## AND as an electrical circuit

A circuit with a battery, two simple switches, and a light.

The light only lights if both switches are closed.

Open corresponds to false and closed corresponds to true.

## AND as a water circuit

Water flowing through a pipe with two force-controlled switches. If there's force on both switches, the water flows at the output.

## OR as an electrical circuit

Two parallel switches in circuit with a battery and a light.

The light lights if either switch is (or both are) closed.

Similar for a water circuit.

## NOT as an electrical circuit

A switch and resistor pair in parallel with a light. By managing the resistance ratio of the resistor and the light, closing the switch can be made to turn the light off.

## NOT as a water circuit

A switch that blocks the flow of water when force is applied.

AND, OR, and NOT are *basic* gates, meaning all functions can be made from combinations of those gates.

They form a *fundamental set*.

As well as these, there are other gates which are convenient to have. These are often pre-built using NOT, AND, and OR gates.

## NAND

This is the result of applying NOT to the output of AND.

|  |  |  |
| --- | --- | --- |
| A | B | A NAND B |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Algebraically: A.B (with a bar over all of it)

Circuit symbol: =Do—

## NOR

NOT(OR)

|  |  |  |
| --- | --- | --- |
| A | B | A NOR B |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

Algebraically: A+B (with a bar over all of it)

Circuit symbol: =)>o—

There are two more useful gates:

## Exclusive OR

|  |  |  |
| --- | --- | --- |
| A | B | A XOR B |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

Have seen the algebraic and circuit symbols for this already.

## Exclusive NOR (NOT(XOR))

|  |  |  |
| --- | --- | --- |
| A | B | A XNOR B |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Also called COIN for coincident.

## Making XOR from AND, OR, and NOT

(A.B')+(A'.B)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| A | B | A' | B' | A.B' | B.A' | OR |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 |

This truth table is an exhaustive proof of (A.B')+(A'.B) = AXORB

This tabulation method is called perfect induction because it lists all possibilities and all results.