trees. Knuth illustrates the algorithms using programs for an idealized machine: "The machine we use is a mythical computer called MIX.... Like most machines it has an identifying number—the 1009." Knuth arrived at this figure by averaging the identifying numbers of 16 popular computers and writing the result, 1009, using roman numerals. Dedicated students all over the world have programmed emulators of the MIX machine.

Volume II is devoted to *seminumerical algorithms*, algorithms dealing not only with numbers, but also symbols. The topics covered range from random number generators to floating-point notation. Its long discussion of numerical bases (decimal, binary, and others) is still one of the best available. Volume III deals with algorithms for sorting and searching. The most popular methods are handled here, and there are long discussions about the best way to sort information on tapes, disks, or memory.

Never one to sit idle, Knuth has already announced that Volume IV (*Combinatorial Algorithms*), divided in three subvolumes, will be ready around 2004. Volume V (*Syntactic Algorithms*) will be finished in 2009. Partial drafts of these works are already available through the Internet. Knuth pays U.S.$2.56 to anyone who first reports an error in his books, because 256 cents are equivalent to a "hexadecimal dollar" (16 times 16—instead of 10 times 10—cents).

Donald Knuth received the Turing Award in 1974. The citation, awarded by the **Association for Computing Machinery**, refers to **TeX**, his computerized typesetting system, but it is safe to say that Knuth was known to most programmers because of *The Art of Computer Programming*.

FURTHER READING

Knuth, Donald. *The Art of Computer Programming*, Vols. 1–3, 3rd ed. Reading, Mass.: Addison-Wesley, 1997.

—Raúl Rojas

ASCII

Alphanumerical characters must be translated for computers into sequences of binary digits (**bits**). Early computers used various conventions to represent letters and other symbols until some standard coding methods emerged. One of them, and the most popular today, is the American Standard Code for Information Interchange (ASCII), which represents symbols using seven bits (and in some instances, eight).

PLAIN ASCII TABLE

	0000	0001	0010	0011	0100	0101	0110	0111
0000	NUL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	)	8	H	X	h	x
1001	HT	EM	(	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	-	]	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	_	o	DEL

ASCII was defined in the 1960s and became a U.S. government standard in 1968, when it was defined by the **American National Standards Institute** (ANSI) as ANSI Standard x3.4. Internationally, it has also been referred to as ISO 636. To deal with other languages, the ASCII code has been extended by computer manufacturers, sometimes in incompatible ways.

Some ASCII characters are not printable; they are used as commands for the computer screen. Their names were coined according to their former use in teletypes. The character NUL, for example, was used as a filler after a carriage return (CR) to give the teletype printing head enough time to move to the beginning of the next line. The character ESC was used to "escape" from a transmission that had failed due to a misconnection. It is used now as the command of last resort to escape from a program that is crashing or has fallen into an unpredictable state.

The characters shown in the accompanying table are the original ASCII set (often referred to as *plain*

ASCII). To deal with symbols needed for other languages, some extensions of the ASCII code have been proposed by various computer manufacturers (*extended ASCII*). The label of each column shows the most significant four bits of the ASCII code for a character, the label of each row shows the four least significant bits. The ASCII code can be obtained by linking the column bits to the row bits. Thus the ASCII code for the character "A" is 0100 0001. Note that in plain ASCII only the seven least significant bits are used; the eighth bit is always zero if a byte is used to store the character.

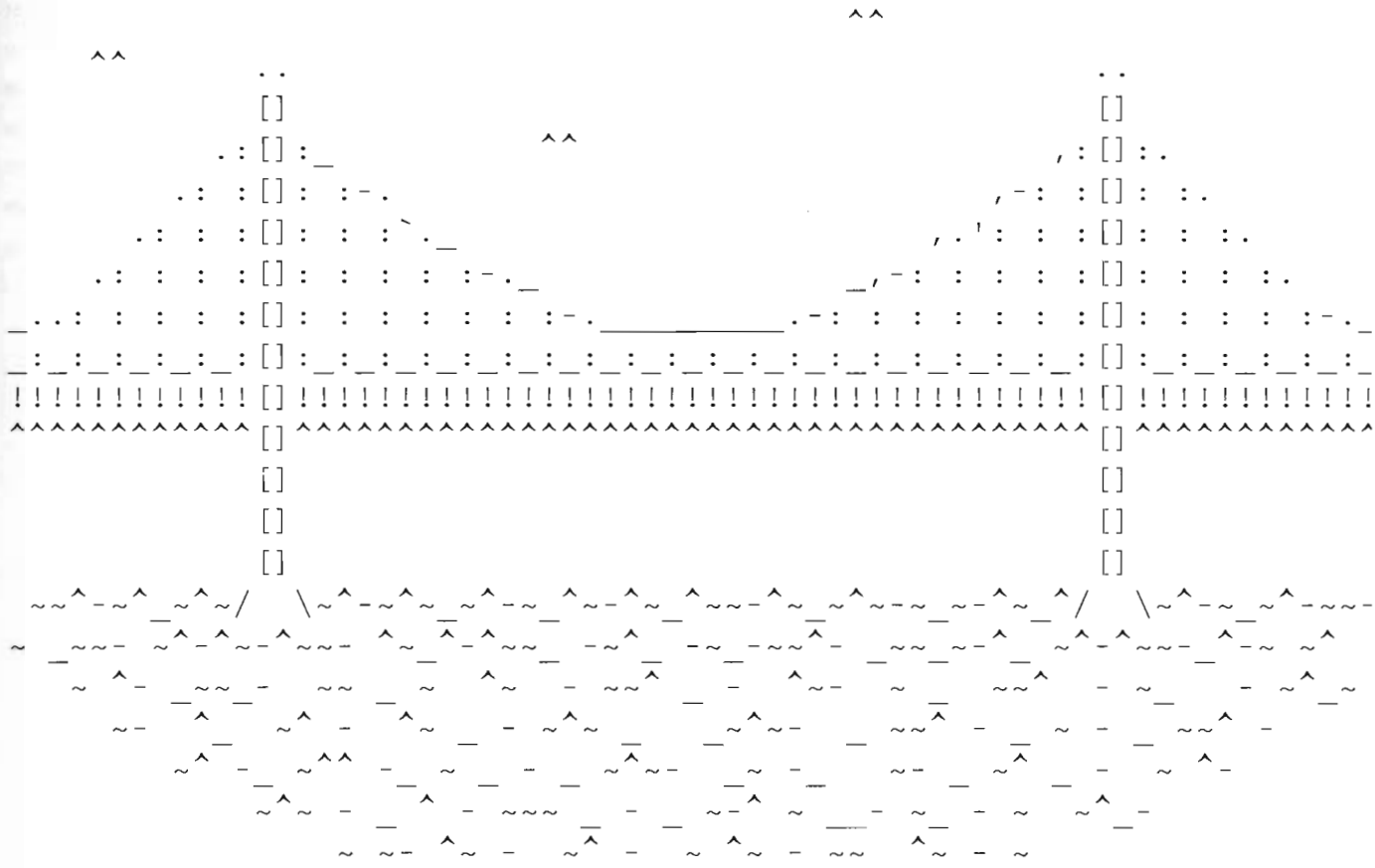
—*Raúl Rojas*

ASCII Art

ASCII art is a form of computer artwork that uses the alphanumerical characters defined by the American Standard Code for Information Interchange (ASCII) to create drawings, charts, cartoons, and pictures without actually using graphics (see figure). For this reason, ASCII art has been called *nongraphical graphics*.

ASCII art developed from typography and later, after the birth of the typewriter in 1867, from typewriter art. After E. Remington and Sons began manufacturing typewriters in 1874, they were soon being used not only for writing but also for creating pictures. The first competitions for typewriter drawing were held as early as 1890, and typewriter art continued to grow in popularity up until the 1970s. Text images were later sent via teletype or RTTY (radio teletype), developed around 1900 for the purpose of transferring text between two ham operators via radio or telephone lines. Drawings transmitted over teletype are done in capital letters and sent with roughly 45 bauds on long paper tapes.

ASCII art took off at the onset of the **Internet** era. Shortly after the **ARPANET** was established in the



ASCII suspension bridge, created by Joan Stark (www.ascii-art.com).