

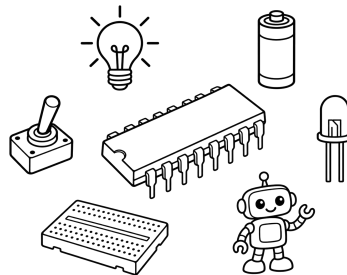
TEACHER GUIDE

ANSWERS AND MARKS

GRADE 10 · INFORMATION AND COMMUNICATION TECHNOLOGY

UNIT 4

Logic Gates with Boolean Functions



! FOR THE TEACHER ONLY

This booklet has the answers to every exercise in the Unit 4 Student Workbook, in the same order. The exercise letters match the workbook.

i WHAT IS IN THIS GUIDE

- **Marks and pacing** - every exercise and its marks
- **Class marks record** - one page to copy for each class
- **Practicals at a glance** - what to check in Practical 1 - 5, safety, a quiz, a practical test
- **Answers** - chapters 1 to 4, in the same order as the workbook
- **Unit 4 Test** - the marking scheme and the common mistakes
- **Extra** - textbook links, homework ideas and teaching tips

★ BEFORE THE FIRST LESSON

- ☐ Two 1.5 V cells, a bulb, two switches and wires are ready for Practical 1.
- ☐ A logic gate simulator (MM Logic, Logisim or CircuitVerse) opens on every computer.
- ☐ A NAND IC, a breadboard, an LED and a 5 V supply are ready for Practical 4.

"Students who build the circuit themselves never forget the truth table."

TEACHER GUIDE

Marks and Pacing

You decide how much class time each part needs

Chapter	Exercise	Marks
Chapter 1	A Complete Table 4.3	10
	B Find P and Q	8
	C Fill in the blanks	8
	D True or false	6
	E Answer these	4
Chapter 2	A Complete the truth tables	8
	B An OR gate with three inputs	9
	C Is the bulb on?	4
	D Find the output	6
	E AND, OR or NOT?	6
Chapter 3	A A NAND gate with three inputs	9
	B Shade the Venn diagrams	5
	C Name the gate	8
	D Label the IC	6
	E Read the IC	4
	F NAND and NOR outputs	8
	G Choose the correct answer	8
Chapter 4	A Draw the circuits	6
	B Truth tables of the expressions	8
	C Values on the wires	5
	D The street lights	8
	E From words to expressions	6
	F Write the Boolean expressions	8
	G Will it open? Will it ring?	8
	H Crossword	10
End	Unit 4 Test	40
TOTAL		216

! SUGGESTED SHAPE OF ONE CHAPTER

READ	Teach the chapter pages. Students read with you and underline the key words.
DO	The practical tasks on real computers, in pairs.
WRITE	The written exercises. Walk around and help.
MARK	Mark the work together. Fill the tick boxes.

★ **TIP:** Draw the AND switch circuit on the board first. Ask: what happens if only switch A is closed?



TEACHER GUIDE

Class Marks Record

Copy this page for each class

No	Student name	Ch 1 (36)	Ch 2 (33)	Ch 3 (48)	Ch 4 (59)	Test (40)	Total (216)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							



TEACHER GUIDE

Practicals at a Glance

Textbook activities on pages 117 - 127

Practical	Students do	Check that ...
1 (p. 117)	AND with switches; AND with three inputs in a simulator	the bulb is on only when both switches are closed; the simulator gives 1 only for 1 1 1.
2 (p. 120)	OR with three inputs (one gate and two gates); a NOT gate	both OR circuits give 0 only for 0 0 0; the NOT gate gives 1 for 0 and 0 for 1.
3 (p. 122)	NAND with three inputs; NOR from OR + NOT	the NAND output is 0 only for 1 1 1; OR + NOT gives the same table as NOR (1, 0, 0, 0).
4 (p. 124)	a NAND IC on a breadboard (the teacher wires it)	the LED is off only when pins 1 and 2 are both 1 (Table 4.8).
5 (p. 127)	Figure 4.21, Activity 2 circuits, the home alarm and the street lights in MM Logic	Figure 4.21 gives 1, 0, 1, 1; one open window sounds the alarm; with the switch open, the lamp is on only at night.

! SAFETY AND MATERIALS

- Practical 1: two 1.5 V cells, a torch bulb in a holder, two switches and short wires. Never use mains.
- Practical 4: a 7400 NAND IC, a breadboard, two switches, an LED with a 330 ohm resistor, a 5 V supply. Only you connect the power.
- Simulators: Multimedia Logic (MM Logic, named in the textbook), Logisim or CircuitVerse. Install and test them before the lesson.

Textbook links

Workbook	Textbook pages	Activities
Chapter 1 - Signals, logic gates and the AND gate	113 - 118	117, 118
Chapter 2 - The OR gate and the NOT gate	118 - 121	120
Chapter 3 - NAND, NOR and integrated circuits	121 - 124, 128, 134 - 137	122, 124
Chapter 4 - Designing and using logic circuits	125 - 133	126, 127
Unit 4 in One Page	134 - 137 (summary)	-

★ TEACHING TIPS

- Say "AND needs all, OR needs one, NOT turns it round" before every truth table.
- Remind the class every lesson: in Boolean algebra $1 + 1 = 1$. The plus sign means OR.
- Write the inputs of every truth table in binary order: 0 0, 0 1, 1 0, 1 1. Insist on it.
- Make students draw the small circle (bubble) on NOT, NAND and NOR. It is the most common lost mark.
- Test the batteries, the bulbs and the switches before Practical 1. A flat cell spoils the lesson.
- Shade Venn diagrams with a pencil, not a pen, so mistakes can be corrected.



? QUICK ORAL QUIZ - START OR END A LESSON WITH IT

Ask the class ...	Answer
1. Name the three basic logic gates.	AND, OR, NOT
2. Name the two combinational gates of the textbook.	NAND, NOR
3. An OR gate has the inputs 1 and 1. Output?	1
4. A NAND gate has the inputs 1 and 1. Output?	0
5. A NOR gate has the inputs 0 and 0. Output?	1
6. How many states for three inputs?	$2^3 = 8$
7. What is the complement of 0?	1
8. Switches in series make which gate?	AND
9. Which pin of the AND IC is VCC?	Pin 14
10. Which gate is used in the home alarm?	OR

> PRACTICAL TEST - 30 MINUTES, 20 MARKS (OPTIONAL)

Use the simulator of Practicals 2, 3 and 5. Step 4 answers: Q = **1, 0, 1, 1** for A B = 0 0, 0 1, 1 0, 1 1.

Step	The student must ...	Marks
1	Open the simulator. Build an AND , an OR and a NOT gate. Show each one working.	3
2	Build a NAND gate as an AND gate followed by a NOT gate. Show its four outputs.	3
3	Build Figure 4.21: $Q = A(\bar{A} + B) + \bar{B}$.	5
4	Write the truth table of Figure 4.21 from the simulator.	4
5	Build the street lights (Figure 4.31). Show that the lamp is on at night (timer 1, light 0).	4
6	Save the file with your name.	1
	Total	20

★ TEACHING TIPS

- Not enough computers? Show the simulator on the projector and let pairs take turns at the mouse.
- For bars over expressions, write slowly on the board and draw the bar exactly over the right letters.
- Teach NAND and NOR as two steps: first the AND (or OR) column, then the opposite of it.
- In circuit exercises, ask students to write the expression on every wire, not only at the end.
- Bring an old IC (a 7400 or 7408 chip) to the class. Let students find the notch and count the pins.



ANSWERS

Chapter 1

Signals, logic gates and the AND gate

A Complete Table 4.3

10 marks

A	B	C	A.B	Q = A.B.C
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	0	0
1	0	0	0	0
1	0	1	0	0
1	1	0	1	0
1	1	1	1	1

1 mark for each of the ten empty cells (bold).
A.B is 1 only when A and B are both 1. $Q = A.B.C$ is 1 only in the last row (1 1 1).

B Find P and Q

8 marks

1. A B C = 1 1 1: P = 1 , Q = 1	2. A B C = 1 1 0: P = 1 , Q = 0
3. A B C = 0 1 1: P = 0 , Q = 0	4. A B C = 1 0 1: P = 0 , Q = 0

1 mark for each box. $P = A.B$, then $Q = P.C$. Q is 1 only when A, B and C are all 1.

C Fill in the blanks

8 marks

1. circuits	2. gates	3. diodes	4. basic
5. combinational	6. series	7. four	8. A.B

D True or false

6 marks

1. **T** - A logic gate gives an output after considering one input or several inputs.
2. **F** - The Central Processing Unit is made of only a few logic gates.
3. **T** - If at least one input of an AND gate is 0, the output is 0.
4. **F** - NAND is a basic logic gate.
5. **T** - An AND gate with three inputs has 8 states in its truth table.
6. **F** - An AND gate can never have more than two inputs.

★ TEACHING TIP

- Only the teacher connects the power in Practical 4. Use a 5 V supply or a 4.5 V battery pack, never mains.



E Answer these

4 marks

1. What is a logic circuit? (2 marks)

A circuit that builds logical conditions using binary values (1 and 0) and makes decisions.
2 marks (1 mark for "binary values", 1 mark for "makes decisions").

2. Write the observation of the AND gate (textbook p. 116). (2 marks)

If at least one input is 0, the output of the AND gate is 0. (The output is 1 only when all the inputs are 1.) 2 marks.

ANSWERS

Chapter 2

The OR gate and the NOT gate

A Complete the truth tables

8 marks

Input		Output
A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	1

Input	Output
A	$\bar{A}$
0	1
1	0

OR: 1 mark for the heading **A + B**, 1 mark for each output (0, 1, 1, 1). NOT: 1 mark for the heading $\bar{A}$, 1 mark for each output (1, 0).

B An OR gate with three inputs

9 marks

$$Q = A + B + C$$

A	B	C	Q
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

1 mark for **Q = A + B + C**. 1 mark for each output. The output is 0 only when all three inputs are 0 (the observation on page 119). Note: the textbook activity says "for AND" but the figure shows OR gates.

★ TEACHING TIPS

- Use the street lights near the school as an example: who decides when they come on?
- Let pairs swap books and check each other's truth tables before you mark them.
- Read the crossword clues aloud for weaker readers. The words are all in the word list.



C Is the bulb on?

4 marks

1. AND circuit, A closed, B open: 0	2. OR circuit, A open, B closed: 1
3. NOT circuit, A closed: 0	4. NOT circuit, A open: 1

AND: on only when both switches are closed. OR: on when at least one is closed. NOT: the closed switch is across the bulb, so the bulb is off.

D Find the output

6 marks

1. OR (1, 0): 1	2. NOT (1): 0	3. AND (1, 0): 0
4. OR (0, 0): 0	5. NOT (0): 1	6. AND (1, 1): 1

E AND, OR or NOT?

6 marks

It works like ...	AND gate	OR gate	NOT gate
You can get down from a two-door bus by either door.	☐	☒	☐
A safe opens only when both keys are used.	☒	☐	☐
The output is always the complement of the input.	☐	☐	☒
You can reach home by any one of several routes.	☐	☒	☐
The lab door opens only with both of its keys.	☒	☐	☐
In Figure 4.12 the bulb is on only when A is open.	☐	☐	☒

ANSWERS

Chapter 3

NAND, NOR and integrated circuits

A A NAND gate with three inputs

9 marks

$$Q = \overline{A.B.C}$$

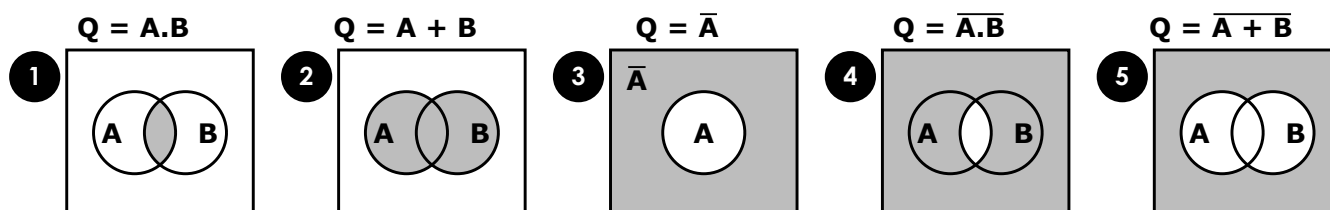
A	B	C	Q
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

1 mark for $Q = \overline{A.B.C}$ (one bar over the whole of A.B.C). 1 mark for each output: the output is 0 only for 1 1 1 (when all the inputs are 1, the output is always 0).



B Shade the Venn diagrams

5 marks



1 mark for each diagram shaded exactly like this (the shaded part is where $Q = 1$).

C Name the gate

8 marks

1. NOR (symbol)	2. AND (Venn)	3. NAND (table)	4. NAND (symbol)
5. NOR (Venn)	6. OR (table)	7. NOT (Venn)	8. OR (symbol)

D Label the IC

6 marks

- $X = VCC$ (pin 14), $Y = GND$ (pin 7)
- Inputs: pins 1, 2, 4, 5, 9, 10, 12, 13
- Outputs: pins 3, 6, 8, 11

The OR IC has the same pins as the AND IC (textbook page 135). 2 marks for each line: give 1 mark when half of the pins are right.

E Read the IC

4 marks

1. NOR IC: pin 1 = 1	2. NOR IC: pin 4 = 0
3. NAND IC: pin 3 = 0	4. NAND IC: pin 11 = 1

Figure 4.19 (NOR IC): pin 1 is the output of the gate with inputs 2 and 3; pin 4 of 5 and 6.
Figure 4.20 (NAND IC): pin 3 is the output of 1 and 2; pin 11 of 12 and 13. 1 mark each.

F NAND and NOR outputs

8 marks

A	B	$A.B$	$\overline{A.B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

A	B	$A + B$	$\overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

1 mark for each output.
Each Q is the complement (opposite) of the column before it.

★ TEACHING TIP

- Past O/L papers often ask for the expression of a circuit. Practise one at the start of every lesson.



G Choose the correct answer

8 marks

1. (a) NOT AND	2. (d) NOR
3. (a) 0	4. (c) $Q = \bar{A} + \bar{B}$
5. (b) AND	6. (a) diodes
7. (b) 7	8. (d) NOR

ANSWERS

Chapter 4

Designing and using logic circuits

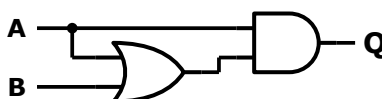
A Draw the circuits

6 marks

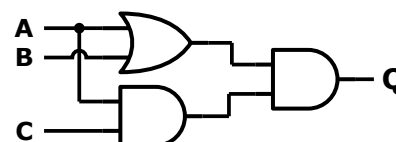
(a) $Q = A + A.B$



(b) $Q = A.(A + B)$



(c) $Q = (A + B).(A.C)$



2 marks for each circuit: 1 mark for the right gates, 1 mark for the right connections and labels. (c) can also be drawn with a 3-input AND gate. Textbook page 126 prints a small stray bar after (A.C): if your class reads it as NOT C, accept a NOT gate on C.

B Truth tables of the expressions

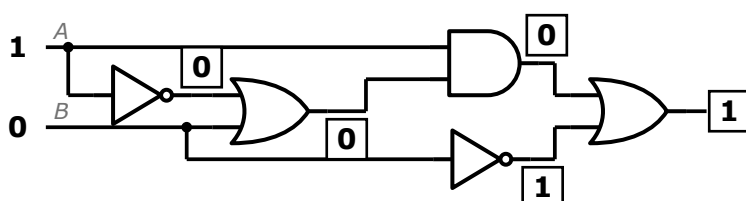
8 marks

A	B	A.B	$A + A.B$	$A + B$	$A.(A + B)$
0	0	0	0	0	0
0	1	0	0	1	0
1	0	0	1	1	1
1	1	1	1	1	1

Half a mark for each cell. Both $A + A.B$ and $A.(A + B)$ give 0, 0, 1, 1 - the same as A. Give a bonus word of praise for students who notice it.

C Values on the wires

5 marks



$A = 1, B = 0: \bar{A} = 0, \bar{A} + B = 0, A.(\bar{A} + B) = 0, \bar{B} = 1, Q = 1$. 1 mark each.

★ TEACHING TIP

- Students who finish early can draw a circuit for a friend, and then check it in the simulator.



D The street lights

8 marks

S	T	L	Q
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

1 mark for each row. The lamp is on when $S = 1$ (any time), or when $T = 1$ and $L = 0$ (night and dark). Rows 0 1 0 and every row with $S = 1$ give 1.

E From words to expressions

6 marks

1. $Q = X.Y$ - AND
2. $Q = W + X + Y + Z$ - OR
3. $Q = T.\bar{L}$ - AND and NOT

1 mark for Q, 1 mark for the gate(s). Accept other letters if they are explained.

F Write the Boolean expressions

8 marks

1. (b) $Q = \overline{A.B.B}$ (also: it is the same as B)
2. (c) $Q = \overline{A.B.(B.C)}$
3. (d) $Q = A.B + B.C + C.A$ (also: $A.B + B.C + A.C$)
4. (e) $Q = A + \overline{B.C}$

2 marks each: 1 mark for the gates nearest the inputs, 1 mark for the whole expression. Bars must cover the right letters.

G Will it open? Will it ring?

8 marks

1. Gate 1: 1	2. Gate 2: 0	3. Gate 3: 1	4. Gate 4: 0
5. Alarm 1: 1	6. Alarm 2: 0	7. Alarm 3: 0	8. Alarm 4: 0

Gate: $Q = A.B + C$ (vehicle AND pass, OR the switch). Alarm: $Q = A.B.\bar{C}$ - it rings only with heat AND speed AND NO maintenance. 1 mark each.

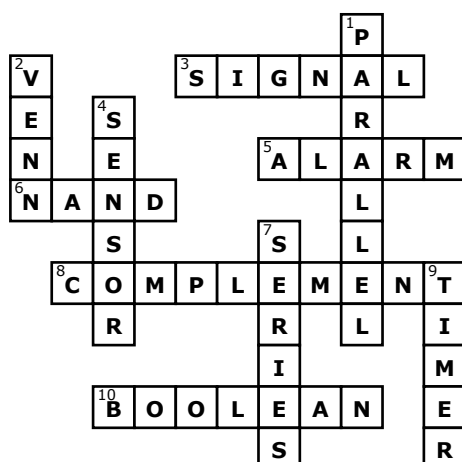
★ TEACHING TIPS

- For the scenarios, ask: what are the inputs? what is the output? which words mean AND, OR and NOT?
- Keep a poster of the five gates (symbol, expression, truth table) on the wall during the whole unit.



H Crossword

10 marks



Across: 3 SIGNAL, 5 ALARM, 6 NAND, 8 COMPLEMENT, 10 BOOLEAN

Down: 1 PARALLEL, 2 VENN, 4 SENSOR, 7 SERIES, 9 TIMER

MARKING SCHEME

Unit 4 Test

Total 40 marks

1 Choose the correct answer

8 marks (1 each)

1. (b) AND	2. (a) $Q = \overline{A} \cdot \overline{B}$
3. (d) 8	4. (c) in parallel
5. (b) 1	6. (d) VCC
7. (a) AND and OR	8. (c) A, C only

2 Fill in the blanks

8 marks (1 each)

1. output	2. complement	3. AND	4. 1
5. four	6. GND	7. alarm	8. +

3 Look at the gates

8 marks (1 + 1 each)

1. NOR gate: $Q = \overline{A + B}$	2. NAND gate: $Q = \overline{A \cdot B}$
3. OR gate: $Q = A + B$	4. NOT gate: $Q = \overline{A}$

1 mark for the name and 1 mark for the Boolean expression of each gate.

★ TEACHING TIP

- Ask students to say the observation of each gate aloud, in the words of the textbook (pages 116 - 123).

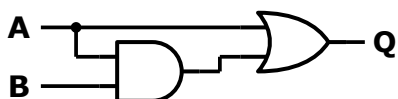


4 Answer these

16 marks

1. Draw the logic circuit of $Q = A + A.B$. Label the inputs and the output. (3 marks)

An AND gate with inputs A and B; its output and A go into an OR gate whose output is Q. 1 mark for the AND gate, 1 mark for the OR gate, 1 mark for the correct inputs and labels.



2. Complete the truth table of the NOR gate. Fill both columns. (4 marks)

$A + B$: 0, 1, 1, 1 and Q : 1, 0, 0, 0. Half a mark for each cell.

A	B	$A + B$	$Q = \overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

3. Write the Boolean expression of this circuit. (3 marks)

$Q = A.B.\overline{C}$ (1 mark for $A.B$, 1 mark for $\overline{C}$, 1 mark for joining them with AND).

4. A door opens only when it is unlocked with a key and the fingerprint reader recognises the fingerprint. Which gate is used? Write the Boolean expression (key A, fingerprint B). (2 marks)

An AND gate (1 mark). $Q = A.B$ (1 mark).

5. Write the input pins and the output pins of the AND IC (Figure 4.22). (2 marks)

Inputs: 1, 2, 4, 5, 9, 10, 12, 13 (1 mark). Outputs: 3, 6, 8, 11 (1 mark).

6. In the street light circuit, the timer is 1 and the light sensor is 0. The manual switch is open (0). Is the lamp on? Explain. (2 marks)

Yes, the lamp is on (1 mark). NOT 0 = 1, the AND gate gets 1 and 1 and gives 1, so the OR gate gives 1 (1 mark).

★ TEACHING TIPS

- For 3-input tables, let students first copy the A, B, C columns (000 to 111) before they think about Q.
- When marking circuits, check that every wire starts at an input or a gate output and ends at a gate.
- Use the human-gate game: two students are inputs (hand up = 1), a third decides the output for AND, OR, NAND.
- Show that two NOT gates in a row give the input back. It helps students to read nested bars.
- Use school examples for "which gate?": the school gate, the bell, the lights in the hall.



WHAT STUDENTS USUALLY GET WRONG

- They write 2 for $1 + 1$. In Boolean algebra $1 + 1 = 1$ (OR).
- They forget the small circle on NOT, NAND and NOR, or the bar in the expression.
- They mix up NAND and NOR. NAND = NOT **AND** (0 only for 1 1); NOR = NOT **OR** (1 only for 0 0).
- They put one long bar over $A + B$ when the circuit has two separate NOT gates ($\overline{A + B}$).
- They miss rows in 3-input truth tables. Write the inputs in binary order: 000 to 111.
- In circuits they start at the output. Work from **left to right**, one gate at a time.
- They think switches in series make an OR gate. Series = AND, parallel (side by side) = OR.

HOMEWORK AND EXTRA PRACTICE

- Draw the five gate symbols with their Boolean expressions and truth tables from memory.
- Textbook Activity 2 (f), page 127: two NAND gates, a NOR gate and a NOT gate. Its output is 1, 1, 1, 0 - the same as one NAND gate ($Q = \overline{A.B}$).
- Write the full 16-row Table 4.11 of the home alarm. Only 0 0 0 0 gives no alarm.
- Fast learners: draw the circuit of $Q = A.B + B.C + C.A$ (Activity 2 (d)) in the simulator.

TEACHING TIPS

- In the IC exercises, let students trace each gate with a finger from its input pins to its output pin.
- Link the home alarm to real life: shops and banks use the same OR idea with many sensors.
- Give a quick five-question oral quiz at the start of the next lesson. Use the list on the practicals page.
- Before the test, let students draw the five Venn diagrams from memory and compare them with a friend.
- When a student is stuck on a circuit, cover all the gates except the first one, then uncover one at a time.
- Draw each input wire in its own colour on the board. Big circuits become easy to follow.
- Remind students that the output of one gate becomes the input of the next gate.

 **TIP:** Let students write their own scenario like the textbook ones, then swap with a friend and solve it.

