PDST

Professional Development Service for Teachers | An tSeirbhís um Fhorbairt Ghairmiúil do Mhúinteoirí

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An Roinn Oideachais
Department of Education

NW4 Session 3

Computer systems 3

LEAVING CERTIFICATE COMPUTER SCIENCE

Session Overview

Section 1	Basic Electronics
Section 2	Logic Gates
Section 3	Group Activity

Section I

Basic electronics

By the end of this session participants will have:

- gained a deeper understanding of computer systems concepts and terminology including basic electronics, logic gates and circuits, truth tables, and computer components
- taken part in and reflected upon an half-adder activity
- acquired additional knowledge and ideas on how they will facilitate the learning of computer systems in their own classrooms

Context

Strand 1: Practices and principles	Strand 2: Core concepts	Strand 3: Computer science in practice
Computers and society	Abstraction	Applied learning task 1 - Interactive information systems
Computational thinking	Algorithms	Applied learning task 2 - Analytics
Design and development	Computer systems	Applied learning task 3 - Modelling and simulation
	Data	Applied learning task 4 - Embedded systems
	Evaluation/Testing	

"The core concepts are developed theoretically and applied practically. In this way, conceptual classroom-based learning is intertwined with experimental computer lab-based learning throughout the two years of the course."

NCCA Curriculum specification, Page 20

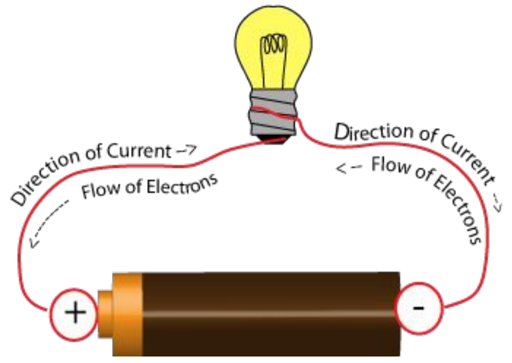
LCCS Learning Outcomes

S2: Computer systems	
CPU: ALU, Registers, Program counter, Memory	2.11 describe the different components within a computer and the function of those components
Basic electronics: voltage, current, resistors, capacitors, transistors	2.12 describe the different types of logic gates **and explain how they can be arranged into larger units to perform more complex tasks**

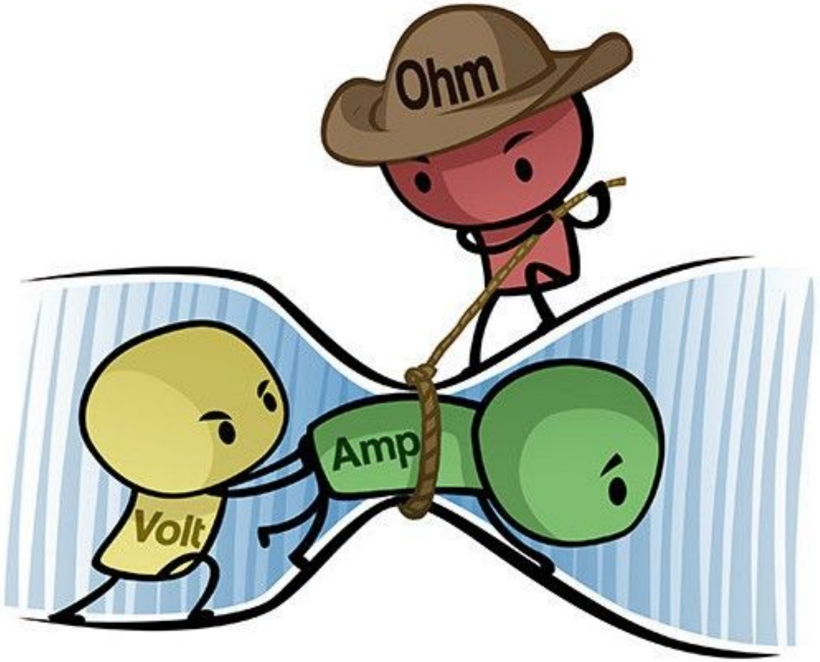
Students learn about:	Students should be able to:
Embedded systems	3.11 use and control digital inputs and outputs within an embedded system
Computing inputs and outputs	3.12 measure and store data returned from an analogue input
Computer systems	3.13 develop a program that utilises digital and analogue inputs
Design process	3.14 design automated applications using embedded systems

Current, Voltage and Resistance

Current is the flow of electrons.
Voltage describes the “pressure” that pushes electrons.
Resistance is something that resists the flow of electrons.



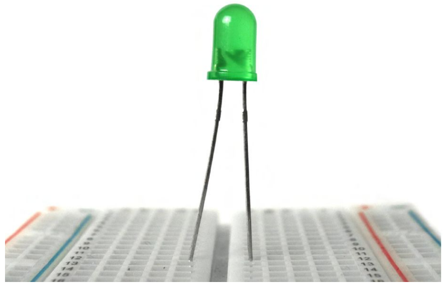
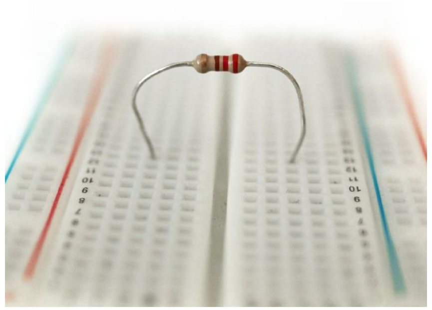
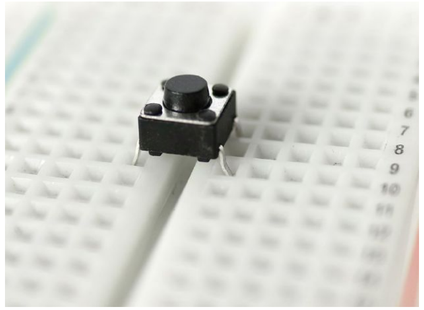
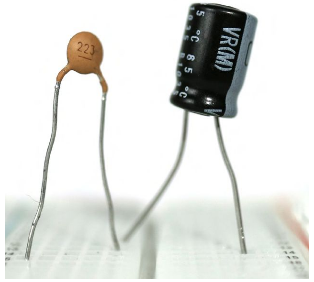
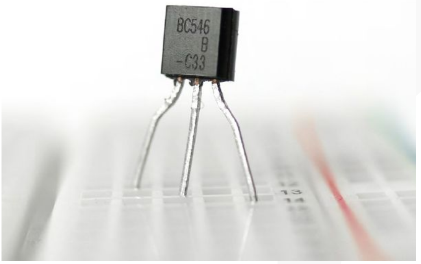
Current is measured in Amperes or A
Voltage is measured in Volts or V
Resistance is measured in Ohms or Ω

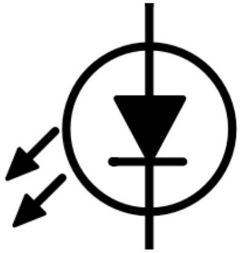
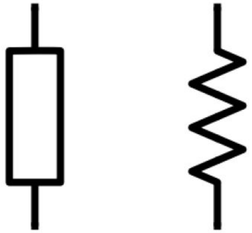
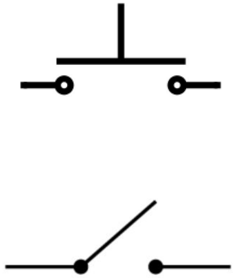
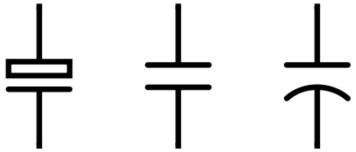
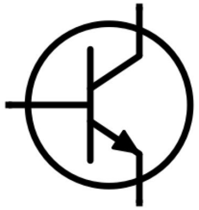


buildelectroniccircuits

https://www.build-electronic-circuits.com/

Electrical components

Light Emitting Diode (LED)

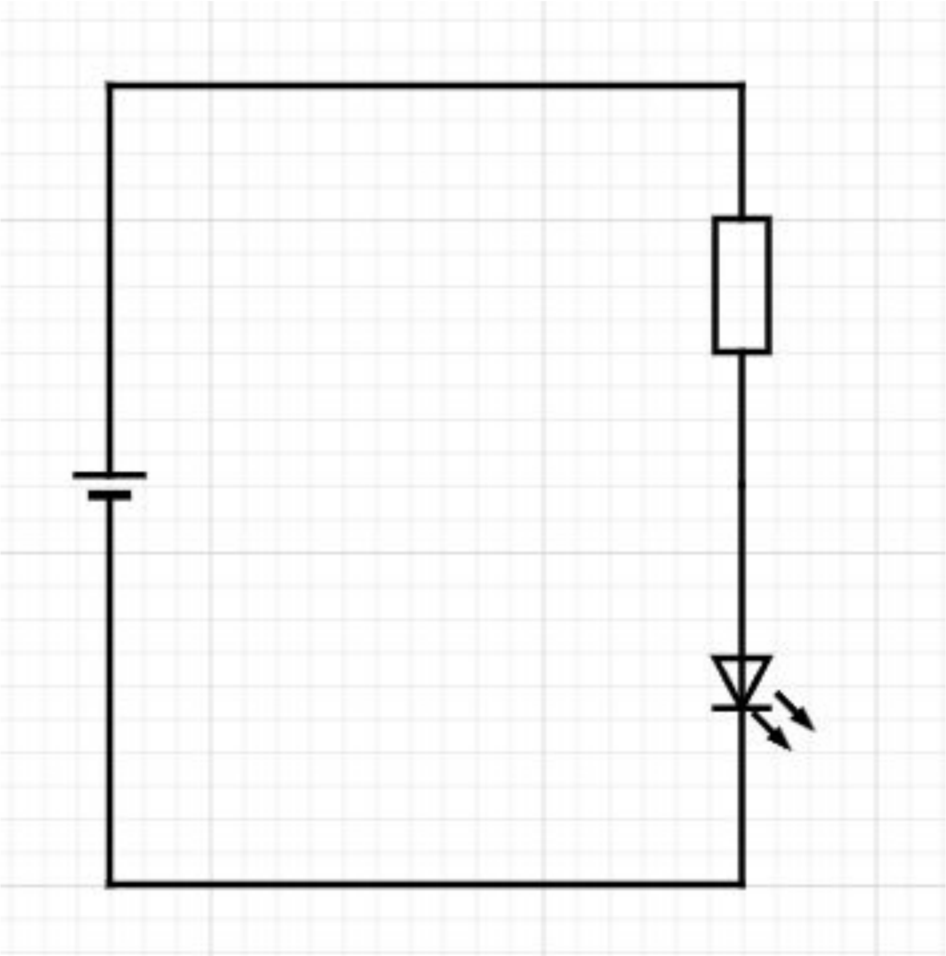
Resistor

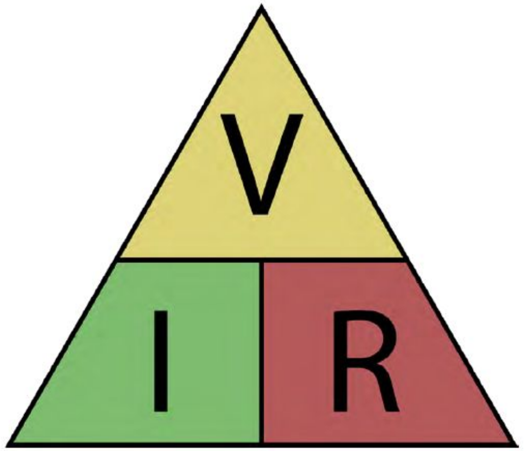
Switch

Capacitor

Transistor

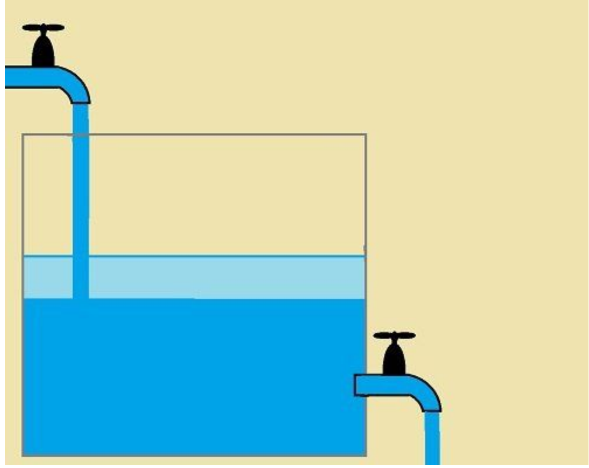
Circuit schematic

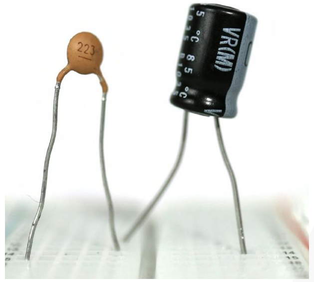


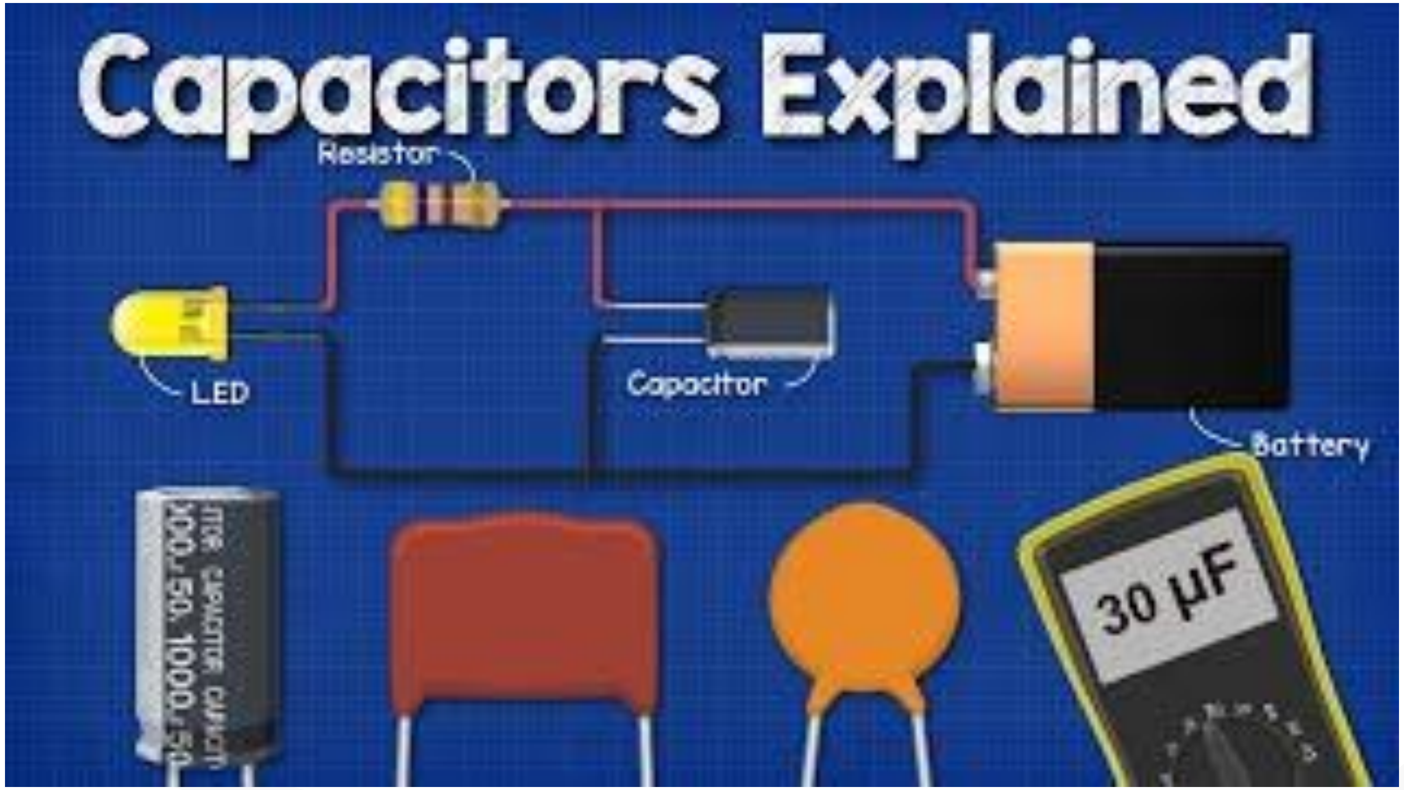


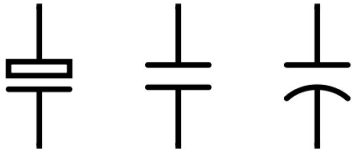
$V = IR$

Capacitors



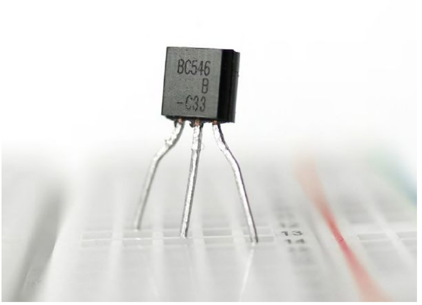


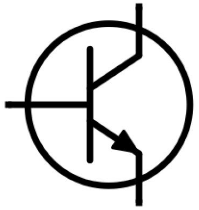


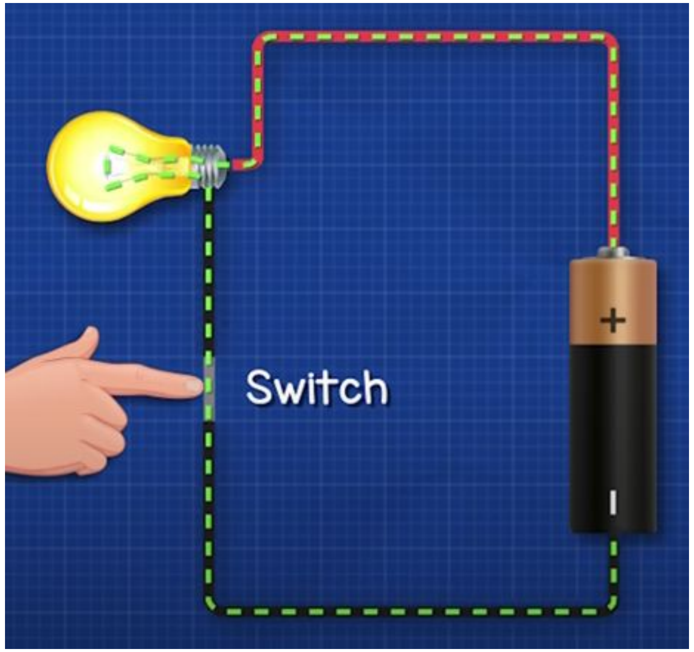


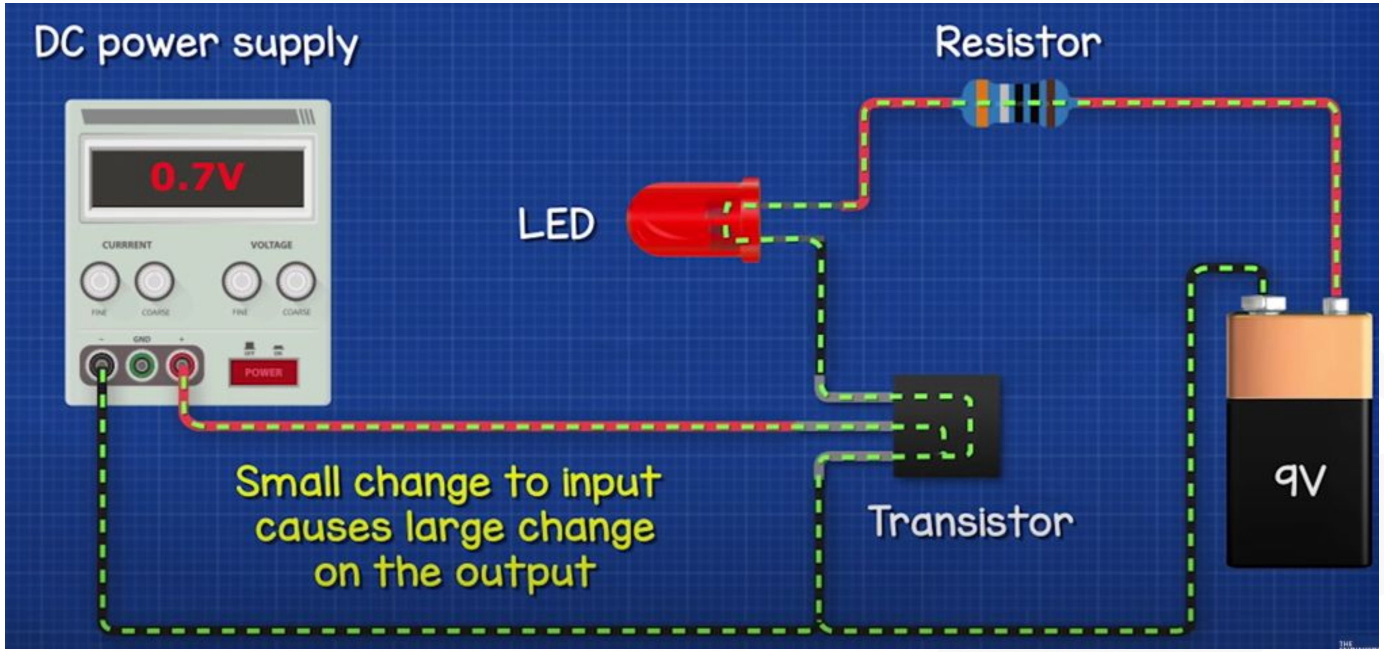
https://www.youtube.com/watch?v=X4EUwTwZ110

Transistors



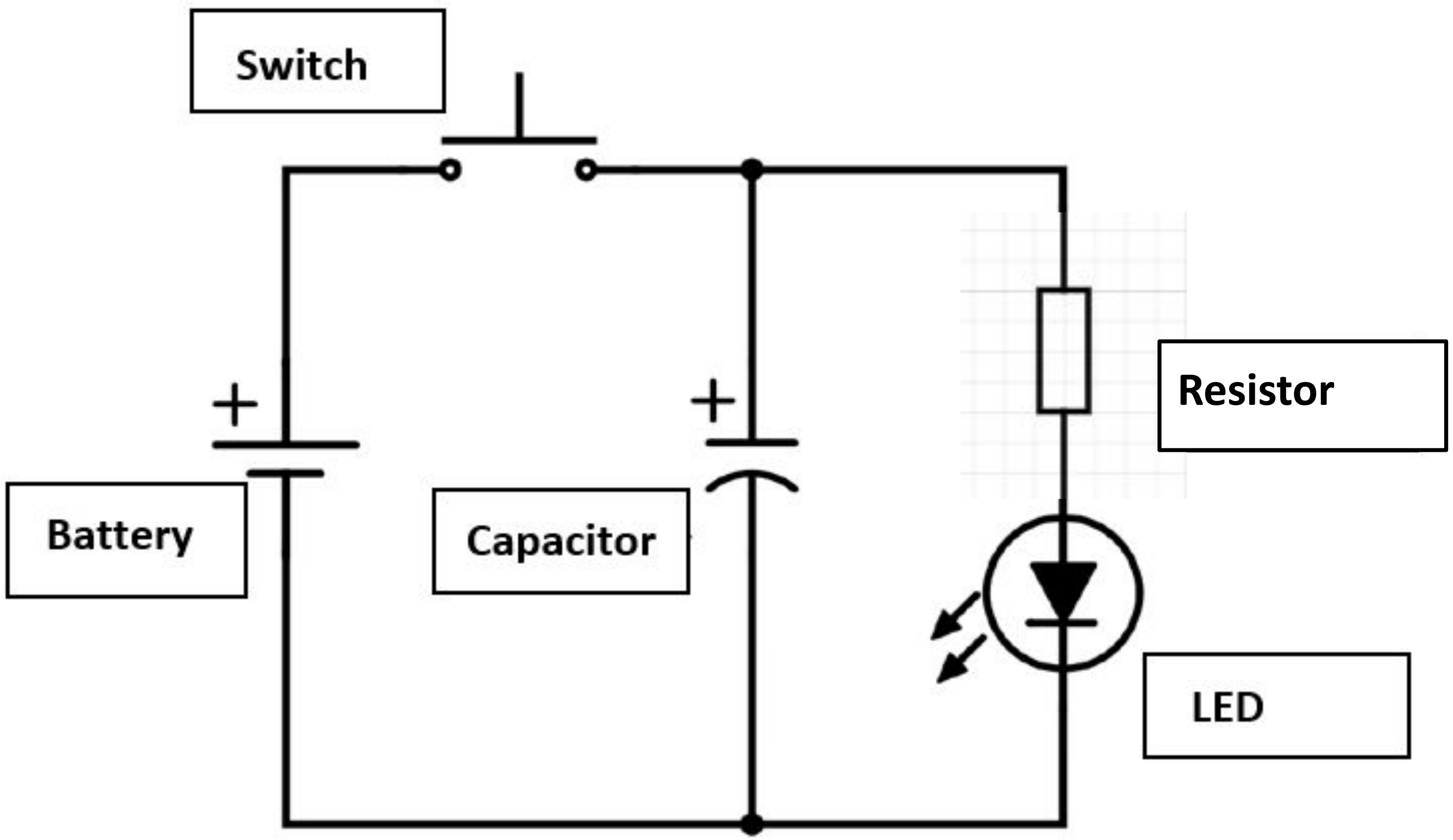


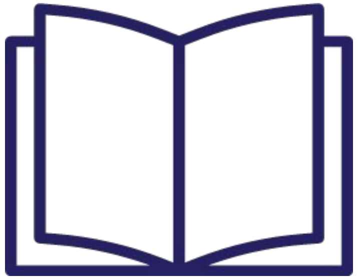




https://youtu.be/J4oO7PT_nzQ

Capacitor in a circuit





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Activity - Think Pair Share

Think

Participants spend time in silence writing or thinking about their own ideas

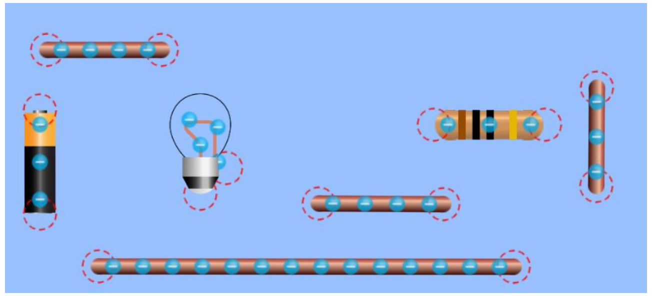
Pair

Participants turn to the person beside them to discuss their ideas

Share

Pairs share their answers with other pairs (square) or the wider group

Circuit with Resistor



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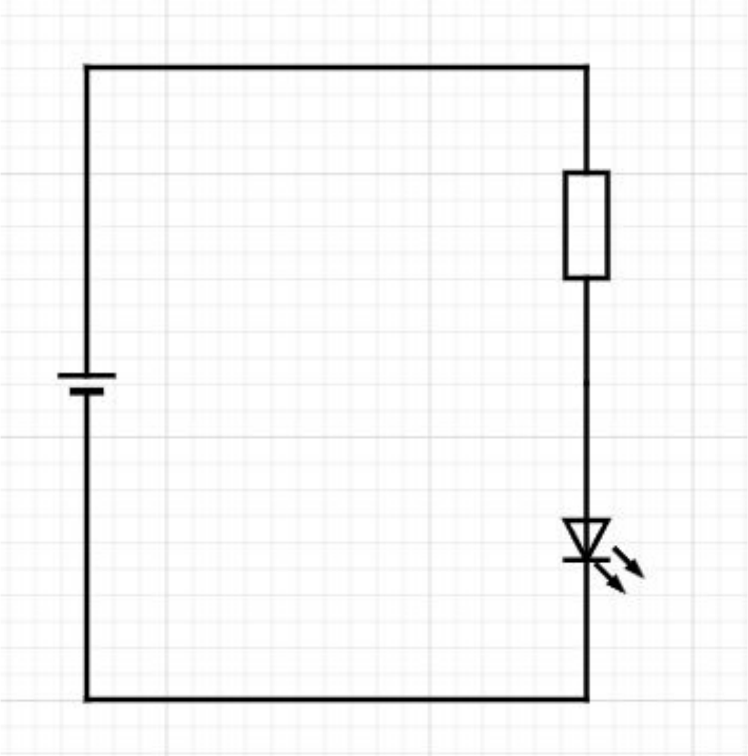
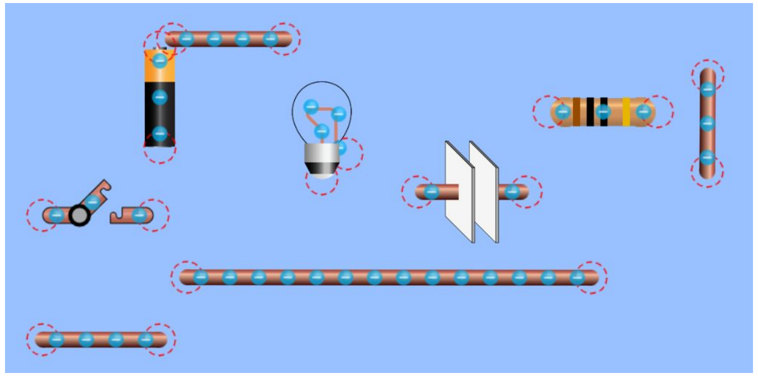
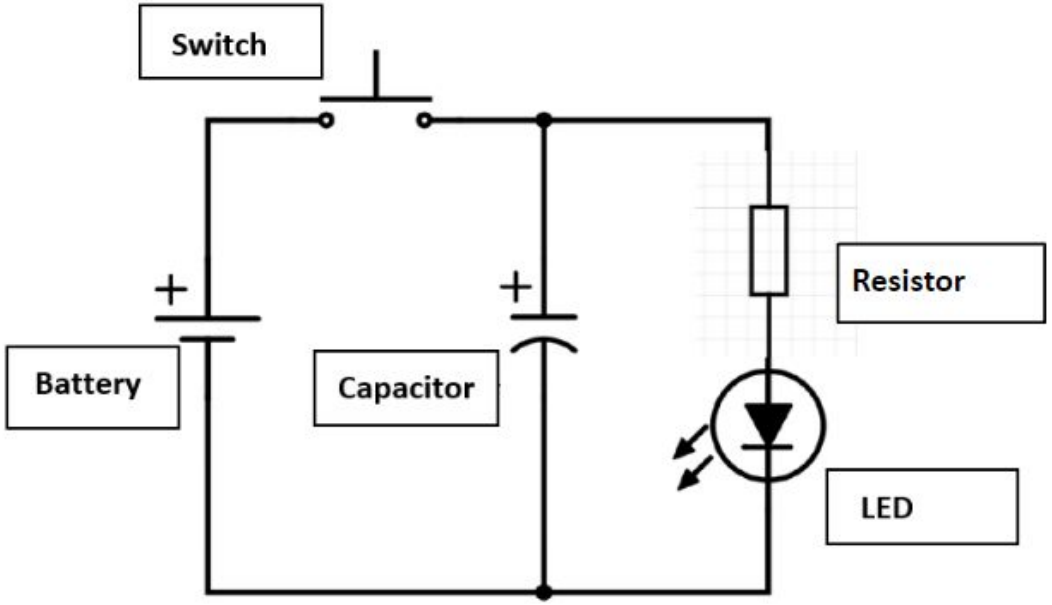


- *Given the components (Battery, wires, light bulb, resistor) build the circuit so the light bulb turns on*
- *What do you notice about the direction of flow of electrons vs the direction of flow of the current?*
- *Change the value of the resistor.*
  - *What do you notice about the current?*
  - *What do you notice about the light?*
- *Add a switch into the circuit. What do you notice if you open or close the switch?*

Circuit with Capacitor



https://phet.colorado.edu/sims/html/circuit-construction-kit-ac-virtual-lab/latest/circuit-construction-kit-ac-virtual-lab_en.html



- *Add a capacitor into the circuit and build the circuit.*
- *What do you notice about the position of the capacitor?*
- *What happens if you close the switch?*
- *What happens if you open the switch?*
- *Place the capacitor in series what do you notice?*
- *Change the display on the simulation to show the circuit diagram or schematic instead.*

Layers of a Computing System

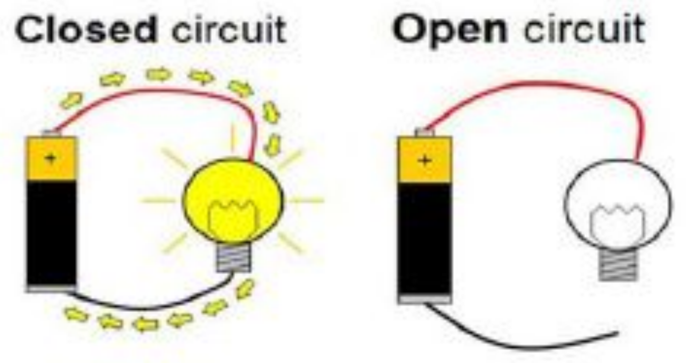
- End-user
- Application Software
- System Software
- Computer Components
- Electronics, Gates and Circuits
- Data Representation

Logic Gates

Logic Gates

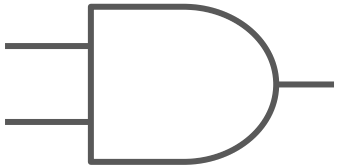
A gate is a device that performs a logical operation on electrical signals
These electrical signals are represented by bits (BInary digiTS) 0 (0V) or 1 (5V)
The logical operations were defined by the mathematician George Boole (1815-64)
The most common logic (Boolean) operations are:

NOT	XOR
AND	NAND
OR	NOR

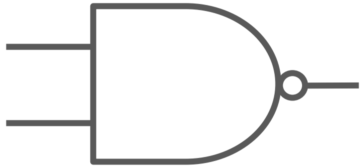


Logic Gate Symbols

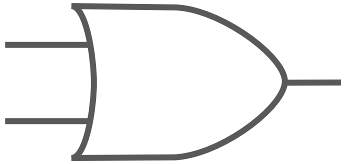
Logic gates have one or more inputs and a single output
Each gate has its own logic symbol which allows circuits to be represented by a logic diagram



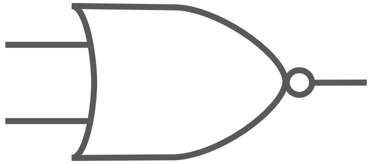
AND



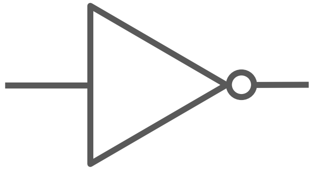
NAND



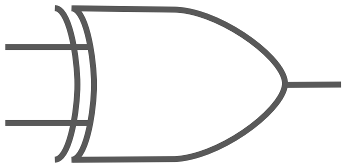
OR



NOR



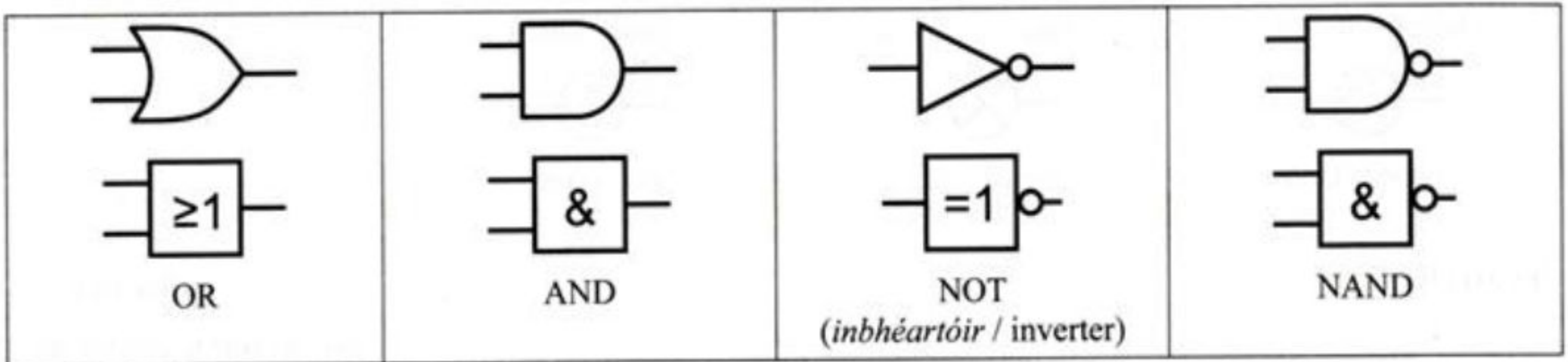
NOT

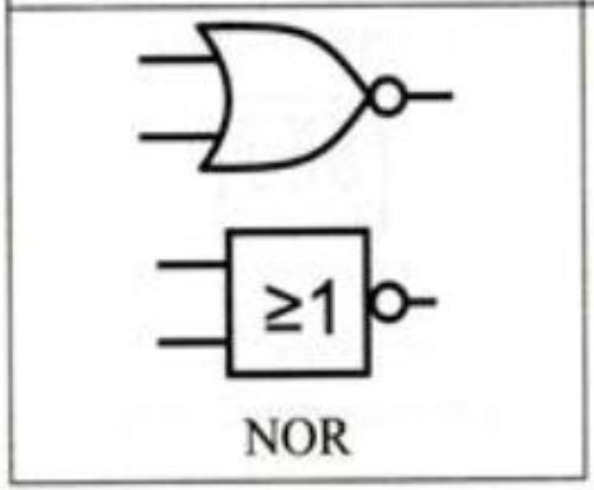


Exclusive OR (XOR)

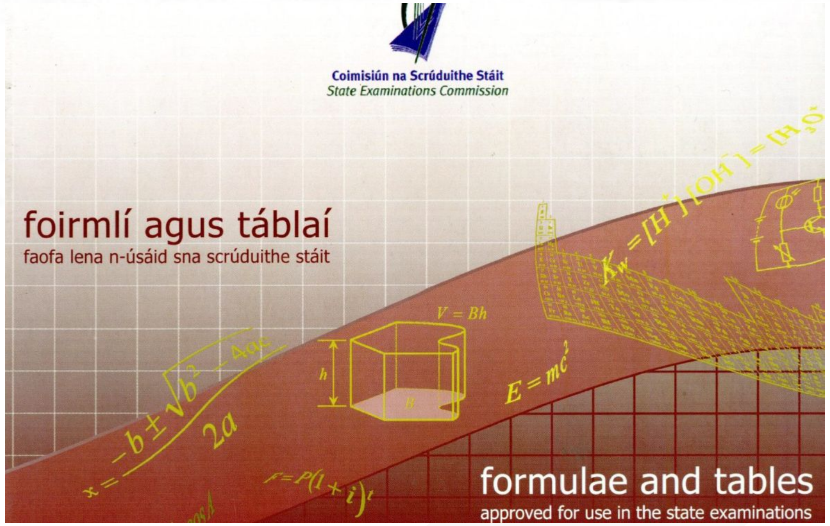
Geataí loighce

Logic gates





Page 78 Formula and Tables book



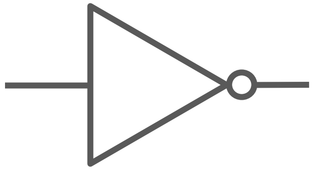
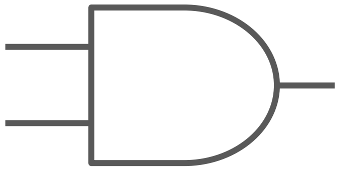
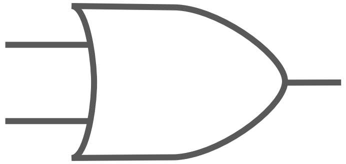
Logic Diagrams, Truth tables and Boolean Expressions

The behaviour of gates (and circuits) are commonly represented in any of the following ways:

Boolean Expressions
Uses Boolean algebra, a mathematical notation for expressing two-valued logic

Truth Tables
A table showing all possible input values and the associated output value

Logic Diagrams
A graphical representation of a circuit; each gate has its own symbol

	Operator	Boolean
	NOT	$\overline{A}$
	AND	A.B
	OR	A + B

The NOT operation

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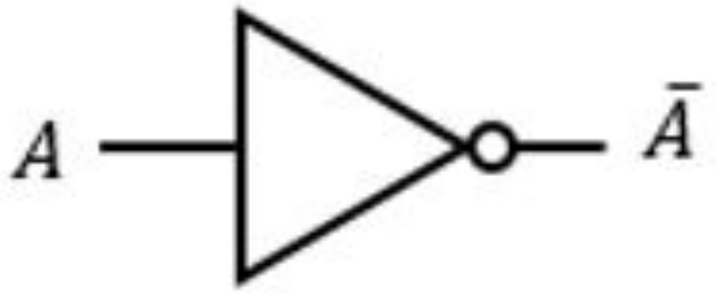


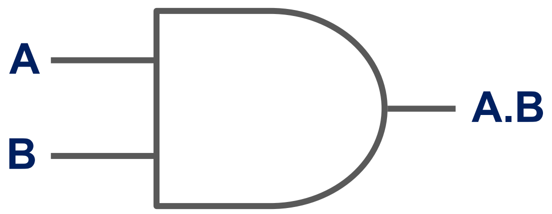
Logic Gate Symbol

A	$\bar{A}$
0	1
1	0

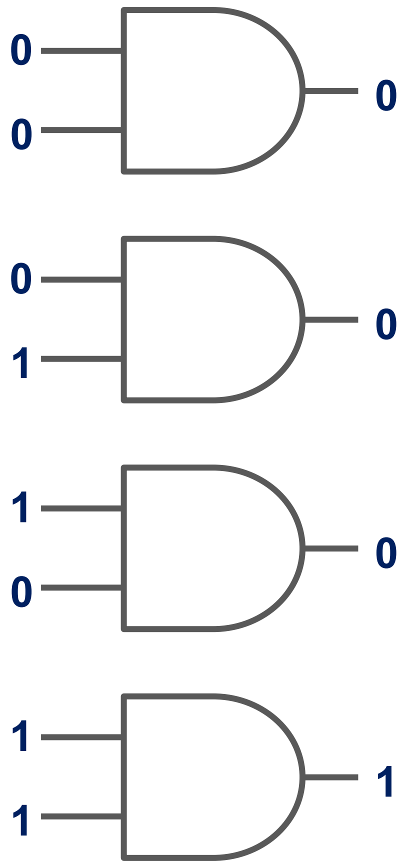
Truth Table

Inverts a single input. Also called an *inverter*.

The AND operation



Logic Gate Symbol

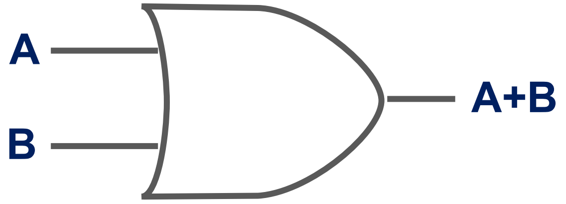


A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

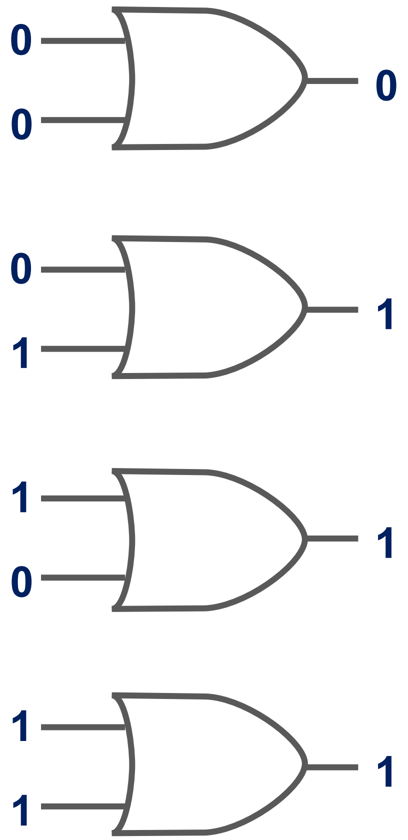
Truth Table

In order for the output to be 1 both inputs must be 1

The OR operation



Logic Gate Symbol

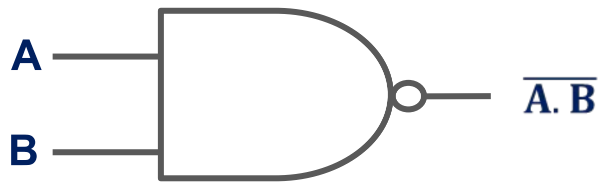


A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table

In order for the output to be 1 either input must be 1

The NAND operation



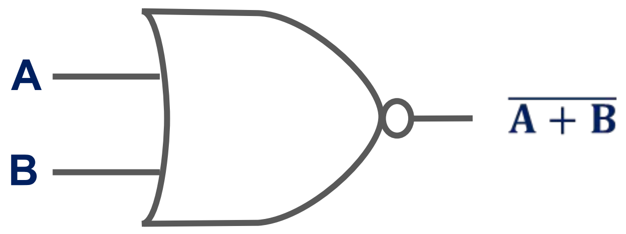
Logic Gate Symbol

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

Truth Table

The output is 1 if either input is 0

The NOR operation



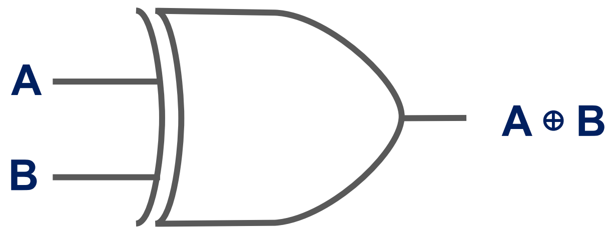
Logic Gate Symbol

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

Truth Table

The output is 1 if both inputs are 0

The XOR operation



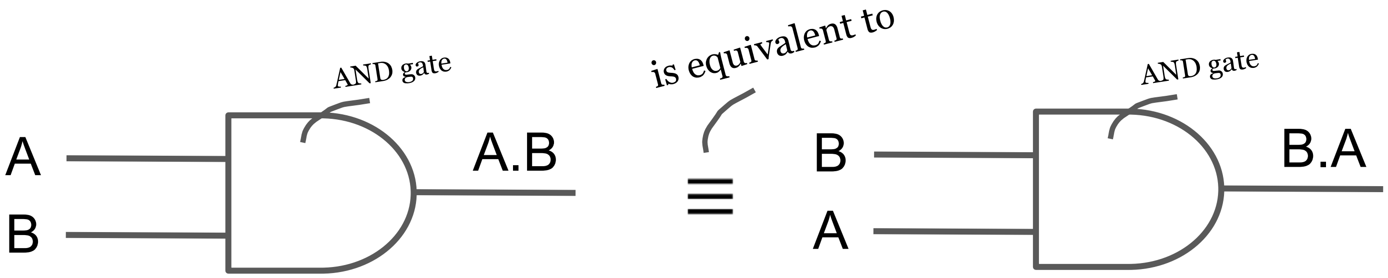
Logic Gate Symbol

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

Truth Table

The output is 1 if both inputs are different

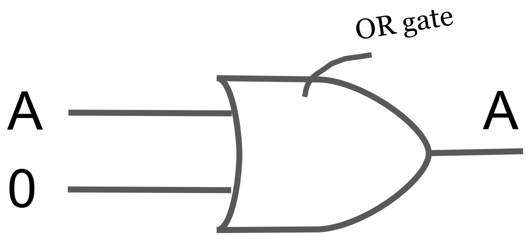
Boolean Algebra



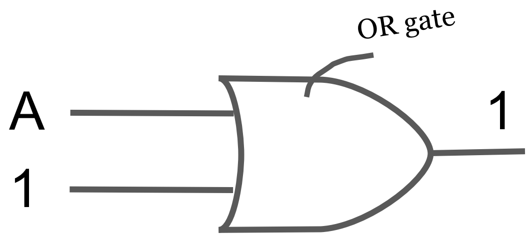
The logical `AND` operation is **commutative**

Law	AND	OR
Commutative	$A.B = B.A$	$A + B = B + A$
Associative	$A.(B.C) = (A.B).C$	$A + (B + C) = (A + B) + C$
Absorption	$A.(A + B) = A$	$A + (A.B) = A$
Distributive	$A.(B + C) = (A.B) + (B.C)$	$A + (B.C) = (A + B).(B + C)$
De Morgan's Law	$\overline{A.B} = \bar{A} + \bar{B}$	$\overline{A + B} = \bar{A}.\bar{B}$

Boolean Algebra

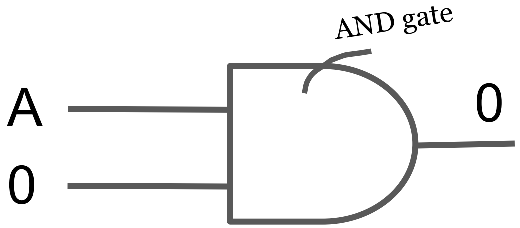


A variable ORed with 0 always gives the variable

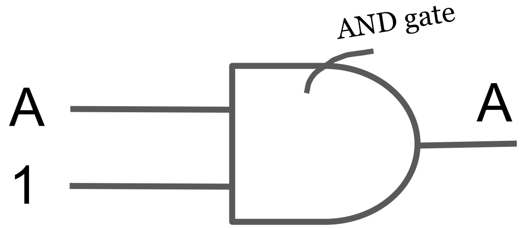


When a variable is ORed with 1 the output is always 1

1. $A + 0 = A$	7. $A \cdot A = A$
2. $A + 1 = 1$	8. $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	9. $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	10. $A + AB = A$
5. $A + A = A$	11. $A + \overline{A}B = A + B$
6. $A + \overline{A} = 1$	12. $(A + B)(A + C) = A + BC$



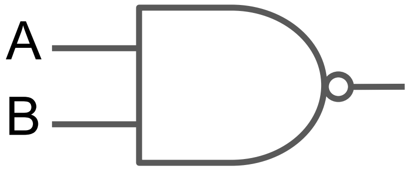
When a variable is ANDed with 0 the output is always 0.



Here we can see that when a variable is ANDed with 1 the output is always the variable

Using truth tables to verify identities

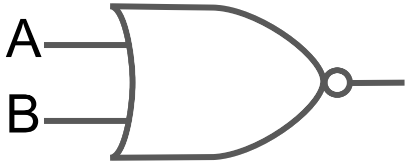
$$\overline{A.B} = \bar{A} + \bar{B}$$



A NAND B

A	B	$A.B$	$\overline{A.B}$	$\bar{A}$	$\bar{B}$	$\bar{A}+\bar{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

$$\overline{A+B} = \bar{A}.\bar{B}$$



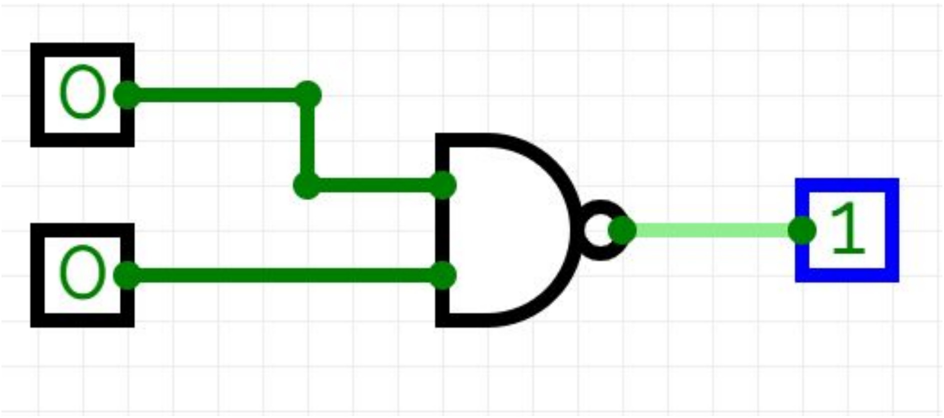
A NOR B

A	B	$A+B$	$\overline{A+B}$	$\bar{A}$	$\bar{B}$	$\bar{A}.\bar{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

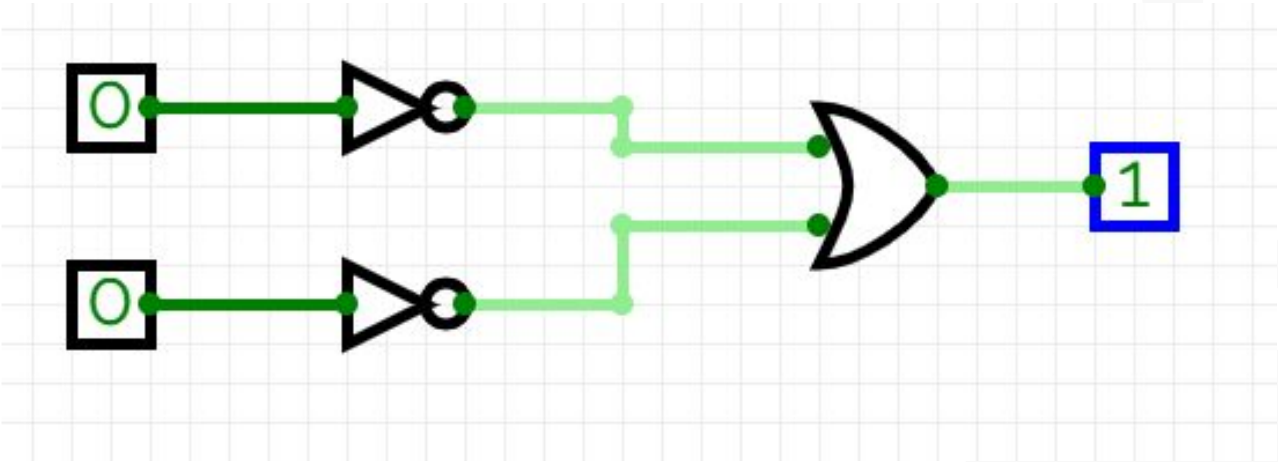
Using Logic Gates to verify identities

$$\overline{A.B} = \bar{A} + \bar{B}$$

$\overline{A.B}$



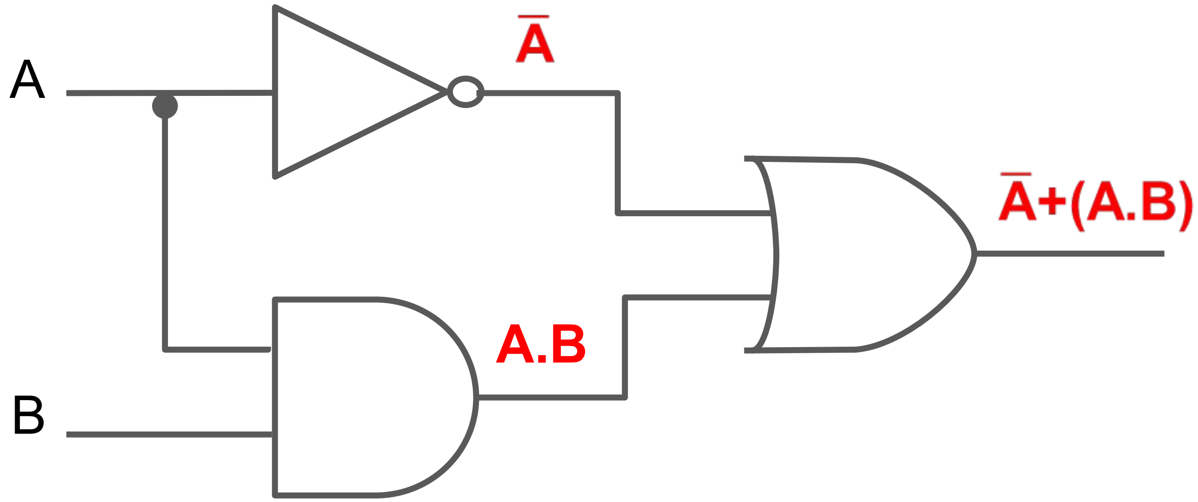
$\bar{A} + \bar{B}$



CircuitVerse https://circuitverse.org/

Connecting Logic Gates

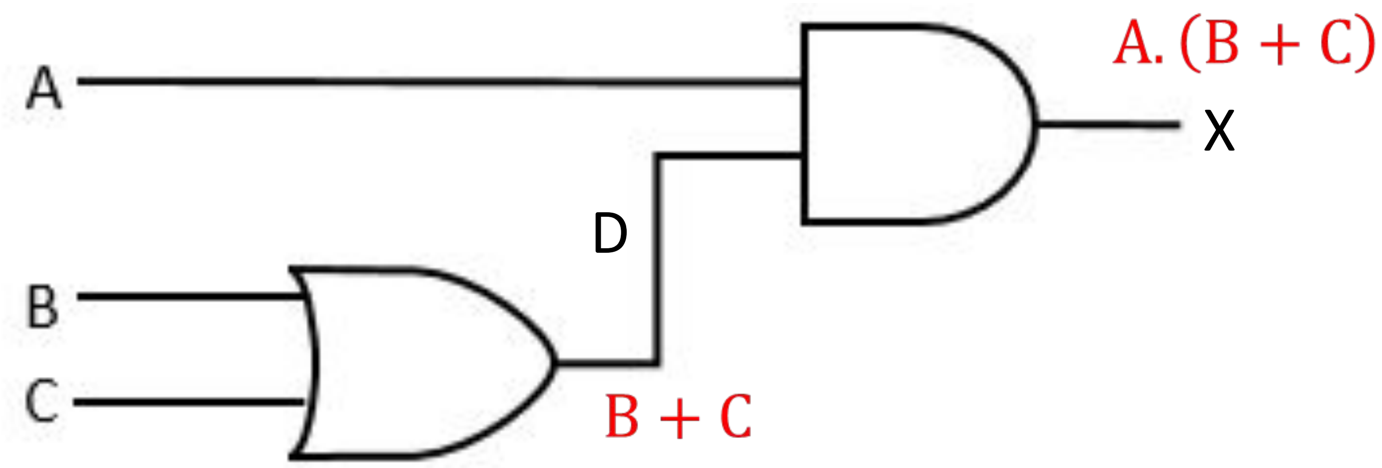
Logic gates may be combined by using the output of one gate as the input to another.



Work progressively from the inputs to the output …adding logic expressions to the output of each gate in turn

Connecting Logic Gates to create circuits

Consider this circuit used to model a burglar alarm. Once the alarm is ON (input A) then either a PIR sensor (input B) or a sound sensor (PIR B) can trigger the alarm.



A	B	C	D	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

What about a truth table for the above circuit?

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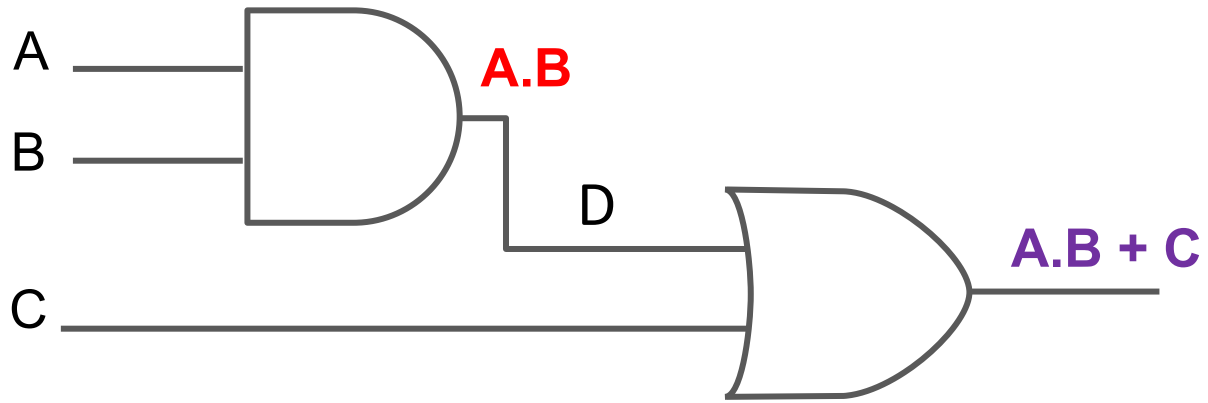
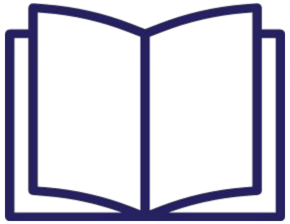
Connect Logic Gates (to create circuits)

Consider this circuit used to model a smart light. The light comes on if it is dark (input A) and it detects motion (input B) or it is switched on manually (C).



A	B	C	D	X
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



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Group Activity

In your groups, allocate the following tasks (one task per person preferably):

- build the logic gate circuitry with pen & paper
- build the logic gate circuitry using CircuitVerse software
- write the boolean expressions
- write the python code

Present your findings to the other groups.

Group Task

Task :Design a Half-Adder
(NCCA booklet p23)

Design your own half-adder in some language you have learned, for example Python or Scratch

INPUTS		OUTPUT	
A	B	Sum (S)	Carry (C)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

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