Electronics

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Electronics

Semiconductor Diodes

A **diode** is made from a semiconductor material (silicon or germanium) with a junction that allows current to flow in only one direction:

- **Forward-biased:** positive terminal connected to the p-type side, current flows.
- **Reverse-biased:** positive terminal connected to the n-type side, current is blocked.

The I-V characteristic of a diode is non-ohmic. Forward current rises sharply after a small threshold voltage (~0.6 V for silicon). In reverse, only a tiny leakage current flows until breakdown voltage is reached.

Half-Wave Rectification (revisited)

A single diode in series with an AC supply produces a half-wave rectified output, only positive half-cycles pass. This converts AC to a pulsating DC suitable for further filtering.

<ThemedImage

srcLight="/media/physics/electronics-rectification-light.png"

srcDark="/media/physics/electronics-rectification-dark.png"

alt="Half-wave rectification circuit: an AC supply connected in series with a diode (D) and a load resistor (R). The diode allows current through only during positive half-cycles, blocking the negative half-cycles."

caption="Half-wave rectification: the diode blocks reverse current, so only positive half-cycles reach the load resistor."

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Logic Gates

Logic gates are electronic switches with one or more binary inputs and one output. Each input and output is either **0** (low voltage, ~0 V) or **1** (high voltage, e.g. 5 V).

The Five Basic Gates

<ThemedImage

srcLight="/media/physics/electronics-gates-light.png"

srcDark="/media/physics/electronics-gates-dark.png"

alt="Standard logic gate symbols for NOT, AND, OR, NAND, and NOR gates arranged in a row, each labelled with its name"

caption="Standard logic gate symbols. NAND and NOR are AND and OR with an invert bubble on the output."

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NOT gate (inverter): One input, one output. The output is the opposite of the input.

A	Output
0	1
1	0

AND gate: Output is 1 only when **all** inputs are 1.

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

OR gate: Output is 1 when **at least one** input is 1.

A	B	Output
0	0	0
0	1	1
1	0	1

1	1	1

NAND gate: AND followed by NOT. Output is 0 **only** when all inputs are 1 (otherwise 1).

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

NOR gate: OR followed by NOT. Output is 1 **only** when all inputs are 0.

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

Combining Gates

Gates can be wired together to implement any logical function. To find the output for a combination circuit:

- 1. Identify the inputs to each gate.
- 2. Work left to right, computing each gate's output in turn.
- 3. The final gate's output is the circuit output.

Logic gate circuit (2023 Paper 02, Q5)

From 2023 Paper 02, the gate represented by a symbol with one input and one output (inverting output) is the **NOT gate** (single-input gate whose output is the complement of the input).

The truth table with one input:

Input	Output
0	1
1	0

identifies the **NOT gate**.

For a NAND gate (2019 Paper 02):

A	B	NAND output
0	0	1
0	1	1
1	0	1
1	1	0

Societal Impact of Electronics

The development of integrated circuits (microchips containing millions of logic gates) has transformed society:

- **Healthcare:** digital medical equipment, patient monitoring, diagnostic imaging
- **Communications:** smartphones, internet, global telecommunications
- **Industry:** computer-controlled manufacturing, robotics
- **Education:** computers, tablets, e-learning
- **Caribbean relevance:** financial services, tourism booking systems, weather monitoring

Benefits include access to information, improved healthcare, and economic efficiency. Concerns include electronic waste (e-waste), security and privacy risks, and dependence on technology.

📝 Exam Tip

Memorise the NAND truth table: it is the complement of AND, only the 1,1 input combination gives output 0. Similarly, NOR is the complement of OR, only the 0,0 input gives output 1.

For combination circuit truth tables: work gate by gate, computing all intermediate outputs for each row before moving to the next gate. Label each intermediate node.