Logic Gate

College of
Engineering & Technology

Al-Mustaqbal
University

Level 1 , Semester 1
@ Department of prosthetic and orthotic Engineering

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Course Overview & Basic Concepts

The majority of this course material is based on text and presentations of :

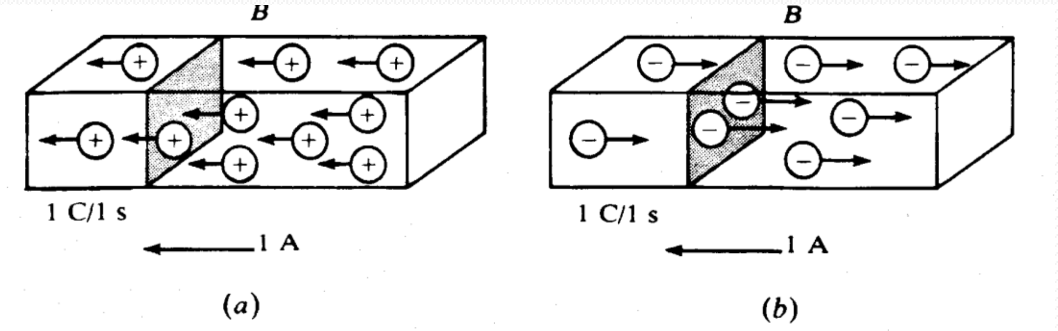
Outline

- **Glimpse from Electronics History**
- **The notion of "*Digital* " in Electronics**
- **The notion of "*Logic*" in Electronics**
- **The notion of "Abstraction" in Electronics**
- **Pre-view at *Digital Logic* Gats in Electronics**

Electronics

Electronics is the branch of electrical science which deals with devices that control the flow of electrons.

Current (I) : flow of electrons, usually expressed in Amperes (A).



Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).

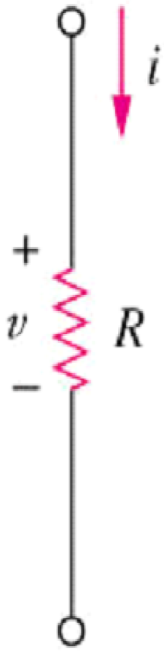
The charge (e)on one electron is negative and equal in magnitude to (1.602×10^{-19} C) which is called as electronic charge.

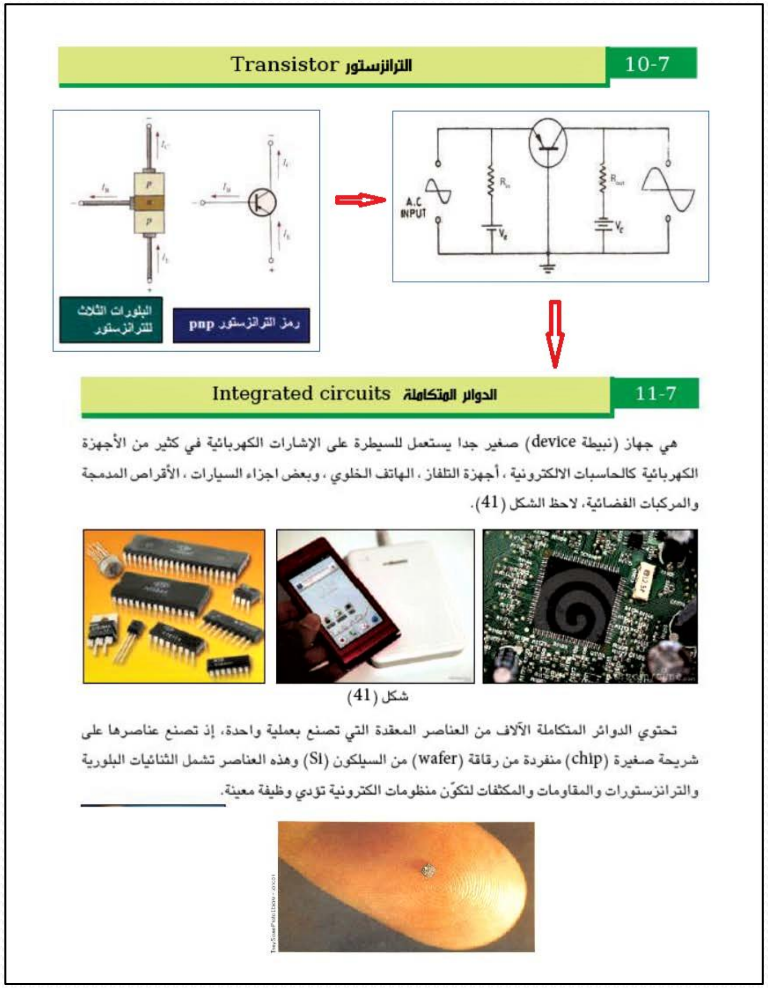
Voltage (V) is the potential difference always across the circuit element or between two points in a circuit.

Ohms Law

Ohm's law states that the voltage (v) across a resistor is directly proportional to the current (i) flowing through the resistor (R). Mathematical expression for Ohm's Law is as follows:

$$v = iR$$





10-7 Transistor الترانزستور

البلورات الثلاث للترانزستور

رمز الترانزستور pnp

11-7 Integrated circuits الدوائر المتكاملة

هي جهاز (نبيطة device) صغير جدا يستعمل للسيطرة على الإشارات الكهربائية في كثير من الأجهزة الكهربائية كالحاسبات الالكترونية ، أجهزة التلفاز ، الهاتف الخلوي ، وبعض اجزاء السيارات ، الأقراص المدمجة والمركبات الفضائية، لاحظ الشكل (41).

شكل (41)

تحتوي الدوائر المتكاملة الآلاف من العناصر المعقدة التي تصنع بعملية واحدة، إذ تصنع عناصرها على شريحة صغيرة (chip) منفردة من رقاقة (wafer) من السيلكون (Si) وهذه العناصر تشمل الثنائيات البلورية والترانزستورات والمقاومات والمكثفات لتكوّن منظومات الكترونية تؤدي وظيفة معينة.

Abstraction

Glimpse from Electronics History

- **Electronics is the branch of Electrical Engineering.**
- **Historically:**

In 1904 :vacuum thermionic tube (*diode)*

(1922 - 1937): > **100 million tubes** used in different industries (mainly, ***radio*** and ***Television***)

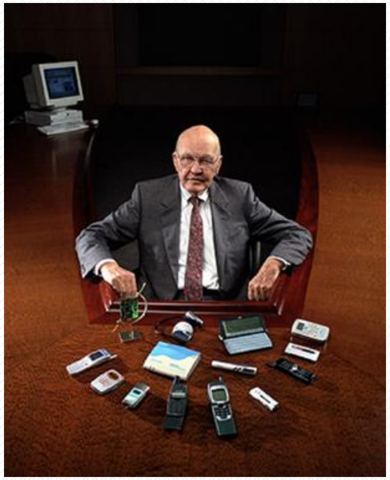
December 1947: 1st **Transistor** (***Solid State Semiconductor***) (*the beginning era of **miniaturization** in electronics*)

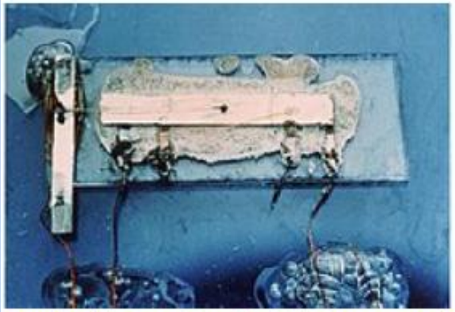
Climbs from Electronics History

December 23, 1947 : a completely new direction in electronics industries :
the first **transistor** (***Solid State semiconductor device***)
was demonstrated at the Bell Telephone Laboratories, USA.
(*the beginning ear of miniaturization in electronics*)

The next major development in electronics came up with the introduction of ***Integrated Circuits (IC)***.

On Sep. 12, 1958, **Jack Kilby**,
a Texas Instruments engineer, invented the first integrated circuit, measuring (***11.1 by 1.6 mm***).





Jack Kilby's original hybrid integrated circuit from 1958. This was the first integrated circuit, and was made from germanium.

Now . . .

Today, the Integrate Circuit of Intel ® Core TM i7 Extreme Edition Processor of has **731 million transistors** in a package that is only slightly larger than a ***1.67 sq. inches***.

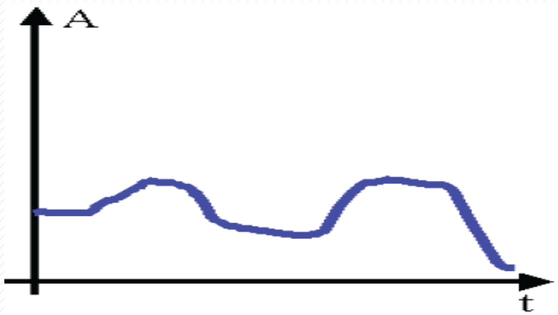
In all cases, the *information* within all *electronic* devices, is in the form of **voltage signals** or **current signals**.

Now, only two things which can be done to information (voltage or current) :
it can be switched or varied.

- *Switching: on / off*
- *Varying : altering the attributes (amplify, change frequency of occurrence)*

Accordingly, there are two main types of signals used in electronics:
Analog signals and ***Digital signals***

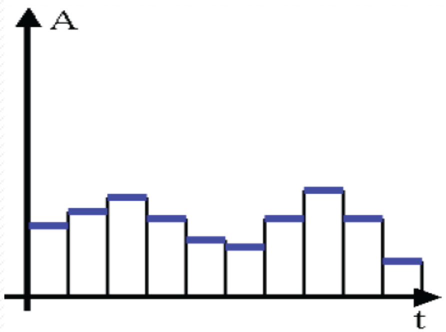
Analog signal is ***time-varying*** and generally bound to a range (e.g. +12V to -12V, if we are talking about **voltage signal**), but there is an infinite number of values within that continuous range.



Analog signal – continuously varying

A digital signal is a signal that represents data as a sequence of ***discrete values***.

A **digital signal** can only take on one value from a finite set of possible values at a given time.



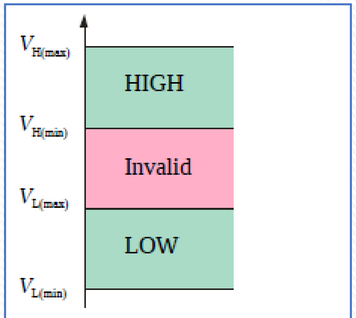
Digital signal – large time divisions

In *Digital Electronic Devices*, signals which can have just **two voltage values** (**two states**):

HIGH Voltage or LOW Voltage …

(true or false … 0 or 1).

This is why we say "Logic" ..

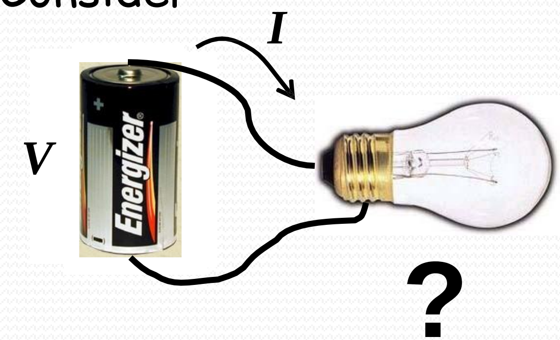


Digital System
functions only in the green zone

Abstraction in Electronics

We could do it the Hard Way…

Consider



What is the current through the bulb?

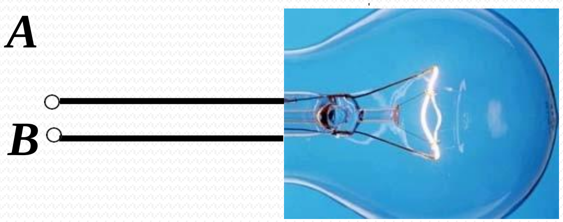
Apply Maxwell's

	Differential form	Integral form
Faraday's	$\nabla \times E = -\frac{\partial B}{\partial t}$	$\oint E \cdot dl = -\frac{\partial \phi_B}{\partial t}$
Continuity	$\nabla \cdot J = -\frac{\partial \rho}{\partial t}$	$\oint J \cdot dS = -\frac{\partial q}{\partial t}$
Others	$\nabla \cdot E = \frac{\rho}{\varepsilon_0}$	$\oint E \cdot dS = \frac{q}{\varepsilon_0}$
	⋮	⋮

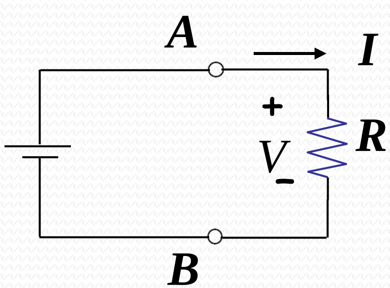
عرف عن (جيمس كليرك ماكسويل) المولود في عام 1831م ، بكونه عبقري يُضاهي بعبقريته كل من العالم آينشتاين ونيوتن، حيث أفنى ماكسويل نفسه لفهم الفيزياء، وأخذ مجموعة من القوانين التجريبية المعروفة، مثل: قانونيّ فاراداي وأمبير، ووحدّها في مجموعة متناسقة ومتماسكة من المعادلات عُرفت باسمه، وكان من أوائل من حددوا أنّ سرعة انتشار الموجات الكهرومغناطيسية هي نفسها سرعة الضوء، واستنتج أنّ الموجات الكهرومغناطيسية والضوء المرئي هما الشي ذاته، وتُوفي ماكسويل عام 1879م.

Abstraction in Electronics

The Easy Way…



Replace the bulb with a *discrete resistor* to calculating the current.



and $I = \frac{V}{R}$

R represents the only property of interest

في علم الإلكترونيك، التجريد (**Abstraction**) هي عملية تجريد التفاصيل غير الضرورية للتركيز على المعلومات الأساسية التي تساعد على فهم وتطوير النظام. حيث يستخدم هذا المفهوم لتحويل النظريات العلمية والقوانين الطبيعية (مثل معادلات ماكسويل) إلى تصميمات عملية للأجهزة والمنظومات.

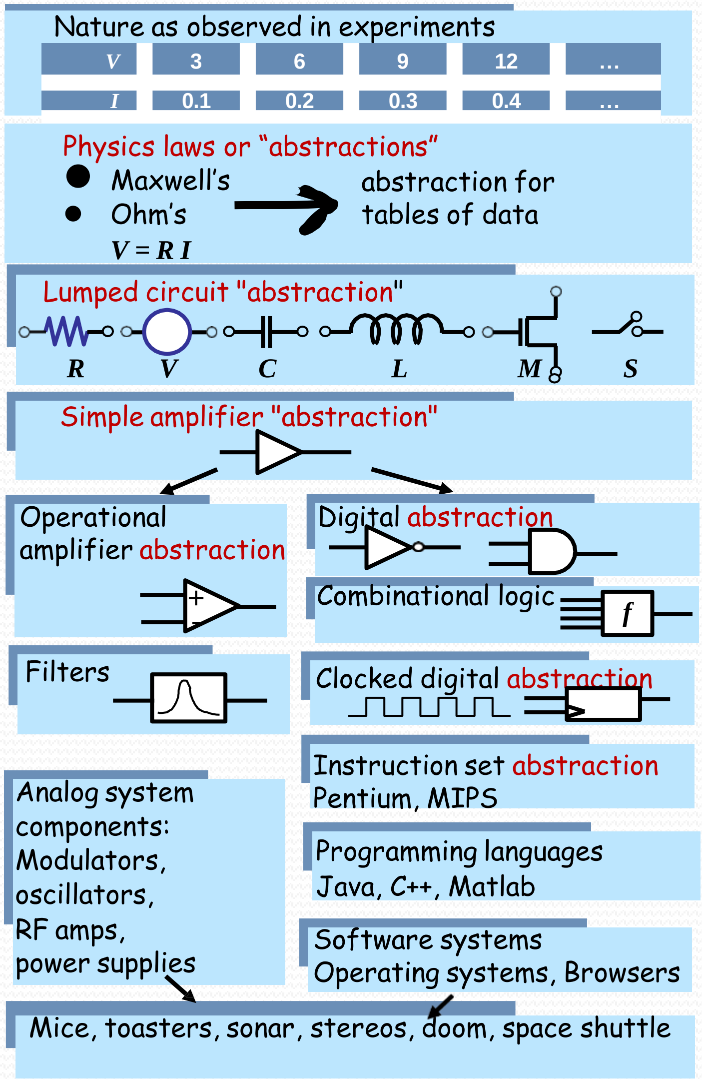
على سبيل المثال، يتم تحويل معادلات ماكسويل العلمية إلى مفاهيم أكثر تجريدًا مثل مفهوم الكهرباء والمغناطيسية وموجات الراديو. ثم يتم تحويل هذه المفاهيم إلى مخططات تصميم الدوائر الإلكترونية والمكونات المستخدمة فيها.

ويستخدم الـ **Abstraction** في تصميم الأجهزة والمنظومات الكبيرة مثل المركبات الفضائية وأجهزة الرنين المغناطيسي في المستشفيات.

Abstraction in Electronics

Engineering
is
a purposeful use
of Science

الهندسة
هي
الأستخدام الهادف
للعلوم



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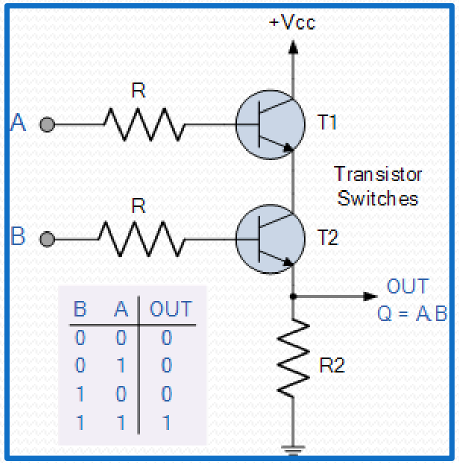
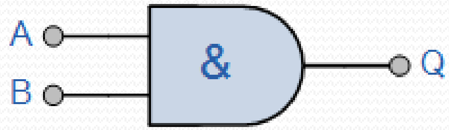
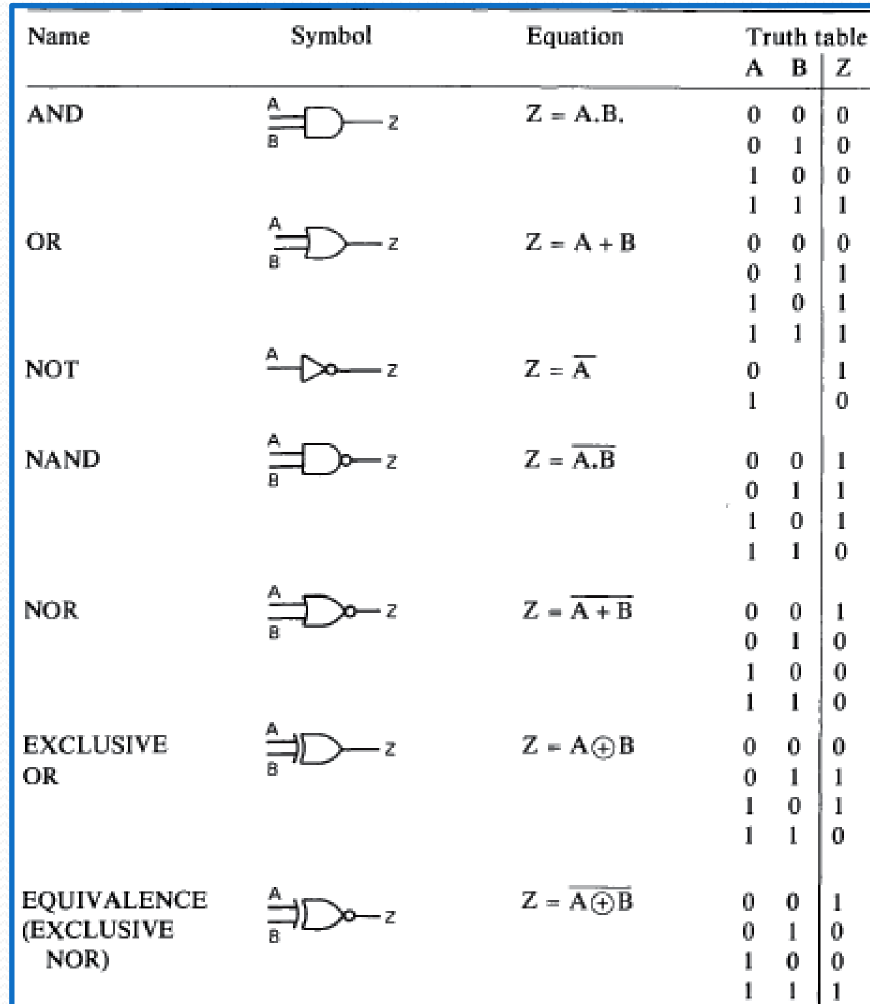
Abstraction in Electronics



AND circuit Abstraction



AND Logic Abstraction



Name	Symbol	Equation	A	B	Z
AND		Z = A.B.	0	0	0
			0	1	0
			1	0	0
			1	1	1
OR		Z = A + B	0	0	0
			0	1	1
			1	0	1
			1	1	1
NOT		$Z = \overline{A}$	0		1
			1		0
NAND		$Z = \overline{A.B}$	0	0	1
			0	1	1
			1	0	1
			1	1	0
NOR		$Z = \overline{A + B}$	0	0	1
			0	1	0
			1	0	0
			1	1	0
EXCLUSIVE OR		$Z = A \oplus B$	0	0	0
			0	1	1
			1	0	1
			1	1	0
EQUIVALENCE (EXCLUSIVE NOR)		$Z = \overline{A \oplus B}$	0	0	1
			0	1	0
			1	0	0
			1	1	1

AND Logics examples

VHDL (programming Language)

```
entity AND_Gate1 is
    port(A,B:in
    bit:Q:out bit);
end entity AND_Gate1
```

Programming Language Abstraction

For the rest of semester, we will work only in the

Digital (Logic) Level

Decimal Numbers

The position of each digit in a weighted number system is assigned a weight based on the **base** or **radix** of the system. The radix of decimal numbers is ten, because only ten symbols (0 through 9) are used to represent any number.

The column weights of decimal numbers are powers of ten that increase from right to left beginning with $10^0 = 1$:

$\ldots 10^5\ 10^4\ 10^3\ 10^2\ 10^1\ 10^0.$

For fractional decimal numbers, the column weights are negative powers of ten that decrease from left to right:

$10^2\ 10^1\ 10^0.\ 10^{-1}\ 10^{-2}\ 10^{-3}\ 10^{-4}\ \ldots$

Decimal Numbers

Decimal numbers can be expressed as the sum of the products of each digit times the column value for that digit. Thus, the number 9240 can be expressed as

$$(9 \times 10^3) + (2 \times 10^2) + (4 \times 10^1) + (0 \times 10^0)$$

or

$$9 \times 1{,}000 + 2 \times 100 + 4 \times 10 + 0 \times 1$$

Example

Express the number 480.52 as the sum of values of each digit.

Solution

$$480.52 = (4 \times 10^2) + (8 \times 10^1) + (0 \times 10^0) + (5 \times 10^{-1}) + (2 \times 10^{-2})$$

Binary Numbers

For digital systems, the binary number system is used. Binary has a radix of two and uses the digits 0 and 1 to represent quantities.

The column weights of binary numbers are powers of two that increase from right to left beginning with $2^0 = 1$:

$$\ldots 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0.$$

For fractional binary numbers, the column weights are negative powers of two that decrease from left to right:

$$2^2\ 2^1\ 2^0.\ 2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4}\ \ldots$$

Binary Numbers

A binary counting sequence for numbers from zero to fifteen is shown.

Notice the pattern of zeros and ones in each column.

Digital counters frequently have this same pattern of digits:

Decimal Number	Binary Number
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0
11	1 0 1 1
12	1 1 0 0
13	1 1 0 1
14	1 1 1 0
15	1 1 1 1

Binary Conversions

The decimal equivalent of a binary number can be determined by adding the column values of all of the bits that are 1 and discarding all of the bits that are 0.

Example Convert the binary number 100101.01 to decimal.

Solution Start by writing the column weights; then add the weights that correspond to each 1 in the number.

2^5	2^4	2^3	2^2	2^1	2^0.	2^{-1}	2^{-2}
32	16	8	4	2	1 .	½	¼
1	0	0	1	0	1.	0	1
32			+4		+1		+¼ = 37¼

Binary Conversions

You can convert a decimal whole number to binary by reversing the procedure. Write the decimal weight of each column and place 1's in the columns that sum to the decimal number.

Example Convert the decimal number 49 to binary.

Solution The column weights double in each position to the right. Write down column weights until the last number is larger than the one you want to convert.

2^6	2^5	2^4	2^3	2^2	2^1	2^0.
64	32	16	8	4	2	1.
0	1	1	0	0	0	1.