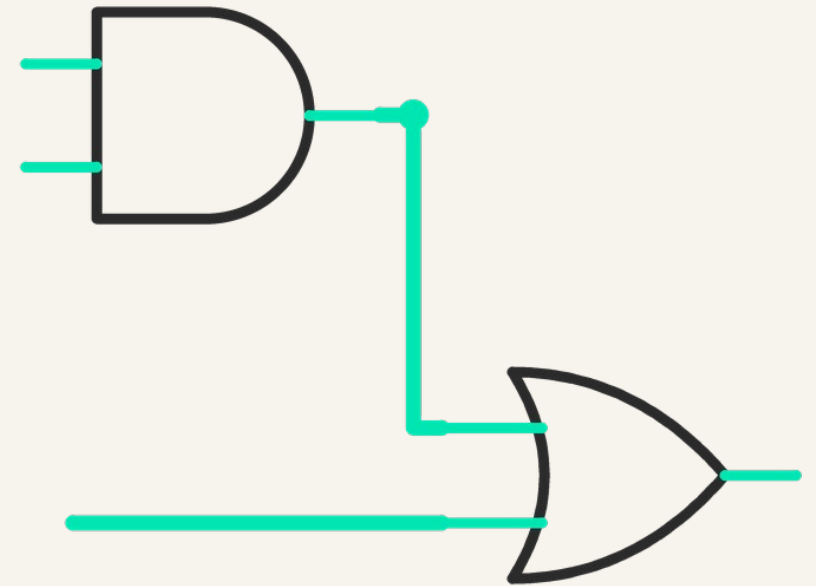


N5 ELECTRONICS • LOGIC

Combinational Logic

Join the gates together and one gate's answer becomes the next one's question.

National 5 Practical Electronics



LEARNING INTENTION

To complete the truth table for a circuit of connected gates, one gate at a time.

Daily Review

SHOW ME BOARDS

- 1 Name the gate that gives 1 only when both inputs are 1.
- 2 When is an XOR output logic 1?
- 3 Which chip holds NOR gates?
- 4 How many inputs does a NOT gate have?
- 5 A gate gives 0 on the 1 1 row only. Name it.

By the end of this lesson...

- 1 I can work out how many rows a truth table needs.
- 2 I can complete a truth table for a circuit with up to four inputs.
- 3 I can work a circuit one gate at a time, using the middle column.

Gates joined together

Booklet section 3.

- Combinational logic means gates joined together.
- The output of one gate becomes an input of the next.
- The joining point is labelled – usually D.
- The final output is still labelled Z.

How many rows?

Every extra input doubles the number of combinations.

Inputs	Working	Rows
1	2	2
2	2×2	4
3	$2 \times 2 \times 2$	8
4	$2 \times 2 \times 2 \times 2$	16

Show Me — How many rows?

SHOW ME BOARDS

- 1 A circuit has two inputs. How many rows?
- 2 A circuit has three inputs. How many rows?
- 3 A circuit has four inputs. How many rows?
- 4 A single NOT gate. How many rows?
- 5 Why does each extra input double the rows?

How many rows?

SHOW ME BOARDS

EXTRA PRACTICE

- 1 A circuit has five inputs. How many rows?
- 2 A truth table has eight rows. How many inputs?
- 3 A truth table has sixteen rows. How many inputs?
- 4 Two gates share three inputs. How many rows?
- 5 Does adding a middle column D add any rows?

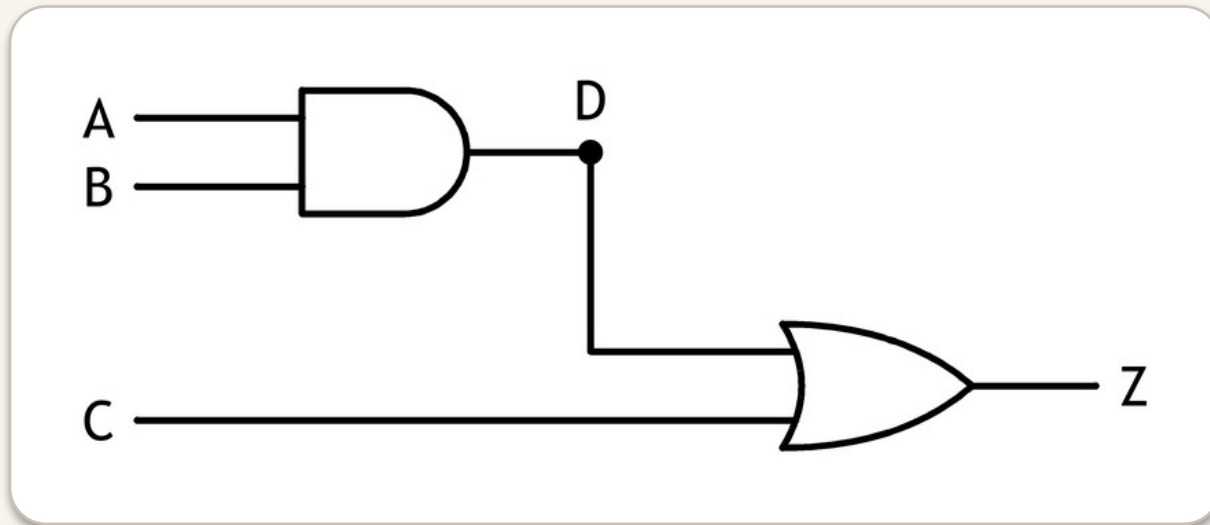
One gate at a time

The booklet's method, and the one the marking instructions reward.

- Write every input combination down first.
- Fill in the middle column D – the first gate only.
- Then use D to work out Z – the second gate only.
- Never work Z out in one go. Show the middle column.

Worked example – column D

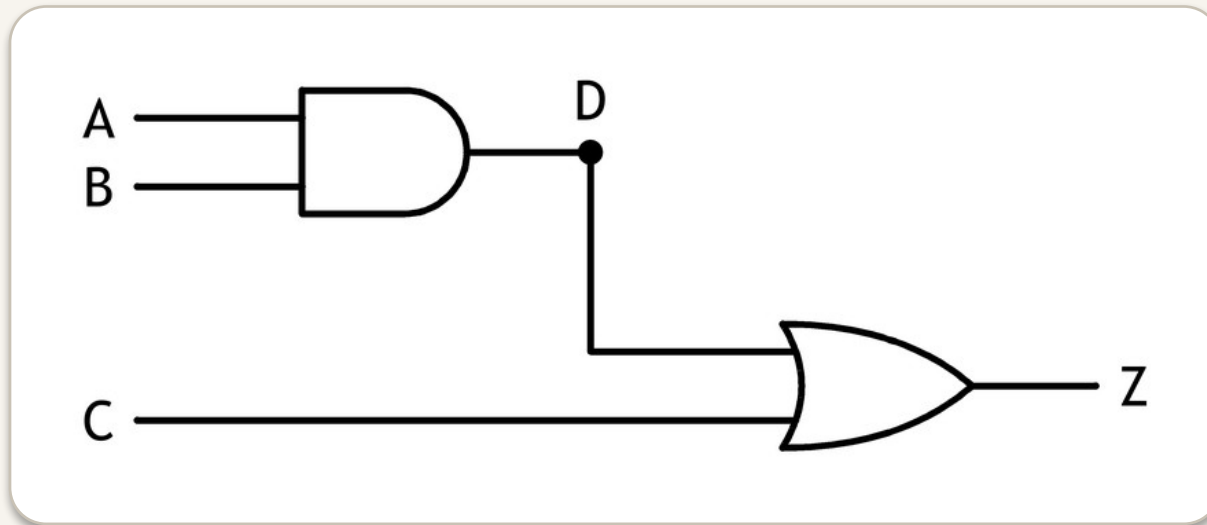
Three inputs, so eight rows. D is the AND gate, fed by A and B only.



A	B	C	D	Z
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	1	
1	1	1	1	

Worked example – column Z

Z is the OR gate, fed by D and C. It is 1 when either is 1, or both.



A	B	C	D	Z
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

Your turn

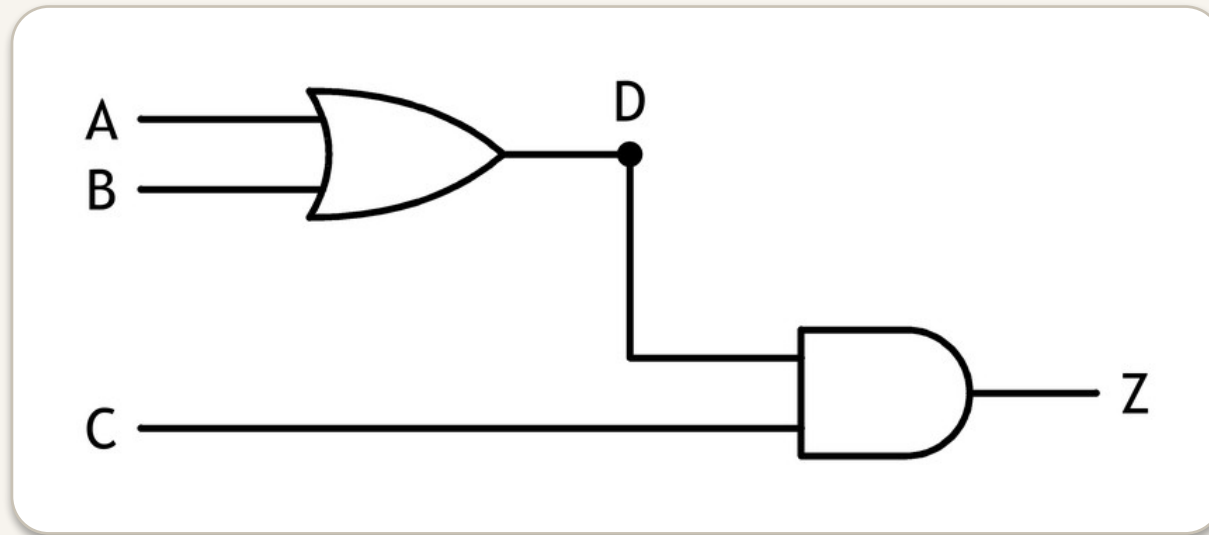
Complete the truth table for circuits (a) and (b).
Fill in the middle column D before you touch Z.

TASK 2 – Complete the truth tables



TASK 2 (a) – Answers

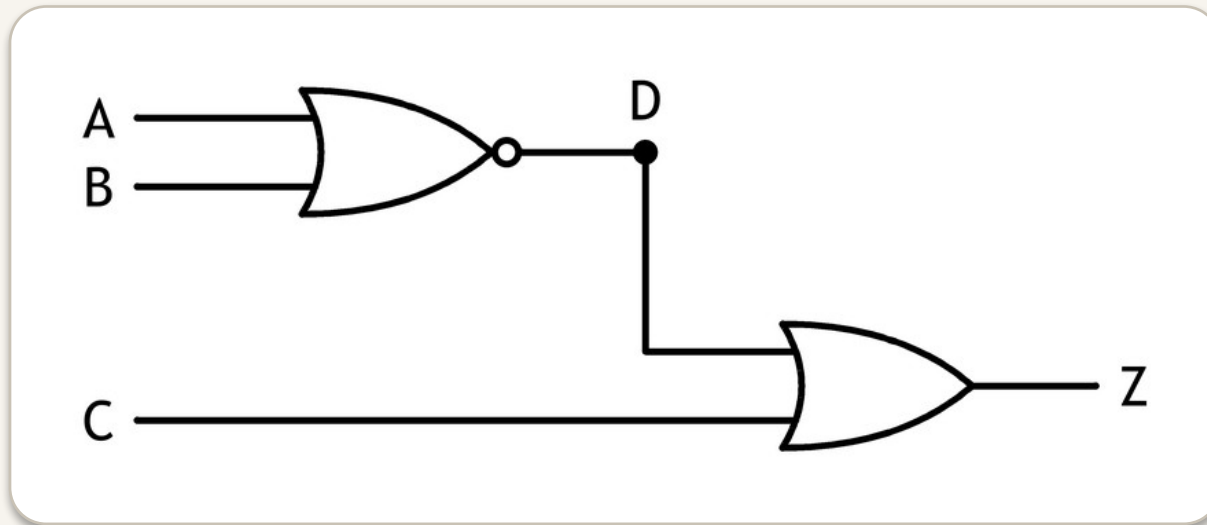
An OR gate, then an AND gate.



A	B	C	D	Z
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	0
1	1	1	1	1

TASK 2 (b) – Answers

A NOR gate, then an OR gate.



A	B	C	D	Z
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

PERIOD 2 STARTS HERE

NAND and NOR

Two gates that are easier to work out backwards.

Daily Review

SHOW ME BOARDS

- 1 A circuit has three inputs. How many rows does its table need?
- 2 What is the middle column of a two-gate circuit usually called?
- 3 Which column do you fill in first?
- 4 An AND gate feeds an OR gate. When is D logic 1?
- 5 Why must the middle column be written down, not worked out in your head?

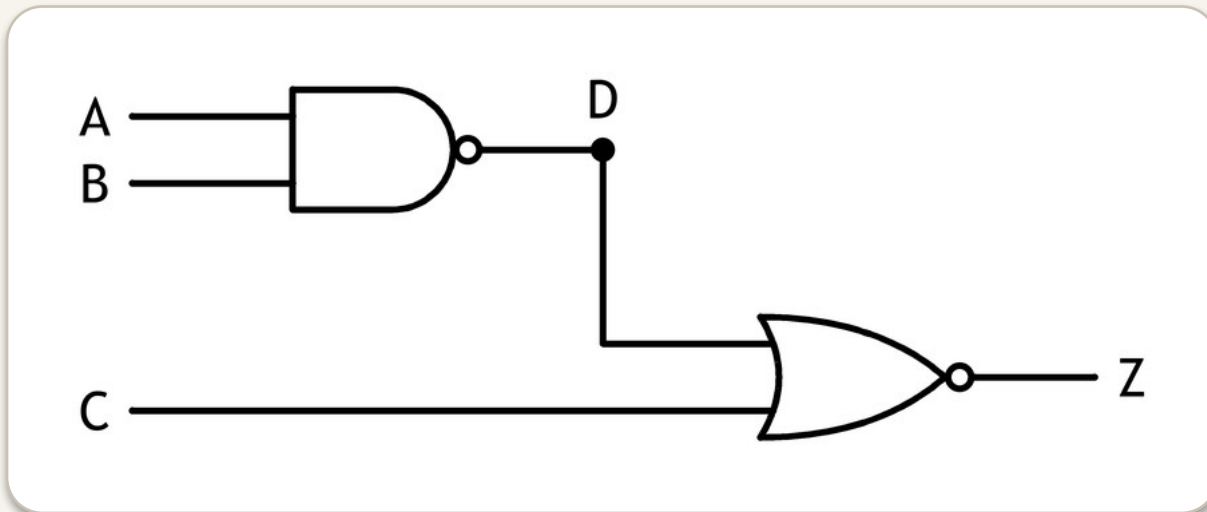
NAND and NOR: pretend, then invert

Booklet section 3 — 'Dealing with NAND and NOR gates'.

- Work out what a plain AND or OR would give.
- Write that in a pretend column, so the working shows.
- Then invert every row of it.
- Invert the ANSWER, never the inputs.

Worked example – the NAND

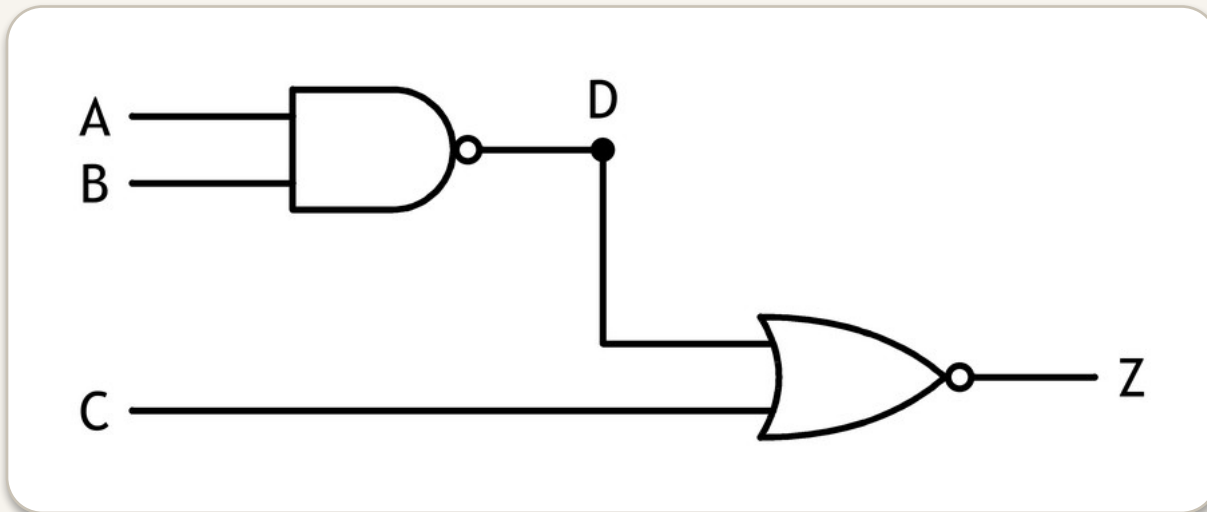
Pretend the NAND is an AND, then invert every row to get D.



A	B	C	A AND B	D
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	1	0
1	1	1	1	0

Worked example – the NOR

Pretend the NOR is an OR fed by C and D, then invert every row to get Z.



A	B	C	D	C OR D	Z
0	0	0	1	1	0
0	0	1	1	1	0
0	1	0	1	1	0
0	1	1	1	1	0
1	0	0	1	1	0
1	0	1	1	1	0
1	1	0	0	0	1
1	1	1	0	1	0

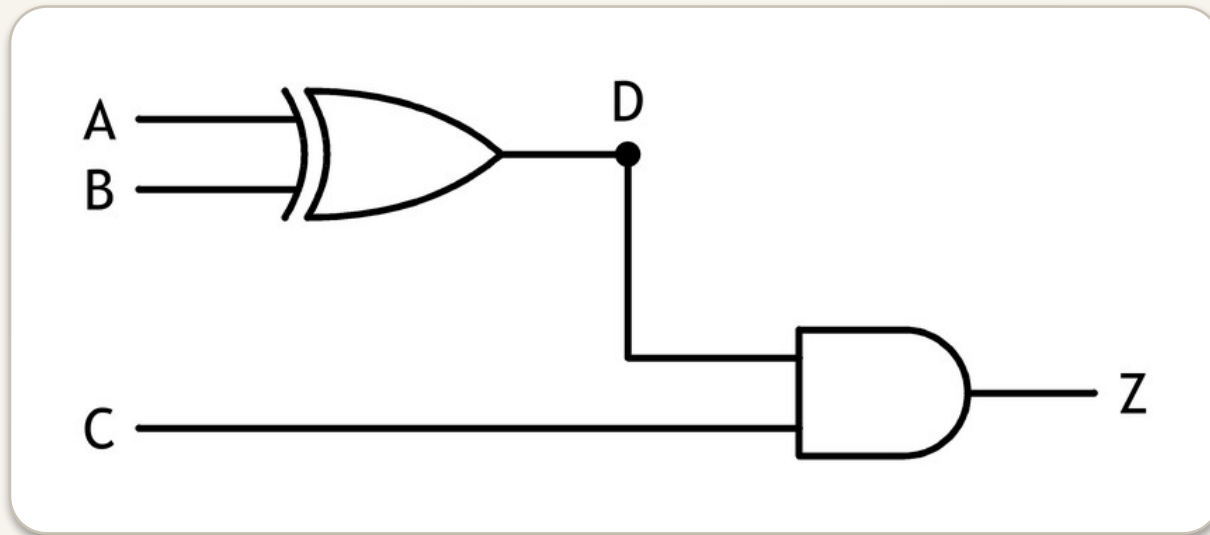
Your turn

Complete the truth tables for circuits (c) and (d).
Then build the section 3 worked example in Yenka.
Label point D on screen and test every combination.

TASK 2 (c) and (d) · PRACTICAL TASK 2

TASK 2 (c) – Answers

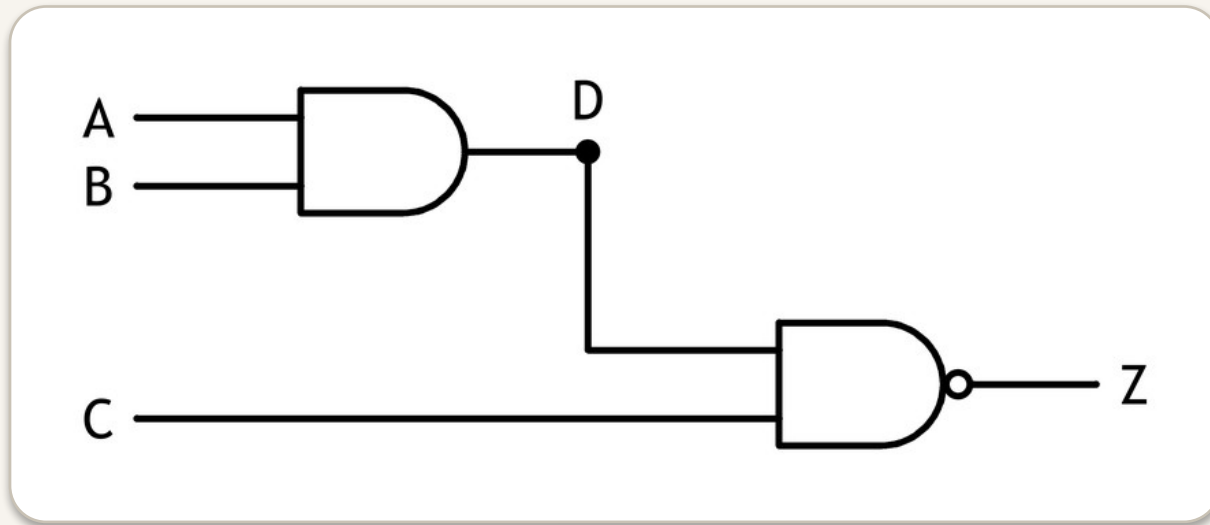
An XOR gate, then an AND gate.



A	B	C	D	Z
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	0	0	0
1	1	1	0	0

TASK 2 (d) – Answers

An AND gate, then a NAND gate.



A	B	C	D	Z
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	1	1
1	1	1	1	0

Watch Out

THE MISTAKE

- Work Z out in your head and leave D blank.
- For a NAND, invert the two inputs.
- Three inputs, so six rows.

THE CORRECT ANSWER

- Fill in D. A wrong D still earns the later marks.
- Work out the AND answer, then invert that.
- Each extra input doubles the rows: three gives eight.

Checkpoint

SHOW ME BOARDS

- 1 A circuit has four inputs. How many rows does its truth table need?
- 2 An AND feeds a NOR. Which column do you complete first, and why?
- 3 Describe how to work out the D column for a NOR gate.

Exam Practice

Complete-the-truth-table questions. Bring the paper; the questions are not reproduced here.

Paper	Question	Marks	What it asks
N5 2024	4 (c)	3	Three gates; columns D, E, Z
N5 2025	4 (c)	4	Four gates; columns D, E, F, Z
Specimen	4 (c)	4	Four gates; columns W, X, Y, Z

LOOKING AHEAD

The systems approach

Next: start from the problem, not the circuit — and design the gates yourself.

Plenary

SHOW ME BOARDS

- 1 How many rows for a three-input circuit?
- 2 What does the middle column D stand for?
- 3 An AND feeds an OR. On your board: the D column.
- 4 How do you work out a NAND column?
- 5 Why is the middle column worth writing down?

Plenary

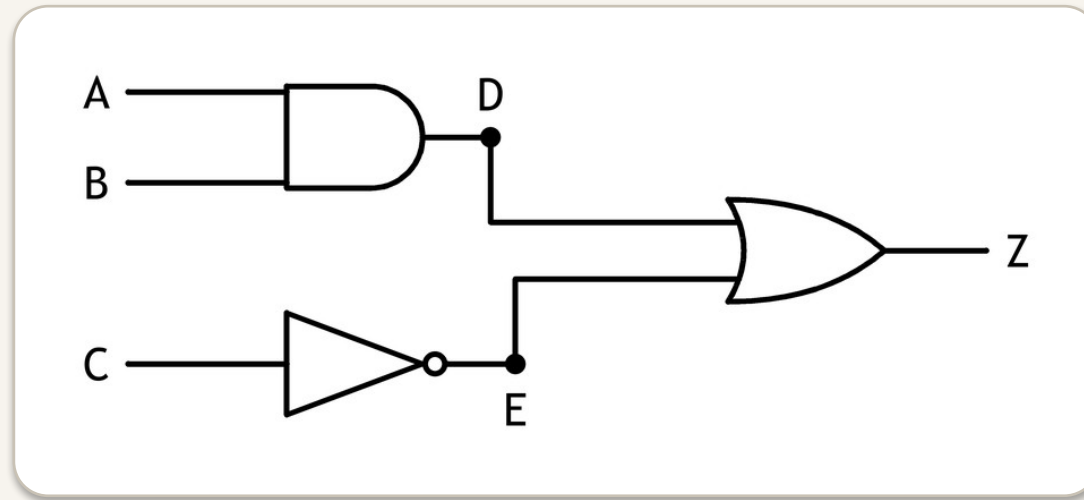
SHOW ME BOARDS

EXTRA PRACTICE

- 1 How many rows for a four-input circuit?
- 2 Which gate does the D column belong to?
- 3 An OR feeds an AND. On your board: the D column.
- 4 How do you work out a NOR column?
- 5 Name the two columns a two-gate circuit adds to A, B and C.

Extension

Three gates, and a middle column on each branch.



An AND and a NOT, both feeding an OR.

- Complete this truth table. You will need columns D and E.
- On how many of the eight rows is Z logic 0?

- 1 A circuit's output is 1 on every row. What has gone wrong?
- 2 Two NOT gates in a row feed an AND. What does the AND actually see?
- 3 Could one gate replace an AND followed by a NOT? Name it.