WIKIPEDIA

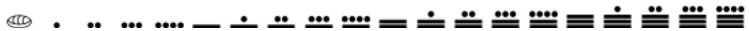
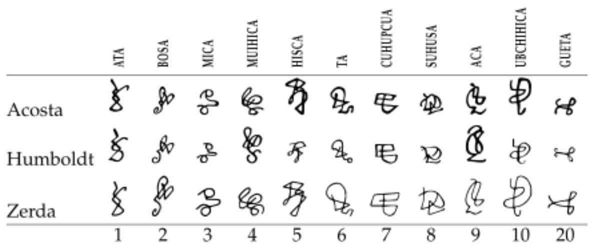
List of numeral systems

There are many different numeral systems, that is, writing systems for expressing numbers.

Contents

By culture / time period

Name	Base	Sample	Approx. First Appearance
Proto-cuneiform numerals	10+60		c. 3500–2000 BCE
Indus numerals			c. 3500–1900 BCE
Proto-Elamite numerals	10+60		3,100 BCE
Sumerian numerals	10+60		3,100 BCE
Egyptian numerals	10		3,000 BCE
Babylonian numerals	10+60	𒐕 𒐖 𒐗 𒐘 𒐙 𒐚 𒐛 𒐜 𒐝 𒌋	2,000 BCE
Chinese numerals Japanese numerals Korean numerals (Sino-Korean) Vietnamese numerals (Sino-Vietnamese)	10	零一二三四五六七八九十百千萬億 (Default, Traditional Chinese) 〇一二三四五六七八九十百千万亿 (Default, Simplified Chinese) 零壹貳參肆伍陸柒捌玖拾佰仟萬億 (Financial, T. Chinese) 零壹贰叁肆伍陆柒捌玖拾佰仟萬億 (Financial, S. Chinese)	1,600 BCE
Aegean numerals	10	𐄇 𐄈 𐄉 𐄊 𐄋 𐄌 𐄍 𐄎 𐄏 (𐄇 𐄈 𐄉 𐄊 𐄋 𐄌 𐄍 𐄎 𐄏) 𐄐 𐄑 𐄒 𐄓 𐄔 𐄕 𐄖 𐄗 𐄘 (𐄐 𐄑 𐄒 𐄓 𐄔 𐄕 𐄖 𐄗 𐄘) 𐄙 𐄚 𐄛 𐄜 𐄝 𐄞 𐄟 𐄠 𐄡 (𐄙 𐄚 𐄛 𐄜 𐄝 𐄞 𐄟 𐄠 𐄡) 𐄢 𐄣 𐄤 𐄥 𐄦 𐄧 𐄨 𐄩 𐄪 (𐄢 𐄣 𐄤 𐄥 𐄦 𐄧 𐄨 𐄩 𐄪) 𐄫 𐄬 𐄭 𐄮 𐄯 𐄰 𐄱 𐄲 𐄳 (𐄫 𐄬 𐄭 𐄮 𐄯 𐄰 𐄱 𐄲 𐄳)	1,500 BCE
Roman numerals		I V X L C D M	1,000 BCE
Hebrew numerals	10	א ב ג ד ה ו ז ח ט י כ ל מ נ ס ע פ צ ק ר ש ת ך ם ן ף ץ	800 BCE
Indian numerals	10	Tamil ௧ ௨ ௩ ௪ ௫ ௬ ௭ ௮ ௯ ௰ Devanagari ० १ २ ३ ४ ५ ६ ७ ८ ९ Tibetan ༠ ༡ ༢ ༣ ༤ ༥ ༦ ༧ ༨ ༩	750–690 BCE
Bengali numerals	10	০ ১ ২ ৩ ৪ ৫ ৬ ৭ ৮ ৯	500 BCE
Greek numerals	10	ō α β γ δ ε ϝ ζ η θ ι ο Αʹ Βʹ Γʹ Δʹ Εʹ Ϛʹ Ζʹ Ηʹ Θʹ	<400 BCE

Name	Base	Sample	Approx. First Appearance
Phoenician numerals	10	𐤖 𐤚 𐤛 𐤖𐤛 𐤚𐤛 𐤛𐤛 𐤖𐤛𐤛 𐤚𐤛𐤛 𐤛𐤛𐤛 𐤗 𐤘 𐤙 [1]	<250 BCE[2]
Chinese rod numerals	10	𝍠 𝍡 𝍢 𝍣 𝍤 𝍥 𝍦 𝍧 𝍨 𝍩	1st Century
Ge'ez numerals	10	፩ ፪ ፫ ፬ ፭ ፮ ፯ ፰ ፱ ፲ ፳ ፴ ፵ ፶ ፷ ፸ ፹ ፺ ፻	3rd–4th Century 15th Century (Modern Style)[3]
Armenian numerals	10	Ա Բ Գ Դ Ե Զ Է Ը Թ Ժ	Early 5th Century
Khmer numerals	10	០ ១ ២ ៣ ៤ ៥ ៦ ៧ ៨ ៩	Early 7th Century
Thai numerals	10	๐ ๑ ๒ ๓ ๔ ๕ ๖ ๗ ๘ ๙	7th Century[4]
Abjad numerals	10	ا ب ج د ه و ز ح ط ي ك ل م ن س ع ف ص ق ر ش ت ث خ ذ ض ظ غ	<8th Century
Eastern Arabic numerals	10	٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩	8th Century
Vietnamese numerals (Chữ Nôm)	10	𠬠 𠄩 𠀧 𦊚 𠄼 𦒹 𦉱 𠔭 𠃩	<9th Century
Western Arabic numerals	10	0 1 2 3 4 5 6 7 8 9	9th Century
Glagolitic numerals	10	Ⰰ Ⰱ Ⰲ Ⰳ Ⰴ Ⰵ Ⰶ Ⰷ Ⰸ ...	9th Century
Cyrillic numerals	10	а в г д е ѕ з и ѳ і ...	10th Century
Rumi numerals	10		10th Century
Burmese numerals	10	၀ ၁ ၂ ၃ ၄ ၅ ၆ ၇ ၈ ၉	11th Century[5]
Tangut numerals	10		11th Century (1036)
Cistercian numerals	10		13th Century
Maya numerals	5+20		<15th Century
Muisca numerals	20		<15th Century

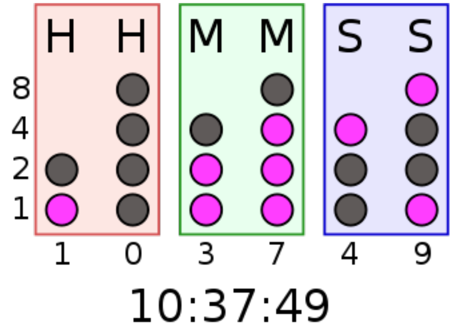
Name	Base	Sample	Approx. First Appearance
Korean numerals (Hangul)	10	하나 둘 셋 넷 다섯 여섯 일곱 여덟 아홉 열	15th Century (1443)
Aztec numerals	20		16th Century
Sinhala numerals	10	[illegible]	<18th Century
Pentadic runes	10	[illegible]	19th Century
Cherokee numerals	10		19th Century (1820s)
Kaktovik numerals	5+20	𝋁 𝋂 𝋃 𝋄 𝋅 𝋆 𝋇 𝋈 𝋉 𝋊 𝋋 𝋌 𝋍 𝋎 𝋏 𝋐 𝋑 𝋒 𝋓 𝋀	20th Century (1994)

By type of notation

Numeral systems are classified here as to whether they use positional notation (also known as place-value notation), and further categorized by radix or base.

Standard positional numeral systems

The common names are derived somewhat arbitrarily from a mix of Latin and Greek, in some cases including roots from both languages within a single name.[6] There have been some proposals for standardisation.[7]



A binary clock might use LEDs to express binary values. In this clock, each column of LEDs shows a binary-coded decimal numeral of the traditional sexagesimal time.

Base	Name	Usage
2	Binary	Digital computing, imperial and customary volume (bushel-kenning-peck-gallon-pottle-quart-pint-cup-gill-jack-fluid ounce-tablespoon)
3	Ternary	Cantor set (all points in [0,1] that *can* be represented in ternary with no 1s); counting Tasbih in Islam; hand-foot-yard and teaspoon-tablespoon-shot measurement systems; most *economical* integer base
4	Quaternary	Data transmission, DNA bases and Hilbert curves; Chumashan languages, and Kharosthi numerals
5	Quinary	Gumatj, Ateso, Nunggubuyu, Kuurn Kopan Noot, and Saraveca languages; common count grouping e.g. tally marks
6	Senary	Diceware, Ndom, Kanum, and Proto-Uralic language (suspected)
7	Septenary	Weeks timekeeping, Western music letter notation
8	Octal	Charles XII of Sweden, Unix-like permissions, Squawk codes, DEC PDP-11, compact notation for binary numbers, Xiantian (I Ching, China)
9	Nonary	Base9 encoding; compact notation for ternary
10	Decimal (also known as denary)	Most widely used by modern civilizations[8][9][10]
11	Undecimal	A base-11 number system was attributed to the Māori (New Zealand) in the 19th century[11] and the Pangwa (Tanzania) in the 20th century.[12] Briefly proposed during the French Revolution to settle a dispute between those proposing a shift to duodecimal and those who were content with decimal. Used as a check digit in ISBN for 10-digit ISBNs.
12	Duodecimal	Languages in the Nigerian Middle Belt Janji, Gbiri-Niragu, Piti, and the Nimbia dialect of Gwandara; Chepang language of Nepal, and the Mahl dialect of Maldivian; dozen-gross-great gross counting; 12-hour clock and months timekeeping; years of Chinese zodiac; foot and inch; Roman fractions; penny and shilling
13	Tridecimal	Base13 encoding; Conway base 13 function.
14	Tetradecimal	Programming for the HP 9100A/B calculator[13] and image processing applications;[14] pound and stone.
15	Pentadecimal	Telephony routing over IP, and the Huli language.
16	Hexadecimal (also known as sexadecimal)	Base16 encoding; compact notation for binary data; tonal system; ounce and pound.
17	Heptadecimal	Base17 encoding.
18	Octodecimal	Base18 encoding; a base such that 7^n is palindromic for n = 3, 4, 6, 9.
19	Enneadecimal	Base19 encoding.

20	Vigesimal	Basque, Celtic, Maya, Muisca, Inuit, Yoruba, Tlingit, and Dzongkha numerals; Santali, and Ainu languages; shilling and pound
21	Unvigesimal	Base21 encoding; also the smallest base where all of $\frac{1}{2}$ to $\frac{1}{18}$ have periods of 4 or shorter.
22	Duovigesimal	Base22 encoding.
23	Trivigesimal	Kalam language,[15] Kobon language
24	Tetravigesimal	24-hour clock timekeeping; Kaugel language.
25	Pentavigesimal	Base25 encoding; sometimes used as compact notation for quinary.
26	Hexavigesimal	Base26 encoding; sometimes used for encryption or ciphering,[16] using all letters in the English alphabet
27	Heptavigesimal Septemvigesimal	Telefol[17] and Oksapmin[18] languages. Mapping the nonzero digits to the alphabet and zero to the space is occasionally used to provide checksums for alphabetic data such as personal names,[19] to provide a concise encoding of alphabetic strings,[20] or as the basis for a form of gematria.[21] Compact notation for ternary.
28	Octovigesimal	Base28 encoding; months timekeeping.
29	Enneavigesimal	Base29 encoding.
30	Trigesimal	The Natural Area Code, this is the smallest base such that all of $\frac{1}{2}$ to $\frac{1}{6}$ terminate, a number n is a regular number if and only if $\frac{1}{n}$ terminates in base 30.
31	Untrigesimal	Base31 encoding.
32	Duotrigesimal	Base32 encoding; the Ngiti language.
33	Tritrigesimal	Use of letters (except I, O, Q) with digits in vehicle registration plates of Hong Kong.
34	Tetratrigesimal	Using all numbers and all letters except I and O; the smallest base where $\frac{1}{2}$ terminates and all of $\frac{1}{2}$ to $\frac{1}{18}$ have periods of 4 or shorter.
35	Pentatrigesimal	Using all numbers and all letters except O.
36	Hexatrigesimal	Base36 encoding; use of letters with digits.
37	Heptatrigesimal	Base37 encoding; using all numbers and all letters of the Spanish alphabet.
38	Octotrigesimal	Base38 encoding; use all duodecimal digits and all letters.
39	Enneatrigesimal	Base39 encoding.
40	Quadragesimal	DEC RADIX 50/MOD40 encoding used to compactly represent file names and other symbols on Digital Equipment Corporation computers. The character set is a subset of ASCII consisting of space, upper case letters, the punctuation marks "$", ".", and "%", and the numerals.

42	Duoquadragesimal	Base42 encoding; largest base for which all minimal primes are known.
45	Pentaquadragesimal	Base45 encoding.
47	Septaquadragesimal	Smallest base for which no generalized Wieferich primes are known.
48	Octoquadragesimal	Base48 encoding.
49	Enneaquadragesimal	Compact notation for septenary.
50	Quinquagesimal	Base50 encoding; SQUOZE encoding used to compactly represent file names and other symbols on some IBM computers. Encoding using all Gurmukhi characters plus the Gurmukhi digits.
52	Duoquinquagesimal	Base52 encoding, a variant of Base62 without vowels except Y and y[22] or a variant of Base26 using all lower and upper case letters.
54	Tetraquinquagesimal	Base54 encoding.
56	Hexaquinquagesimal	Base56 encoding, a variant of Base58.[23]
57	Heptaquinquagesimal	Base57 encoding, a variant of Base62 excluding I, O, l, U, and u[24] or I, 1, l, 0, and O.[25]
58	Octoquinquagesimal	Base58 encoding, a variant of Base62 excluding 0 (zero), I (capital i), O (capital o) and l (lower case L).[26]
60	Sexagesimal	Babylonian numerals; NewBase60 encoding, similar to Base62, excluding I, O, and l, but including _(underscore);[27] degrees-minutes-seconds and hours-minutes-seconds measurement systems; Ekari and Sumerian languages.
62	Duosexagesimal	Base62 encoding, using 0–9, A–Z, and a–z.
64	Tetrasexagesimal	Base64 encoding; I Ching in China. This system is conveniently coded into ASCII by using the 26 letters of the Latin alphabet in both upper and lower case (52 total) plus 10 numerals (62 total) and then adding two special characters (+ and /).
72	Duoseptuagesimal	Base72 encoding; the smallest base >2 such that no three-digit narcissistic number exists.
80	Octogesimal	Base80 encoding.
81	Unoctogesimal	Base81 encoding, using as $81=3^4$ is related to ternary.
85	Pentoctogesimal	Ascii85 encoding. This is the minimum number of characters needed to encode a 32 bit number into 5 printable characters in a process similar to MIME-64 encoding, since 85^5 is only slightly bigger than 2^{32}. Such method is 6.7% more efficient than MIME-64 which encodes a 24 bit number into 4 printable characters.
89	Enneaoctogesimal	Largest base for which all left-truncatable primes are known.
90	Nonagesimal	Related to Goormaghtigh conjecture for the generalized repunit numbers (111 in base 90 = 1111111111111 in base 2).
91	Unnonagesimal	Base91 encoding, using all ASCII except "-" (0x2D), "\" (0x5C), and "'" (0x27); one variant uses "\" (0x5C) in place of """ (0x22).

92	Duononagesimal	Base92 encoding, using all of ASCII except for "`" (0x60) and """ (0x22) due to confusability.[28]
93	Trinonagesimal	Base93 encoding, using all of ASCII printable characters except for "," (0x27) and "-" (0x3D) as well as the Space character. "," is reserved for delimiter and "-" is reserved for negation.[29]
94	Tetranonagesimal	Base94 encoding, using all of ASCII printable characters.[30]
95	Pentanonagesimal	Base95 encoding, a variant of Base94 with the addition of the Space character.[31]
96	Hexanonagesimal	Base96 encoding, using all of ASCII printable characters as well as the two extra duodecimal digits.
97	Septanonagesimal	Smallest base which is not perfect odd power (where generalized Wagstaff numbers can be factored algebraically) for which no generalized Wagstaff primes are known.
100	Centesimal	As $100=10^2$, these are two decimal digits.
120	Centevigesimal	Base120 encoding.
121	Centeunvigesimal	Related to base 11.
125	Centepentavigesimal	Related to base 5.
128	Centeoctovigesimal	Using as $128=2^7$.
144	Centetetraquadragesimal	Two duodecimal digits.
169	Centenovemsexagesimal	Two Tridecimal digits.
185	Centepentoctogesimal	Smallest base which is not perfect power (where generalized repunits can be factored algebraically) for which no generalized repunit primes are known.
196	Centehexanonagesimal	Two tetradecimal digits.
200	Duocentesimal	Base200 encoding.
210	Duocentedecimal	Smallest base such that all of $\frac{1}{2}$ to $\frac{1}{10}$ terminate.
216	Duocentehexidecimal	related to base 6.
225	Duocentepentavigesimal	Two pentadecimal digits.
256	Duocentehexaquinquagesimal	Base256 encoding, as $256=2^8$.
300	Trecentesimal	Base300 encoding.
360	Trecentosexagesimal	Degrees for angle.

Non-standard positional numeral systems

Bijective numeration

Base	Name	Usage
1	Unary (Bijective base-1)	Tally marks, Counting
10	Bijective base-10	To avoid zero
26	Bijective base-26	Spreadsheet column numeration. Also used by John Nash as part of his obsession with numerology and the uncovering of "hidden" messages.[32]

Signed-digit representation

Base	Name	Usage
2	Balanced binary (Non-adjacent form)	
3	Balanced ternary	Ternary computers
4	Balanced quaternary	
5	Balanced quinary	
6	Balanced senary	
7	Balanced septenary	
8	Balanced octal	
9	Balanced nonary	
10	Balanced decimal	John Colson Augustin Cauchy
11	Balanced undecimal	
12	Balanced duodecimal	

Negative bases

The common names of the negative base numeral systems are formed using the prefix *nega-*, giving names such as:

Base	Name	Usage
−2	Negabinary	
−3	Negaternary	
−4	Negaquaternary	
−5	Negaquinary	
−6	Negasenary	
−8	Negaoctal	
−10	Negadecimal	
−12	Negaduodecimal	
−16	Negahexadecimal	

Complex bases

Base	Name	Usage
$2i$	Quater-imaginary base	related to base −4 and base 16
$\sqrt{2}i$	Base $\sqrt{2}i$	related to base −2 and base 4
$\sqrt[4]{2}i$	Base $\sqrt[4]{2}i$	related to base 2
2ω	Base 2ω	related to base 8
$\sqrt[3]{2}\omega$	Base $\sqrt[3]{2}\omega$	related to base 2
$-1 \pm i$	Twindragon base	Twindragon fractal shape, related to base −4 and base 16
$1 \pm i$	Negatwindragon base	related to base −4 and base 16

Non-integer bases

Base	Name	Usage
$\frac{3}{2}$	Base $\frac{3}{2}$	a rational non-integer base
$\frac{4}{3}$	Base $\frac{4}{3}$	related to duodecimal
$\frac{5}{2}$	Base $\frac{5}{2}$	related to decimal
$\sqrt{2}$	Base $\sqrt{2}$	related to base 2
$\sqrt{3}$	Base $\sqrt{3}$	related to base 3
$\sqrt[3]{2}$	Base $\sqrt[3]{2}$	
$\sqrt[4]{2}$	Base $\sqrt[4]{2}$	
$\sqrt[12]{2}$	Base $\sqrt[12]{2}$	usage in 12-tone equal temperament musical system
$2\sqrt{2}$	Base $2\sqrt{2}$	
$-\frac{3}{2}$	Base $-\frac{3}{2}$	a negative rational non-integer base
$-\sqrt{2}$	Base $-\sqrt{2}$	a negative non-integer base, related to base 2
$\sqrt{10}$	Base $\sqrt{10}$	related to decimal
$2\sqrt{3}$	Base $2\sqrt{3}$	related to duodecimal
ϕ	Golden ratio base	Early Beta encoder[33]
ρ	Plastic number base	
ψ	Supergolden ratio base	
$1+\sqrt{2}$	Silver ratio base	
e	Base e	Lowest radix economy
π	Base π	
$e\pi$	Base $e\pi$	

e^π	Base e^π	

n-adic number

Base	Name	Usage
2	Dyadic number	
3	Triadic number	
4	Tetradic number	the same as dyadic number
5	Pentadic number	
6	Hexadic number	not a field
7	Heptadic number	
8	Octadic number	the same as dyadic number
9	Enneadic number	the same as triadic number
10	Decadic number	not a field
11	Hendecadic number	
12	Dodecadic number	not a field

Mixed radix

- Factorial number system {1, 2, 3, 4, 5, 6, ...}
- Even double factorial number system {2, 4, 6, 8, 10, 12, ...}
- Odd double factorial number system {1, 3, 5, 7, 9, 11, ...}
- Primorial number system {2, 3, 5, 7, 11, 13, ...}
- Fibonorial number system {1, 2, 3, 5, 8, 13, ...}
- {60, 60, 24, 7} in timekeeping
- {60, 60, 24, 30 (or 31 or 28 or 29), 12, 10, 10, 10} in timekeeping
- (12, 20) traditional English monetary system (£sd)
- (20, 18, 13) Maya timekeeping

Other

- Quote notation
- Redundant binary representation
- Hereditary base-n notation
- Asymmetric numeral systems optimized for non-uniform probability distribution of symbols
- Combinatorial number system

Non-positional notation

All known numeral systems developed before the Babylonian numerals are non-positional,[34] as are many developed later, such as the Roman numerals. The French Cistercian monks created their own numeral system.

See also

- History of ancient numeral systems – Symbols representing numbers
- History of the Hindu–Arabic numeral system
- List of numeral system topics
- Numeral prefix – Prefix derived from numerals or other numbers
- Radix – Number of unique digits in a positional numeral system
- Radix economy – Number of digits needed to express a number in a particular base
- Table of bases – 0 to 74 in base 2 to 36
- Timeline of numerals and arithmetic – Timeline of arithmetic

References

1. Everson, Michael (2007-07-25). "Proposal to add two numbers for the Phoenician script" (https://www.unicode.org/L2/L2007/07206-n3284-phoenician.pdf) (PDF). *UTC Document Register*. Unicode Consortium. L2/07-206 (WG2 N3284).
2. Cajori, Florian (Sep 1928). *A History Of Mathematical Notations Vol I* (https://archive.org/stream/historyofmathema031756mbp#page/n37/mode/2up). The Open Court Company. p. 18. Retrieved 5 June 2017.

3. Chrisomalis, Stephen (2010-01-18). *Numerical Notation: A Comparative History* (https://books.google.com/books?id=kXZhBAAAQBAJ&q=ethiopic&pg=PA148). ISBN 9781139485333.
4. Chrisomalis, Stephen (2010). *Numerical Notation: A Comparative History* (https://books.google.com/books?id=ux--OWgWvBQC&pg=PA200). Cambridge University Press. p. 200. ISBN 9780521878180.
5. "Burmese/Myanmar script and pronunciation" (http://www.omniglot.com/writing/burmese.htm). *Omniglot*. Retrieved 5 June 2017.
6. For the mixed roots of the word "hexadecimal", see Epp, Susanna (2010), *Discrete Mathematics with Applications* (https://books.google.com/books?id=HUAIAAAAQBAJ&pg=PA91) (4th ed.), Cengage Learning, p. 91, ISBN 9781133168669.
7. Multiplication Tables of Various Bases (http://www.dozenal.org/drupal/sites_bck/default/files/MultiplicationSynopsis.pdf), p. 45, Michael Thomas de Vlieger, Dozenal Society of America
8. *The History of Arithmetic*, Louis Charles Karpinski, 200pp, Rand McNally & Company, 1925.
9. *Histoire universelle des chiffres*, Georges Ifrah, Robert Laffont, 1994.
10. *The Universal History of Numbers: From prehistory to the invention of the computer*, Georges Ifrah, ISBN 0-471-39340-1, John Wiley and Sons Inc., New York, 2000. Translated from the French by David Bellos, E.F. Harding, Sophie Wood and Ian Monk
11. Overmann, Karenleigh A (2020). "The curious idea that Māori once counted by elevens, and the insights it still holds for cross-cultural numerical research" (http://www.thepolynesiansociety.org/jps/index.php/JPS/article/view/458). *Journal of the Polynesian Society*. **129** (1): 59–84. doi:10.15286/jps.129.1.59-84 (https://doi.org/10.15286%2Fjps.129.1.59-84). Retrieved 24 July 2020.
12. Thomas, N.W (1920). "Duodecimal base of numeration" (http://www.jstor.com/stable/2840036). *Man*. **20** (1): 56–60. doi:10.2307/2840036 (https://doi.org/10.2307%2F2840036). JSTOR 2840036 (https://www.jstor.org/stable/2840036). Retrieved 25 July 2020.
13. HP 9100A/B programming, HP Museum (http://www.hpmuseum.org/prog/hp9100pr.htm)
14. Free Patents Online (http://www.freepatentsonline.com/6690378.html)
15. Laycock, Donald (1975). "Observations on Number Systems and Semantics". In Wurm, Stephen (ed.). *New Guinea Area Languages and Language Study, I: Papuan Languages and the New Guinea Linguistic Scene*. Pacific Linguistics C-38. Canberra: Research School of Pacific Studies, Australian National University. pp. 219–233.
16. "Base 26 Cipher (Number ↔ Words) - Online Decoder, Encoder" (http://www.dcode.fr/base-26-cipher).
17. Laycock, Donald (1975). "Observations on Number Systems and Semantics". In Wurm, Stephen (ed.). *New Guinea Area Languages and Language Study, I: Papuan Languages and the New Guinea Linguistic Scene*. Pacific Linguistics C-38. Canberra: Research School of Pacific Studies, Australian National University. pp. 219–233.
18. Saxe, Geoffrey B.; Moylan, Thomas (1982). "The development of measurement operations among the Oksapmin of Papua New Guinea". *Child Development*. **53** (5): 1242–1248. doi:10.1111/j.1467-8624.1982.tb04161.x (https://doi.org/10.1111%2Fj.1467-8624.1982.tb04161.x). JSTOR 1129012 (https://www.jstor.org/stable/1129012)..
19. Grannis, Shaun J.; Overhage, J. Marc; McDonald, Clement J. (2002), "Analysis of identifier performance using a deterministic linkage algorithm", *Proceedings. AMIA Symposium*: 305–309, PMC 2244404 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2244404), PMID 12463836 (https://pubmed.ncbi.nlm.nih.gov/12463836).
20. Stephens, Kenneth Rod (1996), *Visual Basic Algorithms: A Developer's Sourcebook of Ready-to-run Code* (https://archive.org/details/visualbasicalgor00step/page/215), Wiley, p. 215 (https://archive.org/details/visualbasicalgor00step/page/215), ISBN 9780471134183.

21. Sallows, Lee (1993), "Base 27: the key to a new gematria" (http://digitalcommons.butler.edu/wordways/vol26/iss2/2/), *Word Ways*, **26** (2): 67–77.
22. "Base52" (https://github.com/atomaka/base52). *GitHub*. Retrieved 2016-01-03.
23. "Base56" (https://gist.github.com/csnover/1110664). Retrieved 2016-01-03.
24. "Base57" (https://github.com/wyattisimo/base57-ruby). *GitHub*. Retrieved 2016-01-03.
25. "Base57" (https://github.com/skorokithakis/shortuuid). *GitHub*. Retrieved 2019-01-22.
26. "The Base58 Encoding Scheme" (https://web.archive.org/web/20200812103015/https://tools.ietf.org/id/draft-msporny-base58-01.txt). *Internet Engineering Task Force*. November 27, 2019. Archived from the original (https://tools.ietf.org/id/draft-msporny-base58) on August 12, 2020. Retrieved August 12, 2020. "Thanks to Satoshi Nakamoto for inventing the Base58 encoding format"
27. "NewBase60" (http://tantek.pbworks.com/w/page/19402946/NewBase60). Retrieved 2016-01-03.
28. "Base92" (https://github.com/thenoviceoof/base92). *GitHub*. Retrieved 2016-01-03.
29. "Base93" (http://kiwigis.blogspot.com/2013/09/base-93-integer-shortening-in-c.html). 26 September 2013. Retrieved 2017-02-13.
30. "Base94" (https://gist.github.com/4054241). Retrieved 2016-01-03.
31. "base95 Numeric System" (https://web.archive.org/web/20160207170735/http://www.icerealm.org/FTR/?s=docs&p=base95). Archived from the original (http://www.icerealm.org/FTR/?s=docs&p=base95) on 2016-02-07. Retrieved 2016-01-03.
32. Nasar, Sylvia (2001). *A Beautiful Mind* (https://archive.org/details/beautifulmindli00nasa). Simon and Schuster. pp. 333 (https://archive.org/details/beautifulmindli00nasa/page/333)–6. ISBN 0-7432-2457-4.
33. Ward, Rachel (2008), "On Robustness Properties of Beta Encoders and Golden Ratio Encoders", *IEEE Transactions on Information Theory*, **54** (9): 4324–4334, arXiv:0806.1083 (https://arxiv.org/abs/0806.1083), Bibcode:2008arXiv0806.1083W (https://ui.adsabs.harvard.edu/abs/2008arXiv0806.1083W), doi:10.1109/TIT.2008.928235 (https://doi.org/10.1109%2FTIT.2008.928235), S2CID 12926540 (https://api.semanticscholar.org/CorpusID:12926540)
34. Chrisomalis calls the Babylonian system "the first positional system ever" in Chrisomalis, Stephen (2010), *Numerical Notation: A Comparative History* (https://books.google.com/books?id=kXZhBAAAQBAJ&pg=PA254), Cambridge University Press, p. 254, ISBN 9781139485333.