Truth tables and logic

1.3 · Computational thinking · revision notes

The logical operators AND, OR and NOT combine True/False (1/0) values. You need to complete truth tables with up to three inputs and use logic to solve problems, such as writing a logic statement for a control system. Truth table questions are usually worth 2 to 4 marks.

Key facts

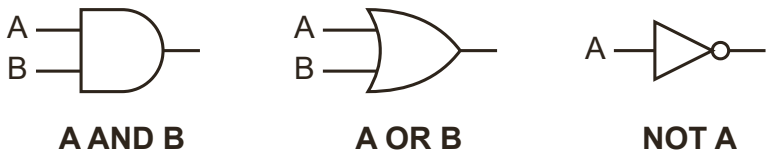
- 1 = True, 0 = False
- OR: 1 if at least one input is 1
- Rows = 2^{inputs}: 2 inputs → 4 rows, 3 inputs → 8 rows
- Order: brackets, NOT, AND, OR
- AND: 1 only if both inputs are 1
- NOT: reverses the input (NOT 1 = 0, NOT 0 = 1)
- Three-input columns: A 00001111, B 00110011, C 01010101
- Python: and, or, not

Notes

The three logical operators

- 1 means True (on, yes) and 0 means False (off, no).
- **AND**: the output is 1 only if **both** inputs are 1.
- **OR**: the output is 1 if **at least one** input is 1.
- **NOT**: has one input, and the output is the opposite: NOT 1 = 0 and NOT 0 = 1.

A	B	A AND B	A OR B
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	1



The three operators drawn as logic gates: AND (D shape), OR (curved) and NOT (triangle with a circle)

- Order: brackets first, then NOT, then AND, then OR.

Building a truth table

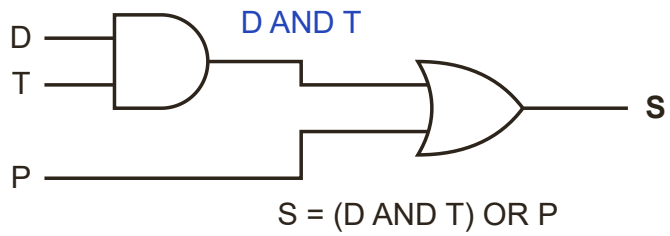
- Number of rows = $2^{\text{number of inputs}}$: 2 inputs give 4 rows and 3 inputs give 8 rows.
- List the inputs in binary counting order, 000 to 111. With three inputs, column A goes 0000 1111, B goes 0011 0011 and C goes 0101 0101.
- Add a working column for each part of the statement, then the output column. For P = (A AND B) OR NOT C:

A	B	C	A AND B	NOT C	P
0	0	0	0	1	1
0	0	1	0	0	0
0	1	0	0	1	1
0	1	1	0	0	0
1	0	0	0	1	1
1	0	1	0	0	0
1	1	0	1	1	1
1	1	1	1	0	1

- P is 1 in every row where at least one of the two working columns is 1.

Solving problems with logic

- Give each condition a letter, then join them with AND, OR and NOT, using brackets to show which parts go together.
- Example: an alarm (S) sounds if a door is opened (D) while the system is set (T), or if the panic button (P) is pressed: S = (D AND T) OR P.



The brackets show which part is worked out first: D AND T, then OR P

- Words to look for: 'both' means AND; 'either' or 'at least one' means OR; 'not' means NOT; 'but not' means AND NOT.
- In Python the operators are `and`, `or` and `not`, used with True and False, e.g. `if (door and alarmSet) or panic:`.
- Edexcel questions write logic statements in words, using AND, OR and NOT with brackets, e.g. P = A AND NOT B. Work through a long statement one part at a time, just like the working columns.

How to answer each type of question

Complete a truth table

2 to 4 marks **Grade 5**

1. Check that the input columns are in binary counting order.
2. Add a working column for the part in brackets.
3. Work out the output row by row from the working column and the other input.

Example. Complete the truth table for X = A AND (B OR C).

A	B	C	B OR C	X
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Model answer.

A	B	C	B OR C	X
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

1 mark for each correct pair of rows in the X column (rows 1–2, 3–4, 5–6, 7–8), 4 marks in total. X is 1 only in the last three rows.

Complete a truth table with NOT outside brackets

3 to 4 marks | **Grade 6**

1. Work out the part inside the brackets first, in its own column.
2. Reverse that whole column for the NOT.
3. Then combine it with the remaining input.

Example. Complete the truth table for P = NOT (A AND B) AND C.

A	B	C	A AND B	NOT (A AND B)	P
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

Model answer.

A	B	C	A AND B	NOT (A AND B)	P
0	0	0	0	1	0
0	0	1	0	1	1
0	1	0	0	1	0
0	1	1	0	1	1
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	0

A AND B column (1); NOT (A AND B) column (1); P column (1).

Write a logic statement for a situation

2 to 3 marks | Grade 7

1. Match each condition in the description to its input letter.
2. Decide which conditions must all be true (AND), which are alternatives (OR) and which must be false (NOT).
3. Add brackets so that the statement groups the conditions as described.

Example. A greenhouse fan (F) is controlled by three inputs:
T is 1 when the temperature is above 30 °C
W is 1 when the window is open
M is 1 when the manual switch is on.
The fan is on when the temperature is above 30 °C and the window is not open, or when the manual switch is on.
Write a logic statement for F.

Model answer.

F = (T AND NOT W) OR M

T AND NOT W (1); OR M, with brackets so that M on its own turns the fan on (1).

Use a truth table to solve a problem

1 to 2 marks | Grade 8

1. Complete (or read) the truth table for the statement.
2. Find the rows where the output has the value you want.
3. Give the inputs for those rows, and explain what they mean if asked.

Example. Use the statement F = (T AND NOT W) OR M for the greenhouse fan.
(a) State the number of rows in a truth table for F.
(b) The manual switch is off (M = 0). State the values of T and W that turn the fan on.

Model answer.

(a) 8 (1): three inputs, and 2 × 2 × 2 = 8

(b) T = 1 and W = 0 (1): the temperature is above 30 °C and the window is closed.

Don’t lose marks

- Missing out or repeating a combination of inputs, so the table has the wrong rows.
- Applying NOT to the whole statement when it only applies to one input, or the other way round.
- Working out OR before AND when there are no brackets.
- Skipping the working columns and then making slips in the output column.
- Mixing 1/0 with True/False in the same table. Use the form the table already uses.

More tips

Memory tricks

- AND = all, OR = any, NOT = opposite.
- Input patterns halve each column: runs of four, then two, then one.
- Quick check: an AND column usually has few 1s; an OR column has few 0s.
- Don't share a NOT across brackets: NOT (A AND B) is not the same as NOT A AND NOT B. Work out the bracket, then reverse it.

Exam technique

- Add working columns even if the table in the question doesn't have them; you can write them next to it.
- Keep the input rows in the order the question gives. Don't reorder them.
- Read descriptions carefully for 'both', 'either', 'not' and 'but not' (AND NOT) before you write a statement.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State the outputs of AND, OR and NOT**
AND needs both inputs to be 1; OR needs at least one; NOT reverses its input.

Grade 4 — **Complete a truth table with two inputs**
Four rows: 00, 01, 10, 11.

Grade 5 — **Complete a truth table with three inputs**
Eight rows, listed in binary counting order from 000 to 111.

Grade 6 — **Use working columns for brackets and NOT**
Work out each part of the statement in its own column before the output.

Grade 7 — **Write a logic statement from a description**
Turn a rule such as 'on if A and not B, or if C' into a statement.

Grade 8 — **Use a truth table to solve a problem**
Find the input combinations that give a required output.

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