

Exercise walk-through

1.3

Logic gates and circuits

International Baccalaureate · IB Diploma · Computer Science · SL

Computing Systems · executable trace

- Trace the state changes and boundary guard.
- Run the boundary case and compare the printed output.

```
size_MB, rate_Mbps = 20, 10
bits = size_MB * 1_000_000 * 8
if rate_Mbps <= 0:
    raise ValueError("Rate must be positive")
seconds = bits / (rate_Mbps * 1_000_000)
print(seconds)
print(0 / (rate_Mbps * 1_000_000))
```

Exercises 2.1·2.2

2.1 Complete the truth table for $X = A \text{ NAND } B$. [2]

2.2 State the output of: (i) $1 \text{ XOR } 1$; (ii) $\text{NOT}(0 \text{ OR } 1)$; (iii) $(1 \text{ AND } 0) \text{ OR } 1$. [3]

Exercises 2.1-2.2

2.1 Complete the truth table for $X = A \text{ NAND } B$. [2]

2.1

- rows 00, 01, 10 give **1**
- row 11 gives **0**

2.2 State the output of: (i) $1 \text{ XOR } 1$; (ii) $\text{NOT}(0 \text{ OR } 1)$; (iii) $(1 \text{ AND } 0) \text{ OR } 1$. [3]

2.2

- (i) **0**
- (ii) $\text{NOT } 1 = \mathbf{0}$
- (iii) $0 \text{ OR } 1 = \mathbf{1}$

Exercise 2.3

2.3 A circuit gives $X = \text{NOT } A \text{ AND } B$. Complete its truth table.

[2]

Exercise 2.3

2.3 A circuit gives $X = \text{NOT } A \text{ AND } B$. Complete its truth table.

[2]

2.3

A	B	NOT A	X
0	0	1	0
0	1	1	1
1	0	0	0
1	1	0	0

- NOT A column
- X is 1 only for $A = 0$, $B = 1$

Exercises 3.1-3.2

3.1 Which gate gives 1 only when both inputs are 0?

[1]

☐

A AND

B NAND

C NOR

D XOR

3.2 How many rows does the truth table of a 4-input circuit have?

[1]

☐

A 4

B 8

C 12

D 16

Exercises 3.1-3.2

3.1 Which gate gives 1 only when both inputs are 0?

[1]

☐

A AND

B NAND

C NOR

D XOR

3.1 C

- NOR: NOT (A OR B)

3.2 How many rows does the truth table of a 4-input circuit have?

[1]

☐

A 4

B 8

C 12

D 16

3.2 D

- $2^4 = 16$

Exercise 3.3

3.3 For the circuit in the worked example, which inputs make $X = 0$?

[1]

☐

A whenever $C = 0$

B $C = 1$ and A, B not both 1

C $A = 1$ and $B = 1$

D never

Exercise 3.3

3.3 For the circuit in the worked example, which inputs make $X = 0$?

[1]

☐

A whenever $C = 0$

B $C = 1$ and A, B not both 1

C $A = 1$ and $B = 1$

D never

3.3 B

- $Q = 0$ needs $C = 1$, and $P = 0$ needs $A \text{ AND } B = 0$

Exercise 3.4 (a)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(a) Write a Boolean expression for F .

[2]

Exercise 3.4 (a)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(a) Write a Boolean expression for F .

[2]

(a)

- $F = (H \text{ AND NOT } D) \text{ OR } M$

Exercise 3.4 (b)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

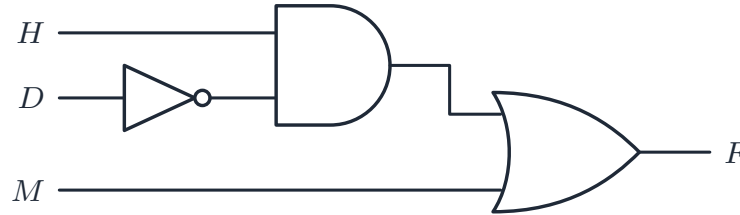
(b) Draw the logic circuit for your expression. [3]

Exercise 3.4 (b)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(b) Draw the logic circuit for your expression. [3]

(b)



- NOT gate on D
- AND gate with inputs H and NOT D
- OR gate with inputs the AND output and M , output F

Exercise 3.4 (c)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(c) Complete the truth table for F , with a column for each intermediate output. [4]

Exercise 3.4 (c)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(c) Complete the truth table for F , with a column for each intermediate output. [4]

(c)

H	D	M	NOT D	H AND NOT D	F
0	0	0	1	0	0
0	0	1	1	0	1
0	1	0	0	0	0
0	1	1	0	0	1
1	0	0	1	1	1
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	0	0	1

- 8 rows in binary order
- NOT D column
- AND column
- F column

Exercise 3.4 (d)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(d) State how many input combinations turn the fan on. [1]

Exercise 3.4 (d)

3.4 A greenhouse fan F must turn on when it is hot ($H = 1$) and the door is closed ($D = 0$), or when the humidity is high ($M = 1$).

(d) State how many input combinations turn the fan on. [1]

(d)

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