

Decimal Codes

Using the ten symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
how many 4-symbol codes such as 0487 and 3056 can you make?

USPS Codes (United States Postal Service)

Uses 65 symbols, each being one of these four: 

Example:



(Some checks have the same code on them.)

Using the four symbols 
how many 65-symbol codes can you make?

$$4^{65} = 1.36 \times 10^{39}$$

(10,000 trillion for every star in the Universe)

Binary Codes

Using the two symbols 0, 1
how many 7-symbol codes such as 0100110 and 1110010 can you make?

$$2^7 = 128$$

ASCII Codes for symbols on the keyboard (American Standard Code for Information Interchange)

Decimal	Binary	ASCII	Decimal	Binary	ASCII	Decimal	Binary	ASCII
32	0100000	(space)	64	1000000	@	96	1100000	~
33	0100001	!	65	1000001	A	97	1100001	a
34	0100010	"	66	1000010	B	98	1100010	b
35	0100011	#	67	1000011	C	99	1100011	c
36	0100100	\$	68	1000100	D	100	1100100	d
37	0100101	%	69	1000101	E	101	1100101	e
38	0100110	&	70	1000110	F	102	1100110	f
39	0100111	'	71	1000111	G	103	1100111	g
40	0101000	(	72	1001000	H	104	1101000	h
41	0101001	)	73	1001001	I	105	1101001	i
42	0101010	*	74	1001010	J	106	1101010	j
43	0101011	+	75	1001011	K	107	1101011	k
44	0101100	,	76	1001100	L	108	1101100	l
45	0101101	-	77	1001101	M	109	1101101	m
46	0101110	.	78	1001110	N	110	1101110	n
47	0101111	/	79	1001111	O	111	1101111	o
48	0110000	0	80	1010000	P	112	1110000	p
49	0110001	1	81	1010001	Q	113	1110001	q
50	0110010	2	82	1010010	R	114	1110010	r
51	0110011	3	83	1010011	S	115	1110011	s
52	0110100	4	84	1010100	T	116	1110100	t
53	0110101	5	85	1010101	U	117	1110101	u
54	0110110	6	86	1010110	V	118	1110110	v
55	0110111	7	87	1010111	W	119	1110111	w
56	0111000	8	88	1011000	X	120	1111000	x
57	0111001	9	89	1011001	Y	121	1111001	y
58	0111010	:	90	1011010	Z	122	1111010	z
59	0111011	;	91	1011011	[	123	1111011	{
60	0111100	<	92	1011100	\	124	1111100	|
61	0111101	=	93	1011101	]	125	1111101	}
62	0111110	>	94	1011110	^	126	1111110	~
63	0111111	?	95	1011111	_	127	1111111	DEL

96 of the 128 possible 7-bit symbols. (The other 32 are for control like **DEL**.)

You can enter them into a document by holding the ALT key and typing a four-digit number on the right number pad. For example, [is 0091.

YouTube Codes

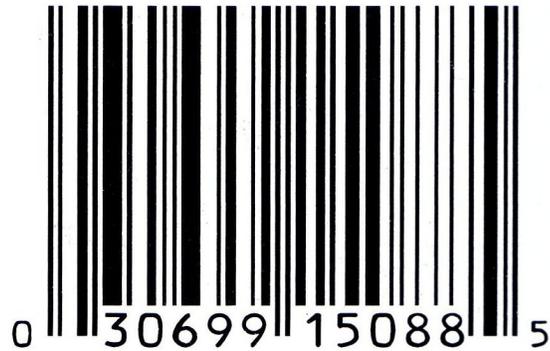
Example: <https://www.youtube.com/watch?v=-cs303ToBY8>

To the right of the "=" sign there are eleven ASCII symbols.
How many different codes are possible?

$$96^{11} = 6,382,393,305,518,410,039,296$$

(900 billion for each person on Earth)

Universal Product Codes (UPC)



LEFT		RIGHT	
0 = 0	0 0 1 1 | 0 1	0 = 1	1 1 0 0 | 1 0
1 = 0	0 1 1 0 | 0 1	1 = 1	1 0 0 1 | 1 0
2 = 0	0 1 0 0 | 1 1	2 = 1	1 0 1 1 | 0 0
3 = 0	1 1 1 1 | 0 1	3 = 1	0 0 0 0 | 1 0
4 = 0	1 0 0 0 | 1 1	4 = 1	0 1 1 1 | 0 0
5 = 0	1 1 0 0 | 0 1	5 = 1	0 0 1 1 | 1 0
6 = 0	1 0 1 1 | 1 1	6 = 1	0 1 0 0 | 0 0
7 = 0	1 1 1 0 | 1 1	7 = 1	0 0 0 1 | 0 0
8 = 0	1 1 0 1 | 1 1	8 = 1	0 0 1 0 | 0 0
9 = 0	0 0 1 0 | 1 1	9 = 1	1 1 0 1 | 0 0
	| info bits |		| info bits |

1 is represented a black line, and a 0 by a white line. So, starting at the left, we have 101|0001101. The first three bits (101) are sync bits. The next 7 (0001101) are the code for the digit 0.

Note that codes for the LEFT numbers (030699 in this example) are the same as the codes for the RIGHT numbers (150885), except that 0s become 1s, and 1s become 0s.

Codes on the LEFT have an odd number of 1s, and codes on the RIGHT have an even number of 1s, thanks to the bits in the sixth column, called the parity bits. They enable error detection if one error in the number's code causes an even number of 1's on the left or an odd number of 1s on the right.

The 101 patterns on extreme left and right, and the 01010 pattern in the middle are sync patterns for measuring the speed of the scan (to know how many 1s a wide black bar represents). The first and last bits in each number form 01 or 10 patterns, which are also sync patterns.

How many products can be uniquely identified by the UPC bar code?

There are 12 decimal symbols (030699150885 in the example above), each represented by 7 binary symbols. Then the number of possible UPC codes is

$$10^{12} = 1 \text{ trillion (140,000 for each person on Earth)}$$

Four info bits in each UPC block are under-used in representing one of 10 digits; four bits can represent 16 different symbol. The base-sixteen number system is called "hexadecimal," or "hex" for short. They are represented by the symbols

0 1 2 3 4 5 6 7 8 9 a b c d e f

If the info bits represented hexadecimal symbols rather than decimal symbols, there could be

$$16^{12} = 281,474,976,710,656$$

different UPC codes (281 times as many). But hexadecimal symbols would not be as easily read by a human as decimal numbers.