

Lecture 0 - Binary World of Computers

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Human

Decimal

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Binary

11111100110

Octal
3746

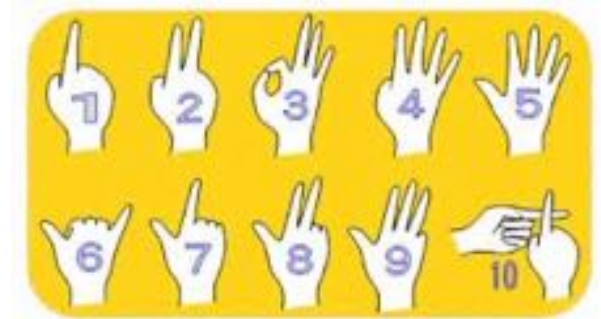
Hexadecimal
7E6



Computer

How high can you count on one hand?

1. 10 (0 ~ 9 or 1 ~ 10)
2. 12
3. 24
4. 32
5. More than 32



How to count to 12 on one hand?

- Each finger is divided into **three sections**.
- Use the thumb as a pointer to point to the 12 numbers.
- You can use **two hands** to count to **144 numbers**.



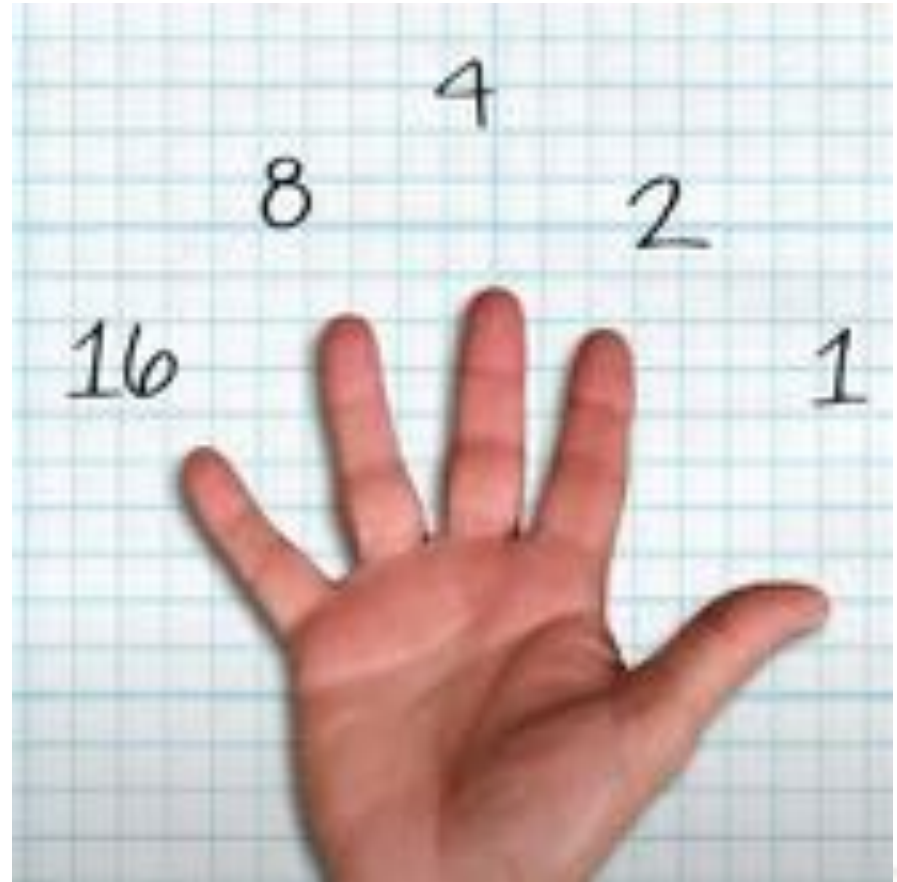
How to count to 24 on one hand?

- Each finger is divided into **three sections** and **three creases**.
- Use the thumb as a pointer to point to the 24 numbers.
- You can use **two hands** to count to **576 numbers**.



How to count to 32 on one hand?

- We can use the **binary representation** (up or down) as well as the **positional notation**.
- Each finger indicates a power of two based on its position.
- You can use **two hands** to count to **1024 numbers**.



What numbers are they indicating?



26



4



How to convert from binary to decimal?

$$11010_2 = 26_{10}$$

Use the positional notation

A handwritten diagram illustrating the conversion of the binary number 11010 to its decimal equivalent. The binary digits are arranged in a horizontal box: 1, 1, 0, 1, 0. Below each digit is its corresponding power of 2: 2^4 , 2^3 , 2^2 , 2^1 , and 2^0 . Arrows point from each digit to its value: 1 to 16, 1 to 8, 0 to 0, 1 to 2, and 0 to 0. These values are then summed: $16 + 8 + 0 + 2 + 0 = 26$.

1	1	0	1	0
2^4	2^3	2^2	2^1	2^0
↓	↓	↓	↓	↓
16	8	0	2	0
$= 26$				

How to convert from decimal to binary?

$$26_{10} = 11010_2$$

1. Performing Short Division by Two with Remainder

Handwritten short division by 2 with remainders:

$$\begin{array}{r} 2 \overline{) 26} \\ 2 \overline{) 13} \dots 0 \uparrow \\ 2 \overline{) 6} \dots 1 \\ 2 \overline{) 3} \dots 0 \\ 1 \dots 1 \end{array}$$

An arrow points from the final remainder 1 to the final binary digit 1 in the result 11010.

2. Descending Powers of Two and Subtraction

16	8	4	2	1
1	1	0	1	0

$$26 - 16 = 10$$

$$10 - 8 = 2$$

$$2 - 2 = 0$$

How to convert from binary to octal and hexadecimal?

$$11111100110_2 = 3746_8 = 7E6_{16}$$

- **Group** each **three** (for octal) or **four** (for hexadecimal) bits from right to left.
- Each group consists of one digit.

$$\begin{array}{cccc} \underline{111} & \underline{110} & \underline{011} & \underline{0} \\ 3 & 7 & 4 & 6 \end{array}$$

$$\begin{array}{ccc} \underline{1111} & \underline{1001} & \underline{10} \\ 7 & E & 6 \end{array}$$

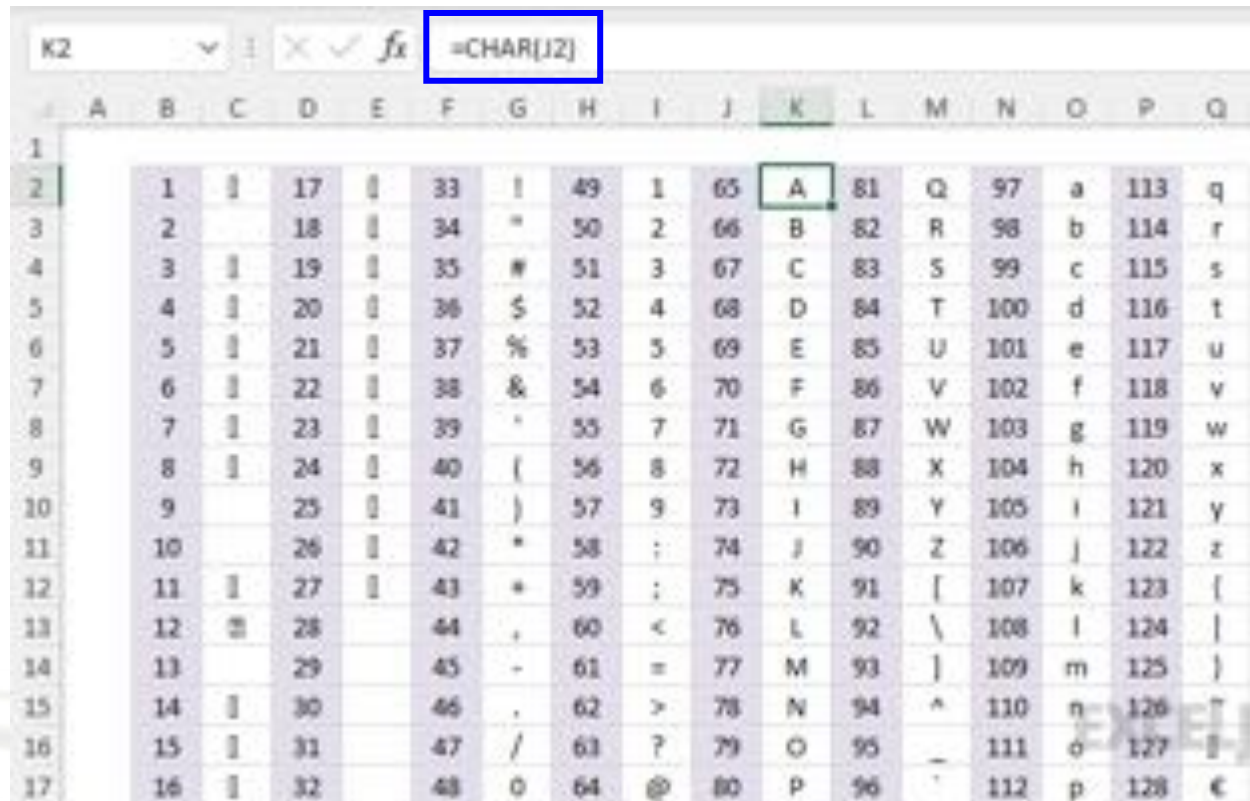
How is the data stored in the computer?

- A **BIT** (Binary Digit) is the most basic unit of information.
- A **BYTE** (Binary Term; deliberate respelling of “bite”) most commonly consists of **eight bits** to encode a single character.
e.g. A is encoded as 01000001 (or decimal 65), and B is encoded as 01000010 (or decimal 66).
- In many computer architectures, **byte is the smallest addressable unit** of memory.

address	content
0x 00000000	
0x 11223344	N
0x 11223345	C
0x 11223346	K
0x 11223347	U
0x FFFFFFFF	

How is the data stored in the computer?

- **ASCII** (American Standard Code for Information Interchange) is the **most common character encoding** format for text data in computers.



The image shows an Excel spreadsheet with a formula bar at the top displaying `=CHAR(J2)`. The spreadsheet contains a table of ASCII values and their corresponding characters. The columns are labeled A through Q, and the rows are numbered 1 through 17. The data is organized into groups of 16 characters each, with the first column (A) containing the ASCII value, the second column (B) containing a small icon, the third column (C) containing the ASCII value, the fourth column (D) containing a small icon, the fifth column (E) containing the ASCII value, the sixth column (F) containing a small icon, the seventh column (G) containing the ASCII value, the eighth column (H) containing a small icon, the ninth column (I) containing the ASCII value, the tenth column (J) containing a small icon, the eleventh column (K) containing the character, the twelfth column (L) containing the ASCII value, the thirteenth column (M) containing a small icon, the fourteenth column (N) containing the ASCII value, the fifteenth column (O) containing a small icon, the sixteenth column (P) containing the ASCII value, and the seventeenth column (Q) containing a small icon. The character 'A' is highlighted in cell K2.

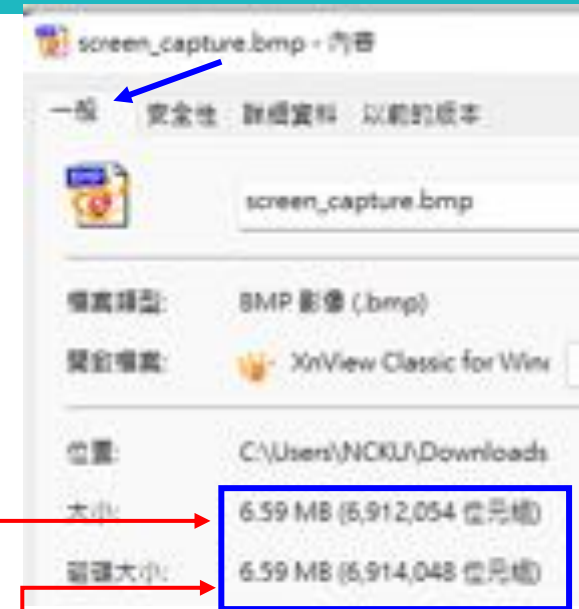
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1																	
2	1	17	33	49	1	65	A	81	Q	97	a	113	q				
3	2	18	34	"	50	2	66	B	82	R	98	b	114	r			
4	3	19	35	#	51	3	67	C	83	S	99	c	115	s			
5	4	20	36	\$	52	4	68	D	84	T	100	d	116	t			
6	5	21	37	%	53	5	69	E	85	U	101	e	117	u			
7	6	22	38	&	54	6	70	F	86	V	102	f	118	v			
8	7	23	39	'	55	7	71	G	87	W	103	g	119	w			
9	8	24	40	(	56	8	72	H	88	X	104	h	120	x			
10	9	25	41	)	57	9	73	I	89	Y	105	i	121	y			
11	10	26	42	*	58	:	74	J	90	Z	106	j	122	z			
12	11	27	43	+	59	;	75	K	91	[	107	k	123	{			
13	12	28	44	,	60	<	76	L	92	\	108	l	124	|			
14	13	29	45	-	61	=	77	M	93	]	109	m	125	}			
15	14	30	46	.	62	>	78	N	94	^	110	n	126	~			
16	15	31	47	/	63	?	79	O	95	_	111	o	127				
17	16	32	48	0	64	@	80	P	96	`	112	p	128	€			

How is a bitmap image stored in computers?

- Color depth is the **number of bits per pixel** (usually 24).
- If we capture a 1920x1200 screen and save as a bitmap file (.bmp), the required storage should be **1920 x 1200 x 3 = 6,912,000 bytes**.
- Since a .bmp file requires a **54-byte header**, the file size should be **6,912,054 bytes**.
- Disk space is **allocated in blocks** (usually **4096 bytes**), so the actual required disk storage space is **6,914,048 bytes**.



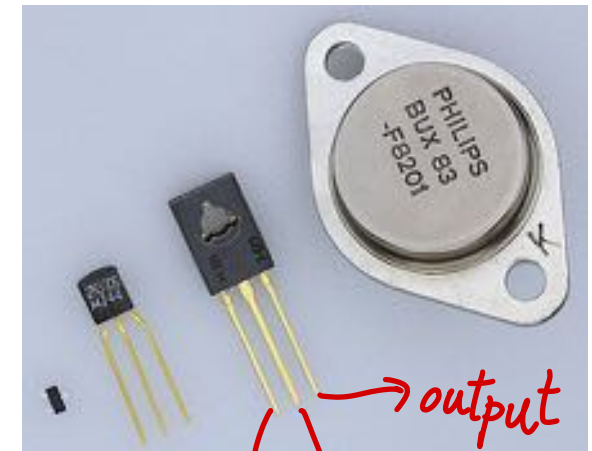
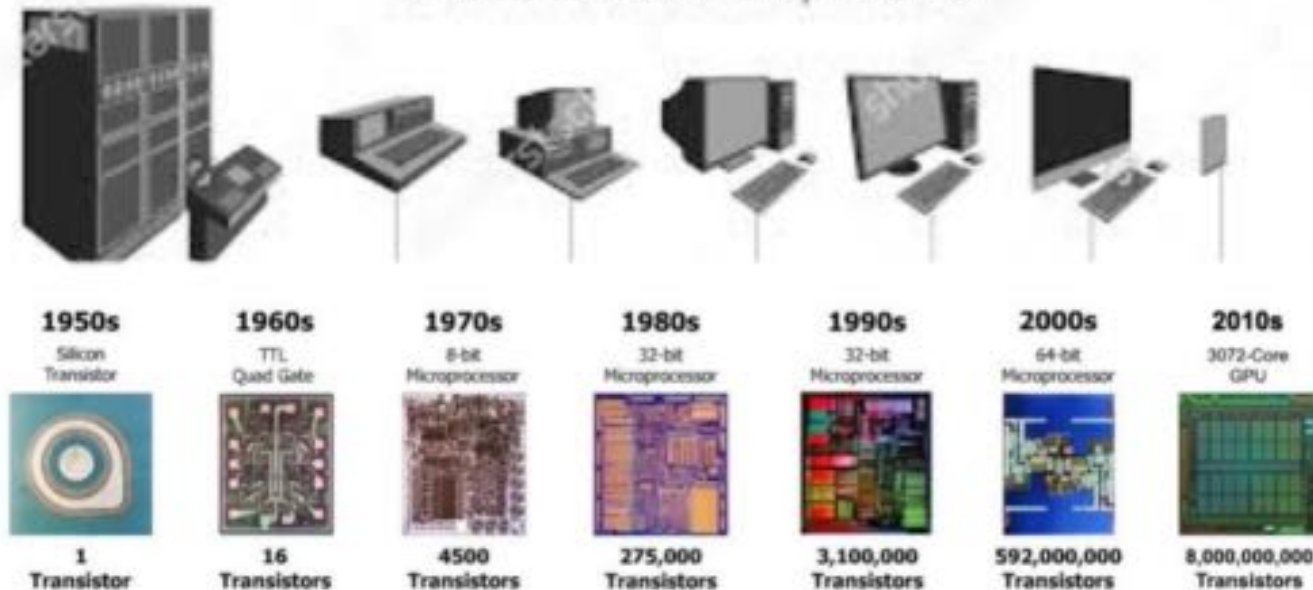
1920 x 1200
screen capture



Why computer world is binary?

- Modern computers are powered by "transistors," a type of electronic switch in digital circuits, that can be either "on" or "off".
- However, it may not be binary in a quantum computer.

Evolution of computers



References

- How high can you count on your fingers? (YouTube video)
<https://www.youtube.com/watch?v=UixU1oRW64Q>
- BMP file format
https://en.wikipedia.org/wiki/BMP_file_format
- 電晶體是如何運作的 - Gokul J. Krishnan
<https://www.youtube.com/watch?v=WhNyURBiJcU>