G.C.E. O/L Grade 10 ICT · Lesson 4

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.

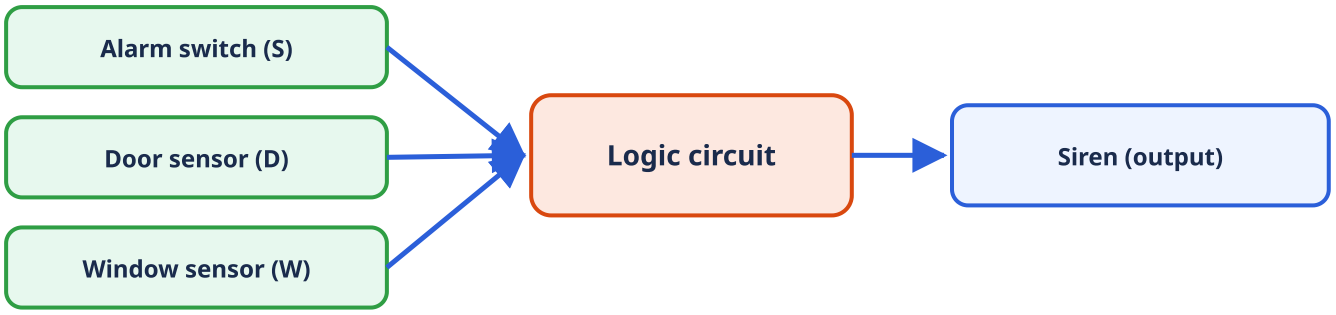
💡 Key words in the problem tell you the gate: **“and”, “both”, “all”** → AND; **“or”, “either”, “any”** → OR; **“not”, “no”, “unless”, “dark (not bright)”** → NOT.

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.

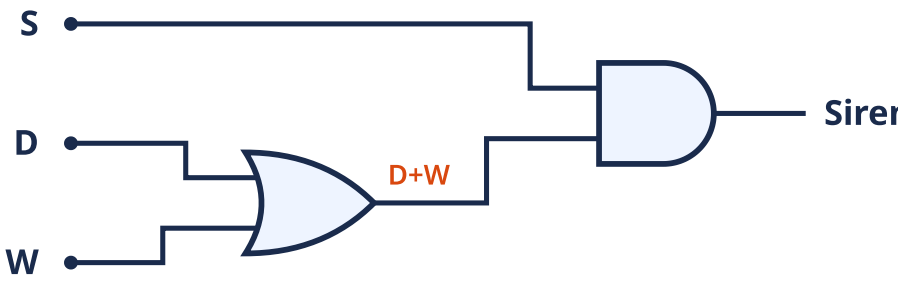
Letter	Input / output	1 means	0 means
S	Alarm switch	ON	OFF
D	Door sensor	Door open	Door closed
W	Window sensor	Glass broken	Glass OK
Siren	Output	Sounds	Silent

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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.

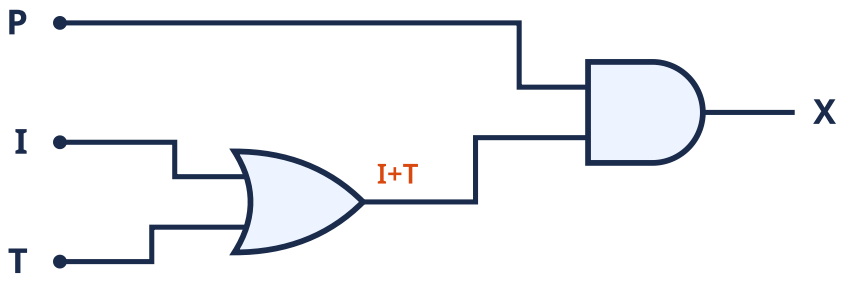
3. Example 2 – Selection criteria (scholarship)

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.

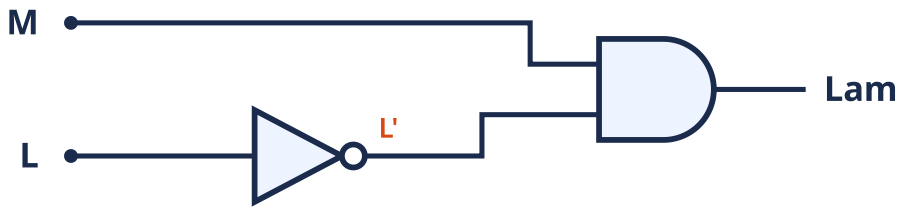
4. Example 3 – Smart home light (uses NOT)

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

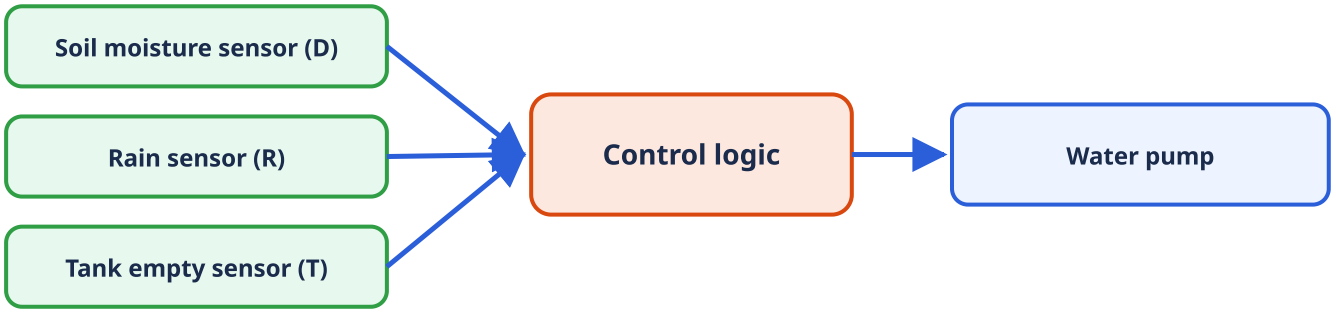


Lamp = M.L'

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

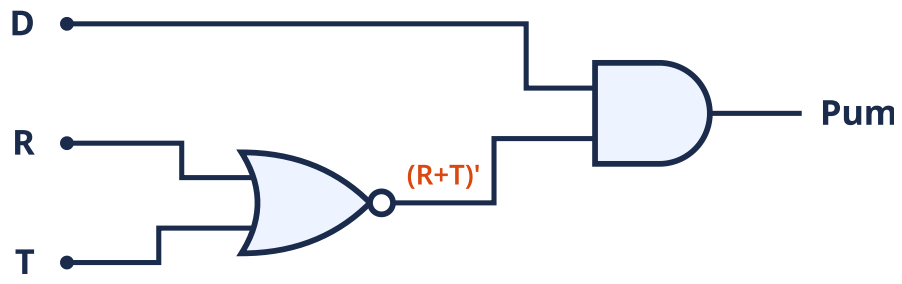
5. Example 4 – Greenhouse / IoT smart agriculture

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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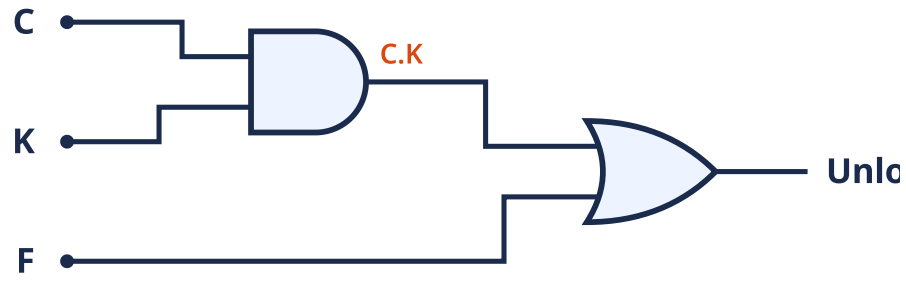
Pump = D.(R+T)'

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).



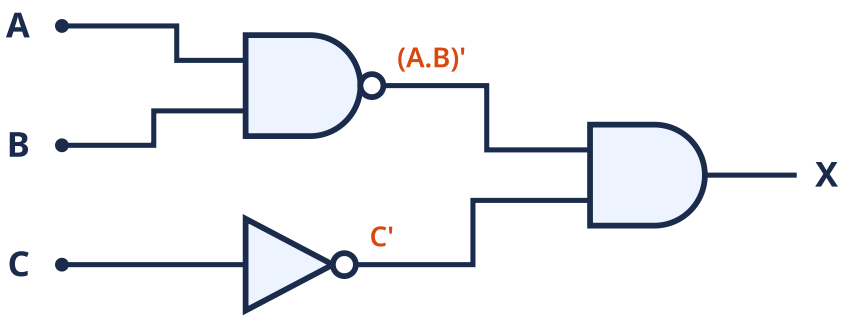
Unlock = C.K + F

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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.



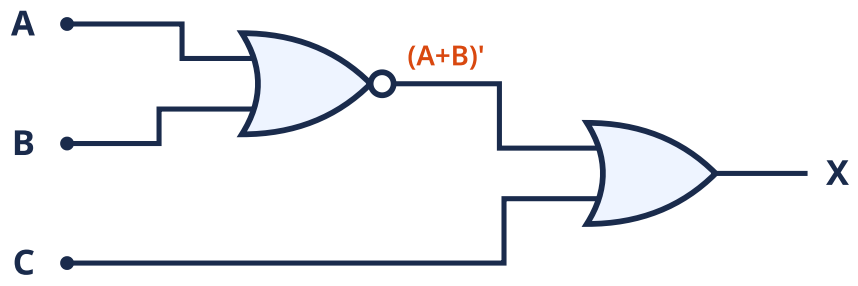
Circuit A: NAND, NOT, then AND

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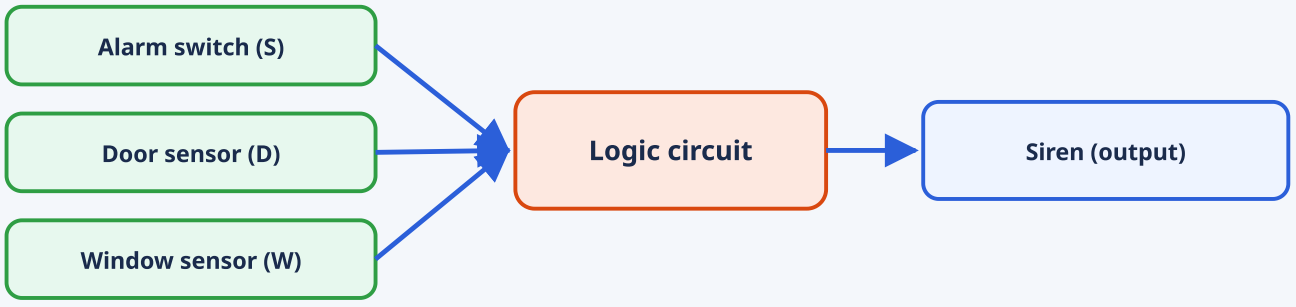
15. Which is the BEST first step when solving a logic problem?

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

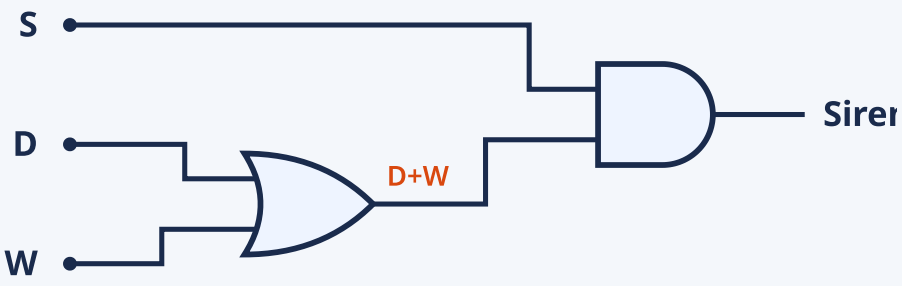
Structured Questions

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

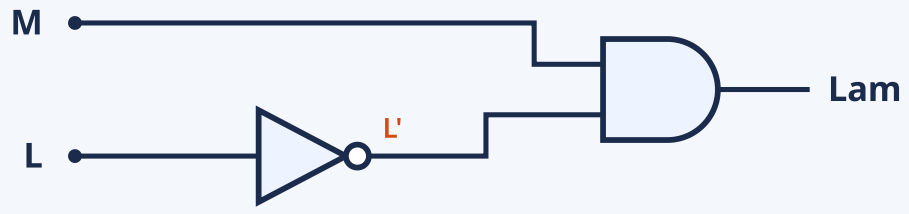
2. Complete the truth table for Siren = S.(D+W). Include a column for D+W. (4 marks) *(4 marks)*

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.



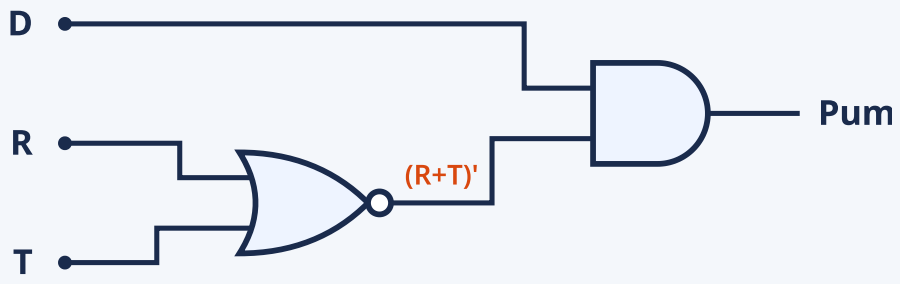
(ii) Circuit

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.



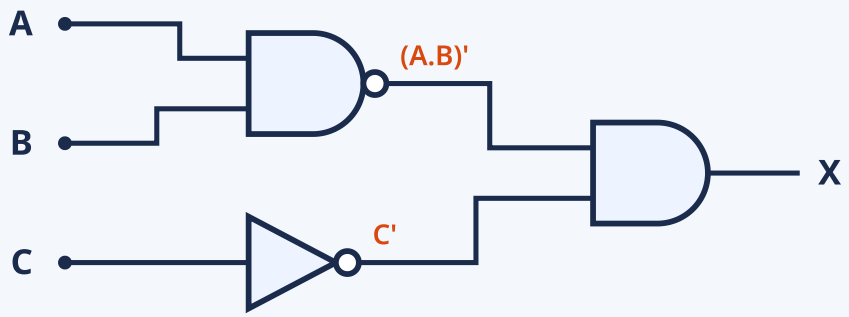
(ii) Circuit with NOR

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.



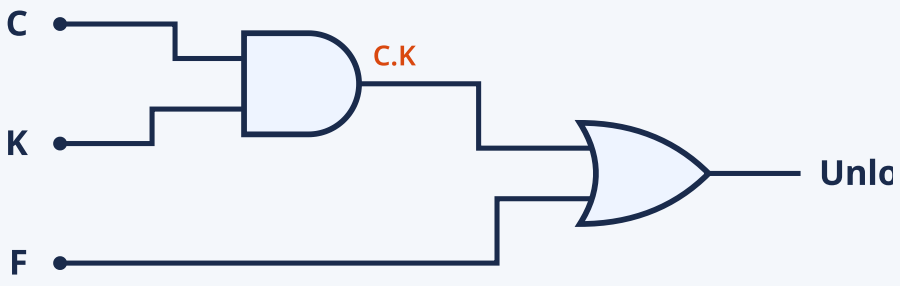
Given circuit

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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