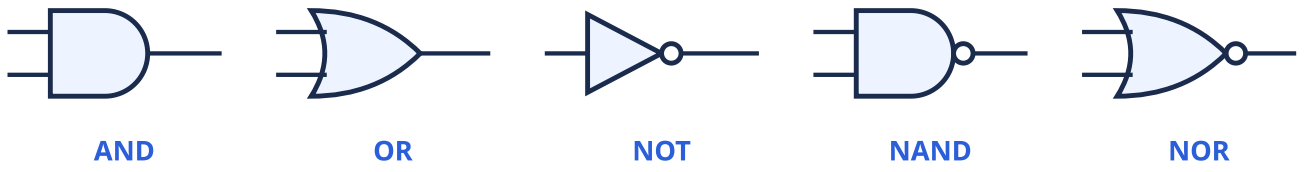
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NOR is an OR gate followed by a NOT gate. Its output is the **opposite of OR**: it is **1 only when all inputs are 0**.

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

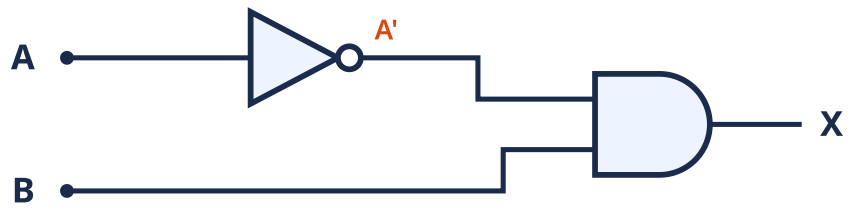
A	B	C	X = A+B+C
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

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

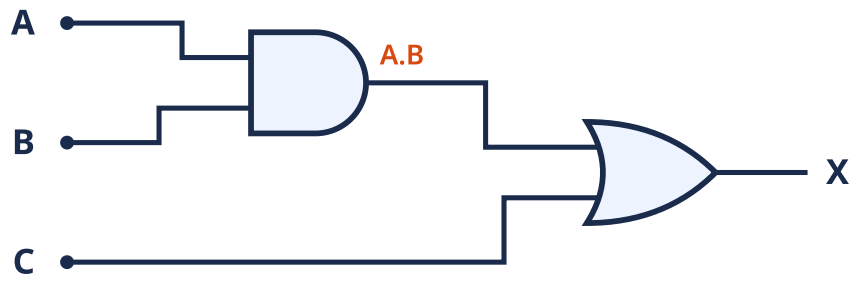
Gates can be joined: the output of one gate becomes the input of the next. To find the output, work **from left to right** and write the expression at each gate.

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

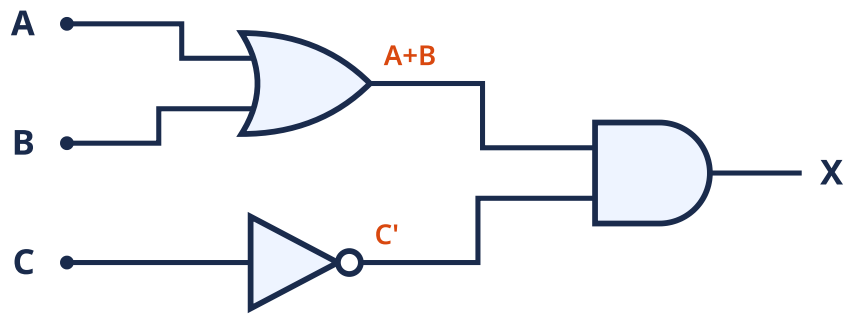
A	B	A'	X = A'.B
0	0	1	0
0	1	1	1
1	0	0	0
1	1	0	0



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 $\bar{A}$).

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?

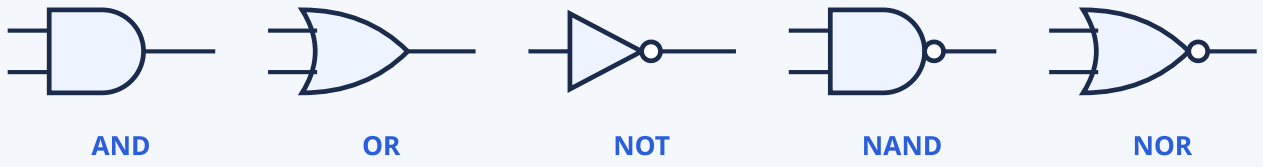
A. 1 + 1 = 2
B. 1 + 1 = 1
C. 1 + 1 = 0
D. 1 + 0 = 0

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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)*

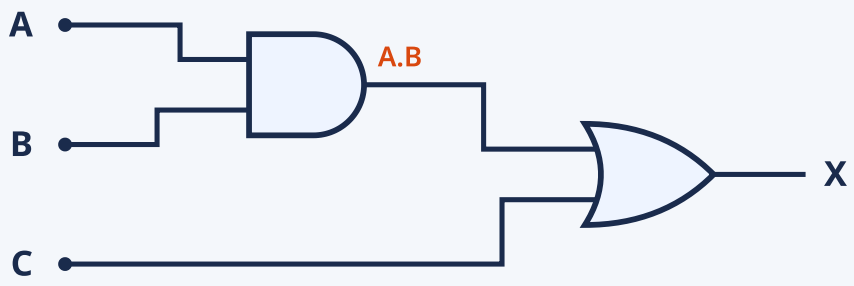
8 rows (1 mark), correct input order (1 mark), output 0 only in row 000 (2 marks).

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.



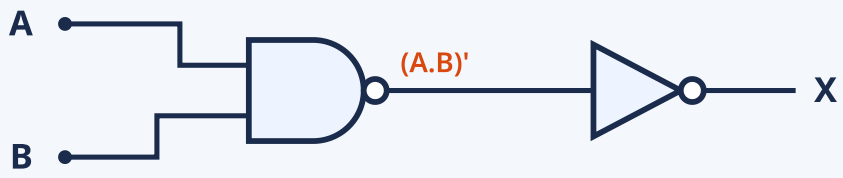
Model circuit

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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4.2 Solving Real-World Problems with Logic Gates

Logic gates are not only for exams – they control **car alarms, door locks, smart home lights, greenhouse water pumps** and even decide who gets a **scholarship**. In this note you will learn a simple step-by-step method: turn a problem written in words into a **block diagram**, then into a **Boolean expression**, a **logic circuit** and a **truth table**. You will also learn to read a circuit and **derive its expression and truth table**.

1. The 5-step method

Step 1 – Inputs and output
Find the conditions (sensors, switches, answers) and the result.

Step 2 – Give letters and meanings
e.g. D = 1 when the door is open, D = 0 when closed.

Step 3 – Block diagram
Draw boxes: inputs → logic → output.

Step 4 – Expression and circuit
Change and → . , or → + , not → ' and draw the gates.

Step 5 – Truth table
Check every input combination.

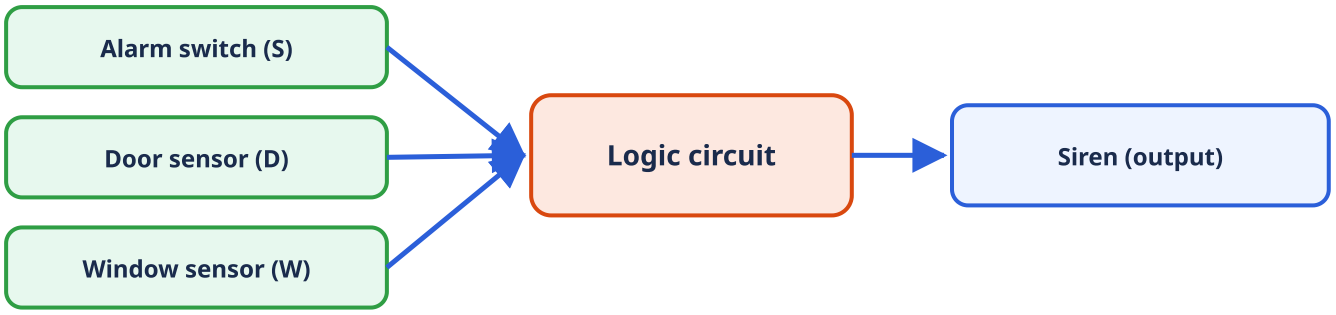
💡 Key words in the problem tell you the gate: **“and”, “both”, “all”** → AND; **“or”, “either”, “any”** → OR; **“not”, “no”, “unless”, “dark (not bright)”** → NOT.

2. Example 1 – Car alarm system

Problem: The siren of a car alarm sounds when the alarm is **switched ON** and **either** a door is opened **or** a window is broken.

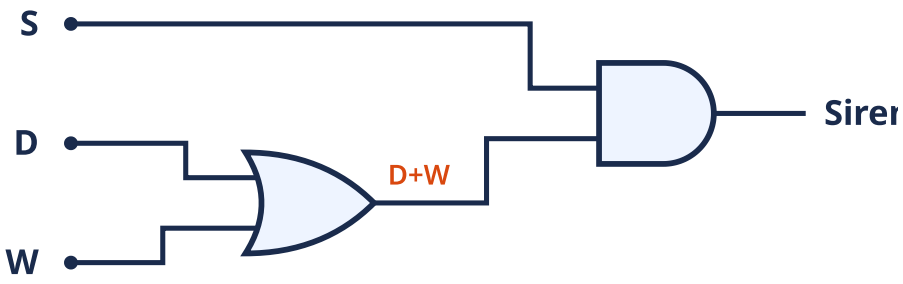
Letter	Input / output	1 means	0 means
S	Alarm switch	ON	OFF
D	Door sensor	Door open	Door closed
W	Window sensor	Glass broken	Glass OK
Siren	Output	Sounds	Silent

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Block diagram: three inputs → logic → siren

In words: Siren = S **AND** (D **OR** W). Expression: **Siren = S.(D+W)**. Logic circuit:



Logic diagram: OR gate for D and W, then AND with S

S	D	W	D+W	Siren
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

The siren sounds in **3** of the 8 cases – only when S = 1 and at least one sensor is 1.

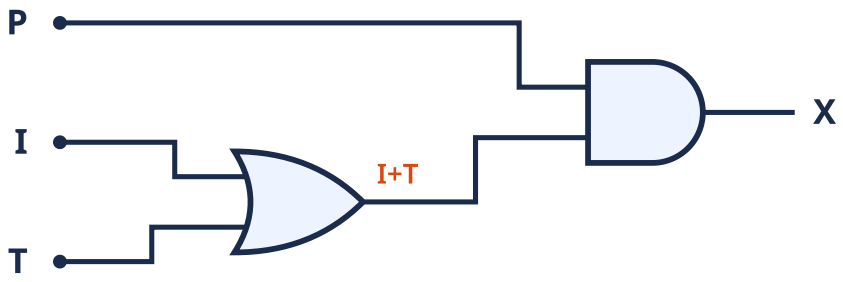
3. Example 2 – Selection criteria (scholarship)

Problem: A school gives a scholarship to a student who has **passed the O/L exam (P)** and who has **either a low family income (I) or a talent in sport (T)**.

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Block diagram for the scholarship



X = P.(I+T)

P	I	T	I+T	X = P.(I+T)
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

> 💡 The same idea is used by online forms and university selection: a computer checks Yes/No answers with AND and OR.

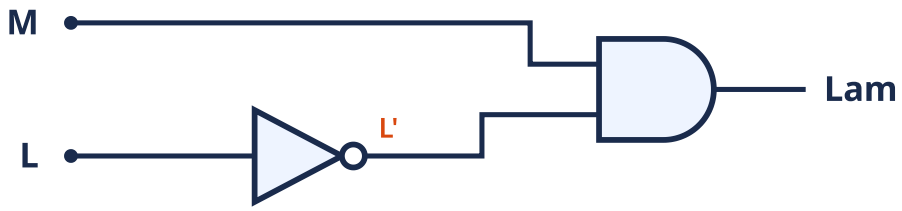
4. Example 3 – Smart home light (uses NOT)

Problem: A garden lamp switches ON when **motion is detected (M = 1)** and it is **dark**. The light sensor gives **L = 1 when it is bright**, so “dark” means **NOT L**.

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Block diagram for the smart light

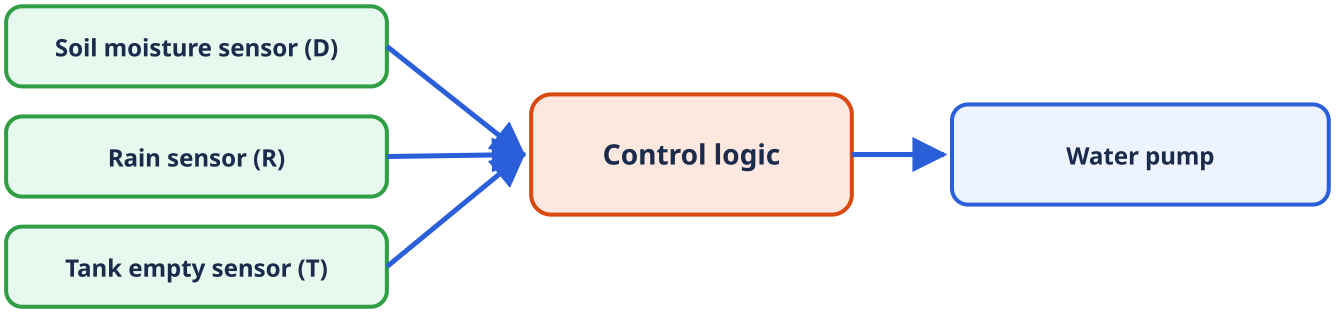


Lamp = M.L'

M	L	L'	Lamp
0	0	1	0
0	1	0	0
1	0	1	1
1	1	0	0

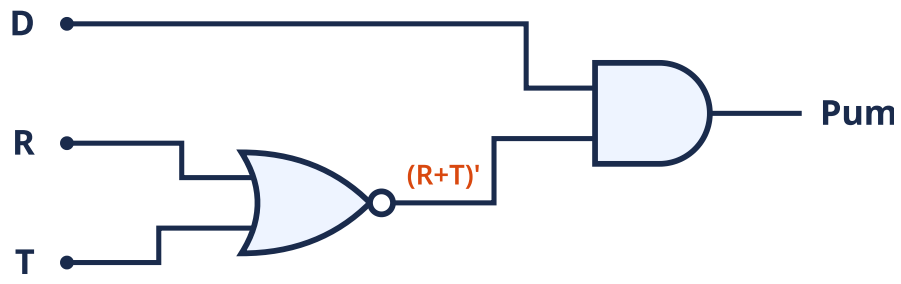
5. Example 4 – Greenhouse / IoT smart agriculture

Problem: In a smart greenhouse the water pump turns ON when the **soil is dry (D)** and it is **not raining (R)** and the **water tank is not empty (T)**. Not raining and not empty = **NOT (R OR T)** = a NOR gate.



Block diagram: IoT sensors control the pump

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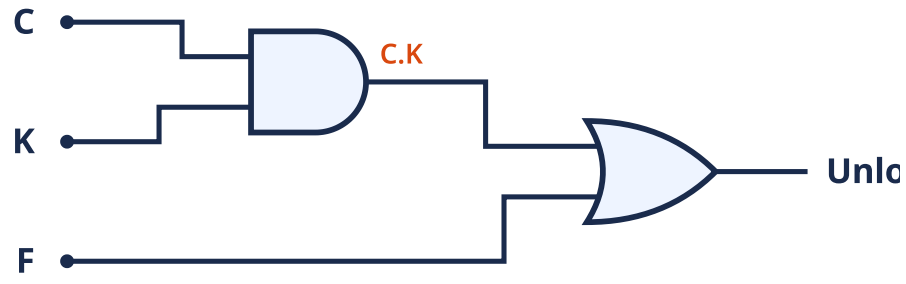
Pump = D.(R+T)'

D	R	T	(R+T)'	Pump
0	0	0	1	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	0
1	0	0	1	1
1	0	1	0	0
1	1	0	0	0
1	1	1	0	0

The pump runs in only **one** case: D = 1, R = 0, T = 0. This saves water and protects the pump – a real use of IoT in Sri Lankan farming.

6. Example 5 – Electronic door lock

Problem: An office door unlocks when a **valid card (C)** is shown **and** the **correct PIN (K)** is typed, **or** when the **fire alarm (F)** is ON (so people can escape).



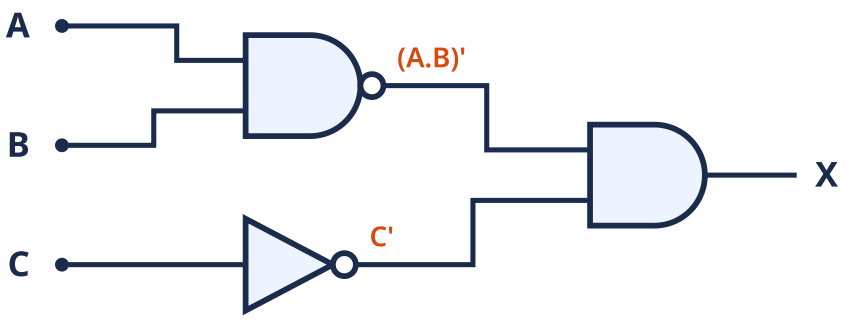
Unlock = C.K + F

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C	K	F	C.K	Unlock
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

7. Reading a circuit: derive the expression and truth table

Go **gate by gate from left to right**. Write the output expression beside each gate, then combine them. Finally evaluate the expression for every row.



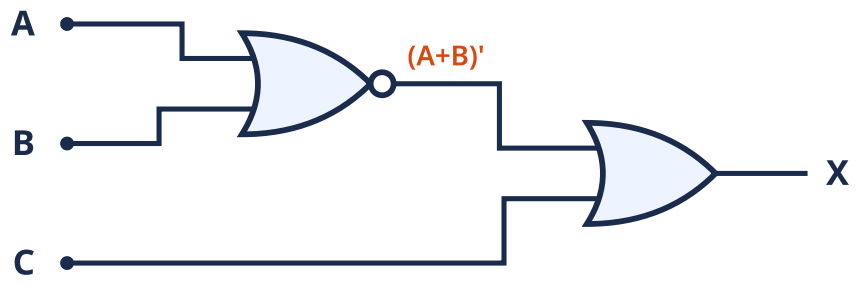
Circuit A: NAND, NOT, then AND

- NAND gate output = (A.B)'
- NOT gate output = C'
- AND gate: X = (A.B)'.C'

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

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1	1	0	0	1	0
1	1	1	0	0	0



Circuit B: NOR then OR

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

💡 Exam check: count the 1s in your output column and compare with a friend – or test one easy row (for example all inputs 0) in your head.

NEW 2026 2026 focus: logic in everyday technology – IoT sensors in smart agriculture, smart homes and security systems all make Yes/No decisions with AND, OR and NOT.

Key Words

Block diagram – A simple drawing of inputs, a logic box and outputs, joined by arrows.

Logic diagram – A drawing of the actual gates and wires that solve a problem.

Sensor – A device that detects a condition (motion, light, rain, door open) and gives 1 or 0.

Input condition – A Yes/No fact used by the circuit, given a letter such as A, D or S.

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Output – The result of the circuit, e.g. siren, lamp, pump or unlock signal.

Alarm system – A system that sounds a warning when sensors detect a problem.

Selection criteria – The rules that decide who is eligible, joined with AND / OR.

Intermediate output – The output of a gate in the middle of a circuit, e.g. D+W.

Derive – To work out the expression or truth table from a given circuit.

IoT – Everyday devices with sensors connected to the internet, e.g. smart farm pumps.

Smart home – A home where lights, locks and appliances are controlled automatically by logic.

Control system – A system that reads inputs and switches outputs ON or OFF automatically.

Sample Q&A

1. List the steps to solve a real-world problem with logic gates.

> **Answer:** Find inputs and output → give letters and 1/0 meanings → draw a block diagram → write the expression and draw the logic circuit → complete the truth table.

2. What is the difference between a block diagram and a logic diagram?

> **Answer:** A block diagram shows only inputs, a logic box and outputs; a logic diagram shows the actual gates (AND, OR, NOT…) and wires.

3. A car siren sounds when the alarm is ON (S) and a door (D) or window (W) is opened. Write the expression.

> **Answer:** Siren = S.(D+W)

4. Why is a NOT gate needed in the smart light circuit?

> **Answer:** The light sensor gives 1 when bright, but the lamp must switch on when dark, so we use L' (NOT L).

5. For Unlock = C.K + F, will the door open if C = 0, K = 1, F = 1?

> **Answer:** Yes. C.K = 0 but F = 1, so Unlock = 1 (fire escape).

6. How do you derive the expression from a given circuit?

> **Answer:** Work from the inputs to the output, writing the expression at the output of each gate, then combine them into one expression for X.

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MCQ

1. In a problem, the word “either … or” usually means which gate?

A. NAND
B. OR
C. NOT
D. AND

2. “Both the card and the PIN must be correct” is best shown by:

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

3. A block diagram shows:

A. Inputs, a logic box and outputs
B. Only the truth table
C. Every transistor in the chip
D. The program code

4. Siren = S.(D+W). What happens when S = 0, D = 1, W = 1?

A. The output is 2
B. Siren is silent (0)
C. Siren sounds (1)
D. It cannot be found

5. In Siren = S.(D+W), how many of the 8 rows give Siren = 1?

A. 3
B. 7
C. 1
D. 4

6. A garden lamp turns on when there is motion (M) and it is dark. The sensor L = 1 when bright. The expression is:

A. (M.L)'
B. M.L
C. M.L'
D. M+L

7. Lamp = M.L'. Which input turns the lamp ON?

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

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8. Pump = D.(R+T)'. For how many input combinations does the pump run?

A. 7
B. 4
C. 3
D. 1

9. “Not raining and tank not empty” = NOT (R OR T). Which single gate does this?

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

10. Unlock = C.K + F. Which input keeps the door LOCKED (0)?

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

11. A circuit has a NAND gate with inputs A and B, a NOT gate on C, and an AND gate joining both. The expression is:

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

12. For X = (A.B)'.C', what is X when A = 0, B = 0, C = 0?

A. 00
B. 0
C. 1
D. 3

13. X = (A+B)' + C. What is X when A = 1, B = 0, C = 0?

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

14. Scholarship X = P.(I+T). A student passed (P=1), has no low income (I=0) but has sport talent (T=1). X =

A. Not defined
B. 2
C. 0
D. 1

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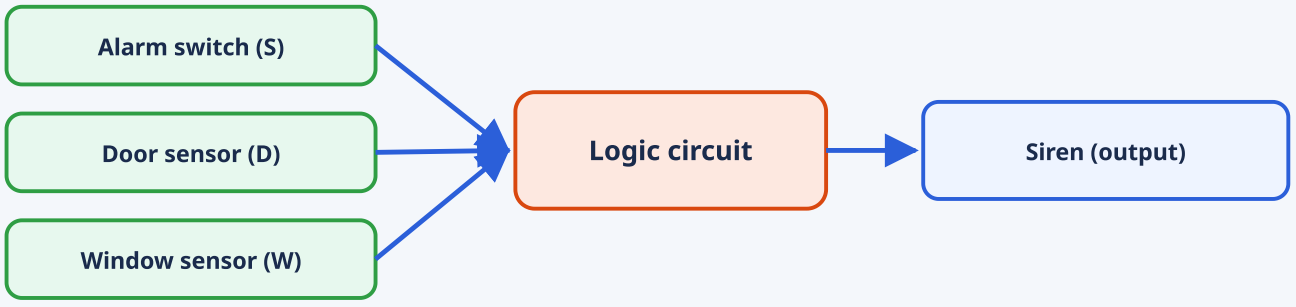
15. Which is the BEST first step when solving a logic problem?

A. Write the program
B. Draw the truth table first
C. Identify the inputs and the output
D. Buy the gates

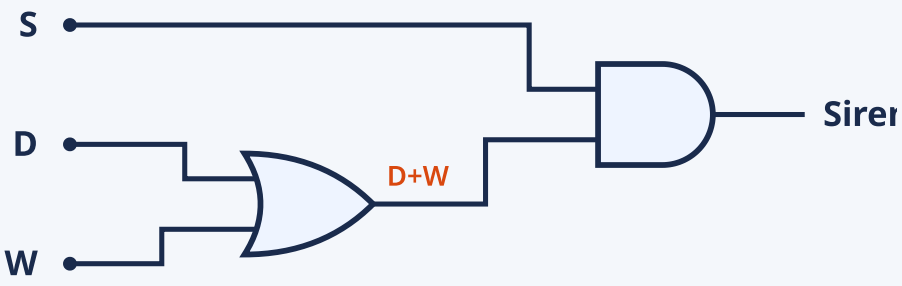
Structured Questions

1. A car alarm siren sounds when the alarm switch is ON (S) and a door is opened (D) or a window is broken (W).
(i) Draw a block diagram. (2 marks)
(ii) Write the Boolean expression. (1 mark)
(iii) Draw the logic circuit. (2 marks) *(5 marks)*

(i) Three input boxes S, D, W → logic box → siren. (ii) Siren = S.(D+W) (iii) OR gate for D and W, then AND with S.



(i) Block diagram



(iii) Logic circuit

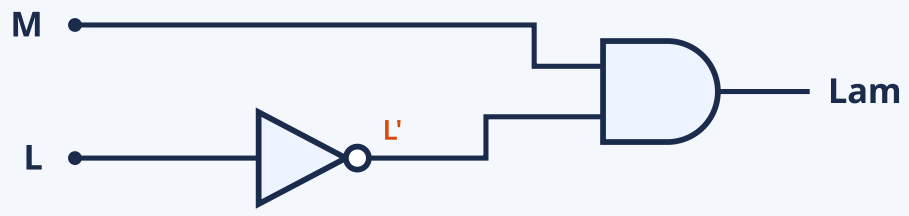
2. Complete the truth table for Siren = S.(D+W). Include a column for D+W. (4 marks) *(4 marks)*

8 rows; D+W column (1 mark); Siren = 1 only for S=1 with D+W=1 (3 rows).

S	D	W	D+W	Siren
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

3. A smart garden lamp (Lamp) turns on when motion is detected (M = 1) and it is dark. The light sensor gives L = 1 when bright.
(i) Write the expression. (1 mark)
(ii) Draw the logic circuit. (2 marks)
(iii) Draw the truth table. (2 marks) *(5 marks)*

(i) Lamp = M.L' (ii) NOT gate on L, then AND with M (iii) Lamp = 1 only when M = 1, L = 0.



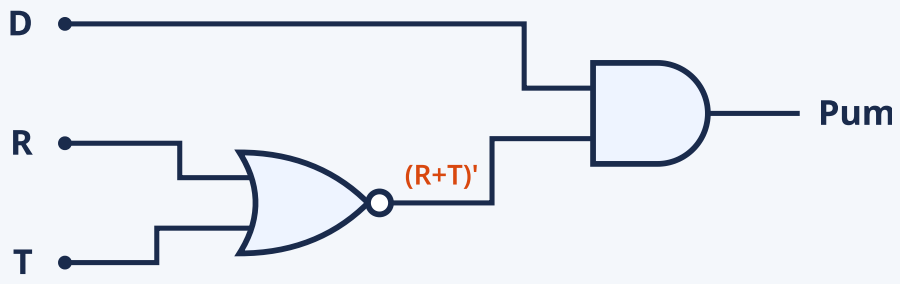
(ii) Circuit

M	L	L'	Lamp
0	0	1	0
0	1	0	0
1	0	1	1
1	1	0	0

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4. A greenhouse pump runs when the soil is dry (D) and it is not raining (R) and the tank is not empty (T).
(i) Show that the condition can be written as Pump = D.(R+T)'. (2 marks)
(ii) Draw the circuit using a NOR gate. (2 marks)
(iii) In which case does the pump run? (1 mark) *(5 marks)*

(i) Not raining AND not empty = R'.T' = (R+T)' (both are 1 only when R = 0 and T = 0); then AND with D. (ii) NOR gate for R and T, then AND with D. (iii) D = 1, R = 0, T = 0 only.



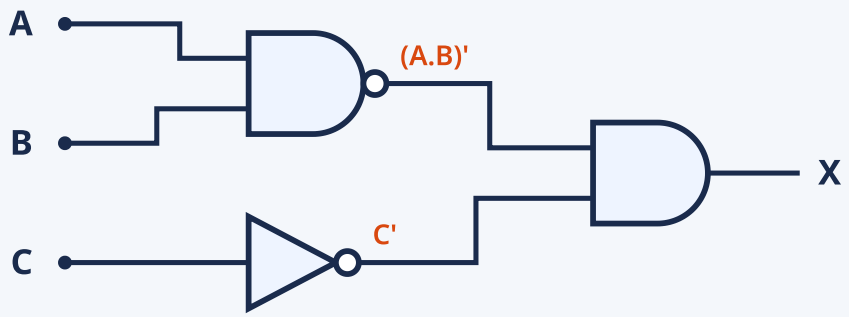
(ii) Circuit with NOR

D	R	T	Pump
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

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5. Study the circuit: a NAND gate with inputs A and B, a NOT gate with input C, and an AND gate whose inputs are the two outputs.
(i) Write the expression for X. (2 marks)
(ii) Complete the truth table. (4 marks) *(6 marks)*

(i) X = (A.B)'.C' (ii) X = 1 in 3 rows: when C = 0 and A.B = 0.



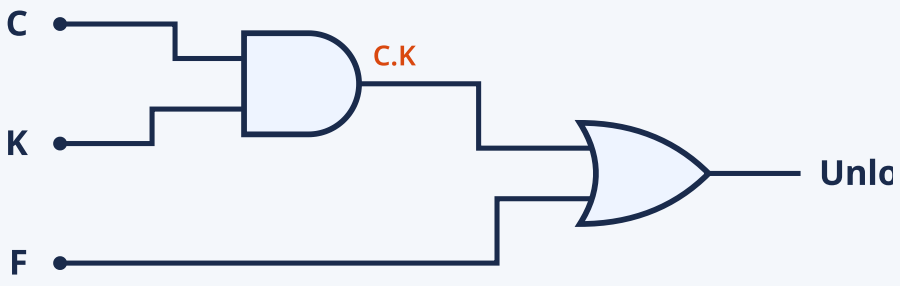
Given circuit

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

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6. An office door unlocks when a valid card (C) and the correct PIN (K) are given, or when the fire alarm (F) is ON.
(i) Write the expression. (1 mark)
(ii) Draw the logic circuit. (2 marks)
(iii) Explain why F is joined with an OR gate. (1 mark) *(4 marks)*

(i) Unlock = C.K + F (ii) AND gate for C and K, then OR with F (iii) In a fire the door must open even without a card or PIN.



(ii) Circuit

Summary

- Real problems are solved in 5 steps: inputs/output → letters → block diagram → expression and circuit → truth table.
- Words give the gate: and/both → AND; or/either → OR; not/dark → NOT.
- Always state what 1 and 0 mean for each input.
- A block diagram shows boxes; a logic diagram shows the gates.
- Car alarm: Siren = S.(D+W); smart light: Lamp = M.L'.
- “Not A and not B” = (A+B)' – a NOR gate.
- To read a circuit, write each gate's output from left to right, then build the truth table.
- IoT, smart homes and security systems use these Yes/No decisions every day.

MCQ answer key – 4.2

1. **B** – Either/or → OR.
2. **D** – Both → AND.
3. **A** – It is a simple overview before drawing gates.
4. **B** – S = 0 so the AND output is 0.
5. **A** – S = 1 with D, W = 01, 10, 11.
6. **C** – Dark = NOT L.
7. **A** – Lamp = 1.0' = 1.1 = 1.
8. **D** – Only D=1, R=0, T=0.

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9. **B** – NOT OR = NOR.
10. **A** – C.K = 0 and F = 0 → 0.
11. **C** – Write each gate output, then AND them.
12. **C** – (0.0)' = 1, C' = 1, 1.1 = 1.
13. **B** – (1+0)' = 0; 0 + 0 = 0.
14. **D** – 1.(0+1) = 1.
15. **C** – Inputs/outputs come first.

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