Representation

CSCI 2330

Data Representation

- Bases: 2, 10, and 16
- Logical and Bitwise Operators
- Integers: Signs and …not
- Floating Point numbers
- Textual Data (ASCII)

Number Systems

Hex	Decimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Binary to Decimal (base 10)

1	0	1	0	1	0	1	0	binary
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	decimal

128 + 32 + 8 + 2 = 170

Binary to Hex (base 16)

$8 + 2 = A_{16}$ **$8 + 2 = A_{16}$** **AA_{16}**

Example

Hex	Decimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Write 42 (base 10) as…

- hexadecimal (base 16) **0x2a**
- binary (base 2) **00101010b**

Exercises 1–4

Boolean Algebra

Logical vs. Bitwise Operators (C)

Operation	Logical	Bitwise
AND	&&	&
OR	||	|
NOT	!	~

1 && 0 = FALSE **1 & 0 = 0**

10 && 4 = TRUE **1010 & 0010 = 0** !

The Big Three

Bitwise AND “&”

x	y	q
0	0	0
0	1	0
1	0	0
1	1	1

Bitwise OR “|”

x	y	q
0	0	0
0	1	1
1	0	1
1	1	1

Bitwise NOT “~”

x	q
0	1
0	1

Shifty Operators

Shift Left “<<”

Number	<<	q
00000101	<< 2	00010100
00000000	<< 6	00000000
10000000	<< 1	00000000
00010000	<< 3	10000000

Shift Right “>>”

Number	>>	q
00000101	>> 2	00000001
00000000	>> 6	00000000
10000000	>> 1	11000000
00010000	>> 3	00000010

Bouns

Bitwise XOR

x	y	q
0	0	0
0	1	1
1	0	1
1	1	**0**

Bitwise NAND

x	y	q
0	0	1
0	1	1
1	0	1
1	1	0

Exercises 5–8

Data Sizes

Data Type	Bytes
char	1
short	2
int	4
long	8
float	4
double	8

Integers

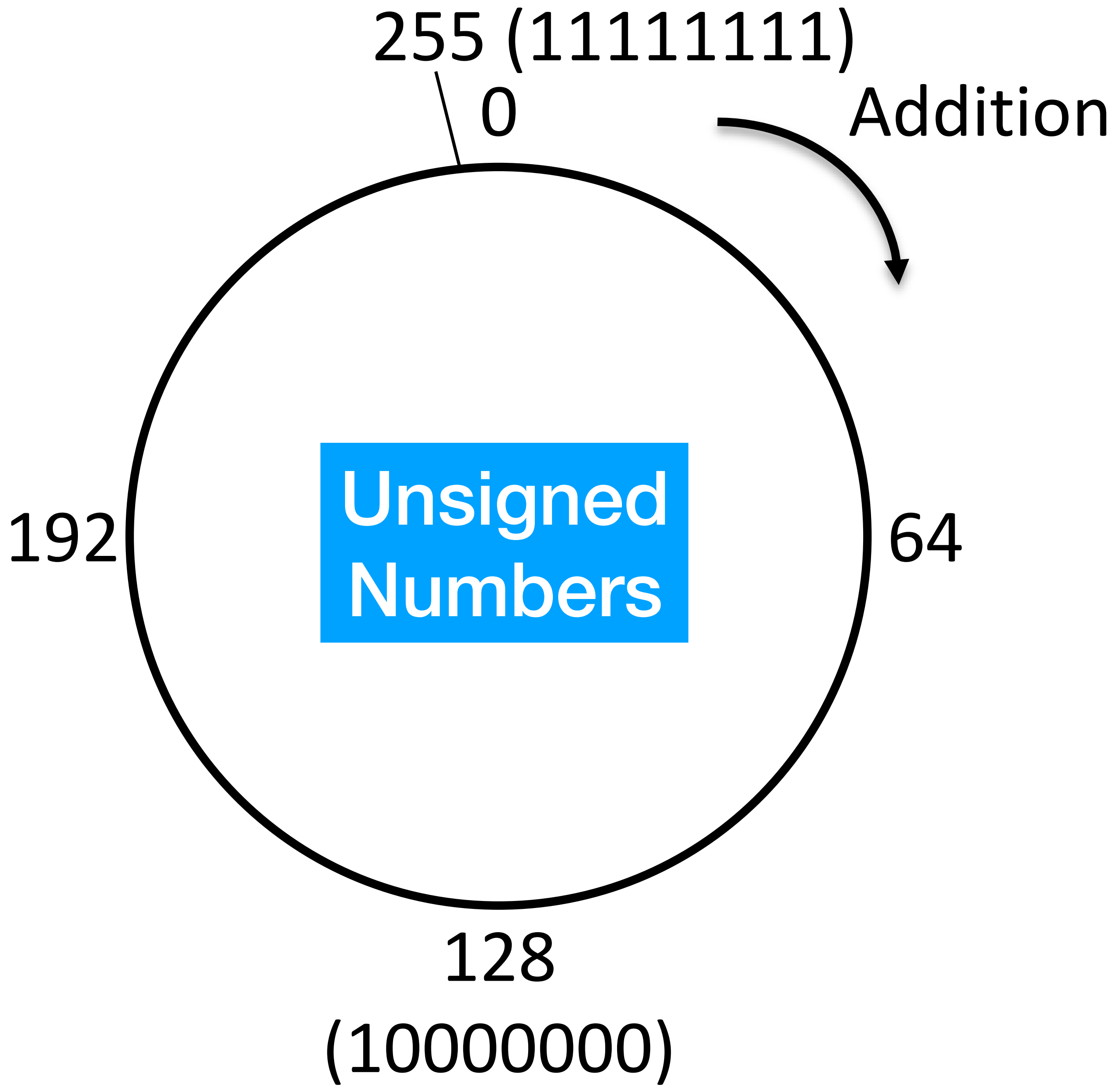
Binary Addition

```
  1
  0110      6
 +0100    + 4
 ------   ----
  1010     10
```

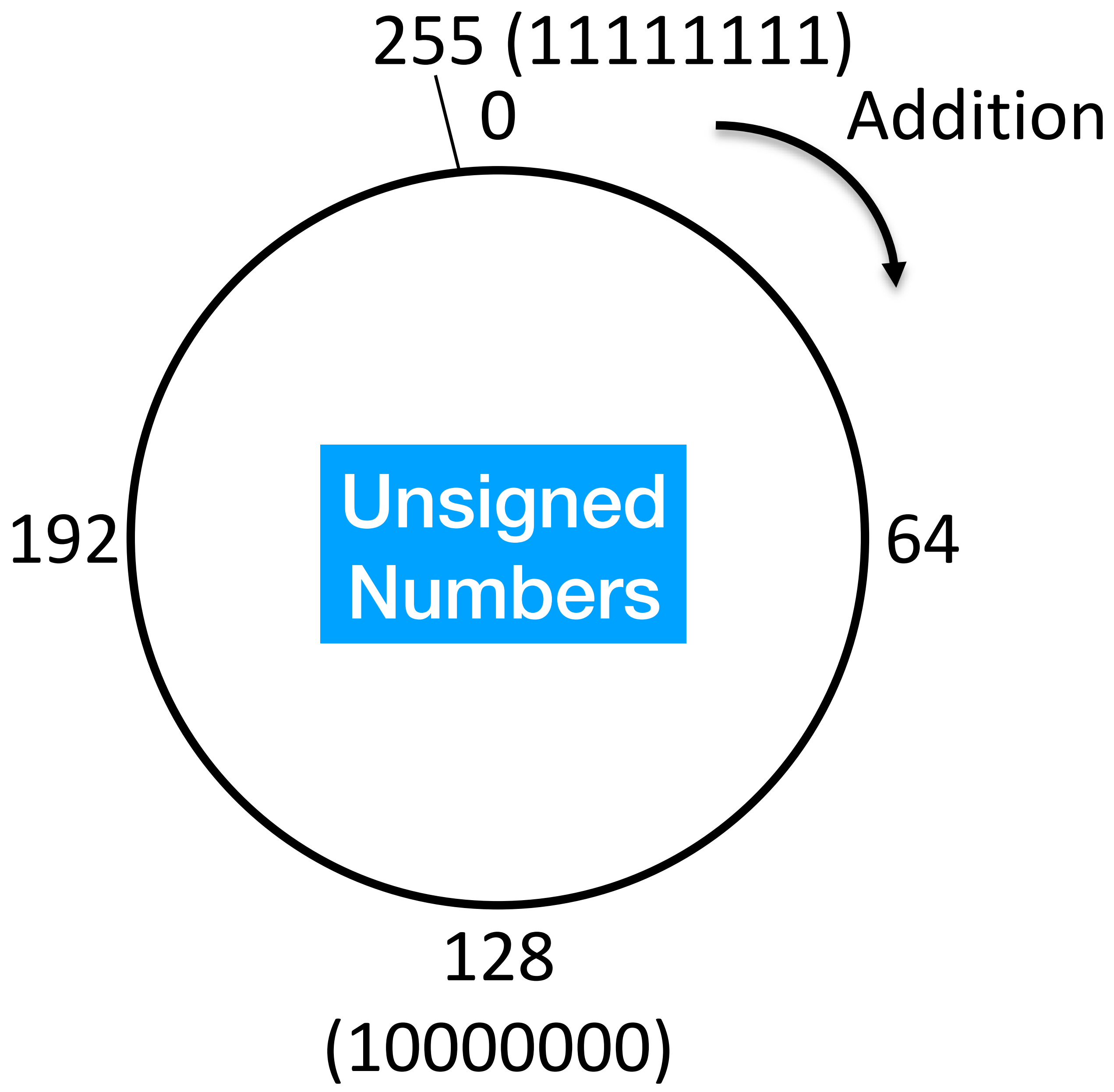
```
    1010     10
 +  1001   +  9
 -------   ----
   10011     19
```

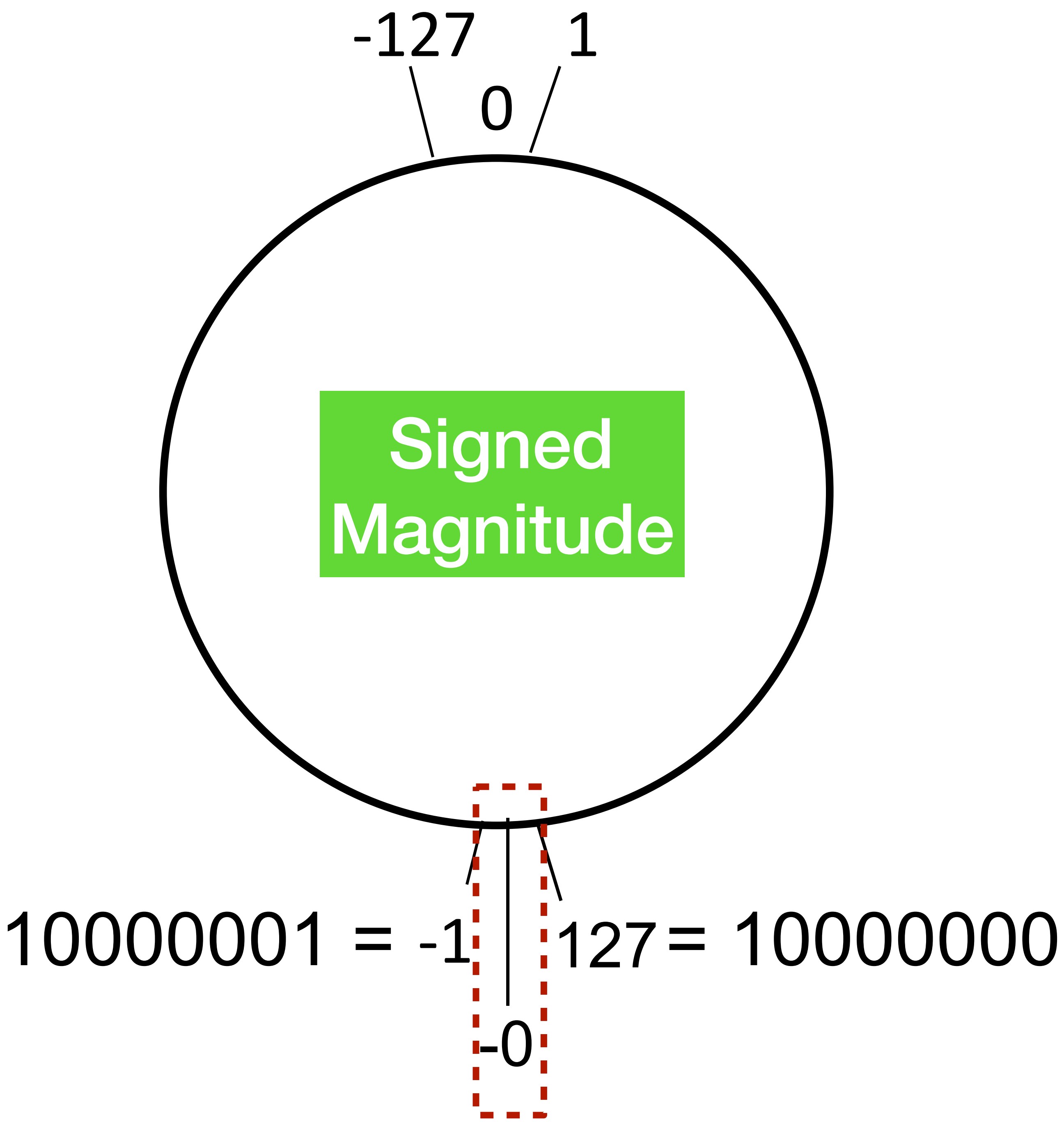
Overflow!

Integers

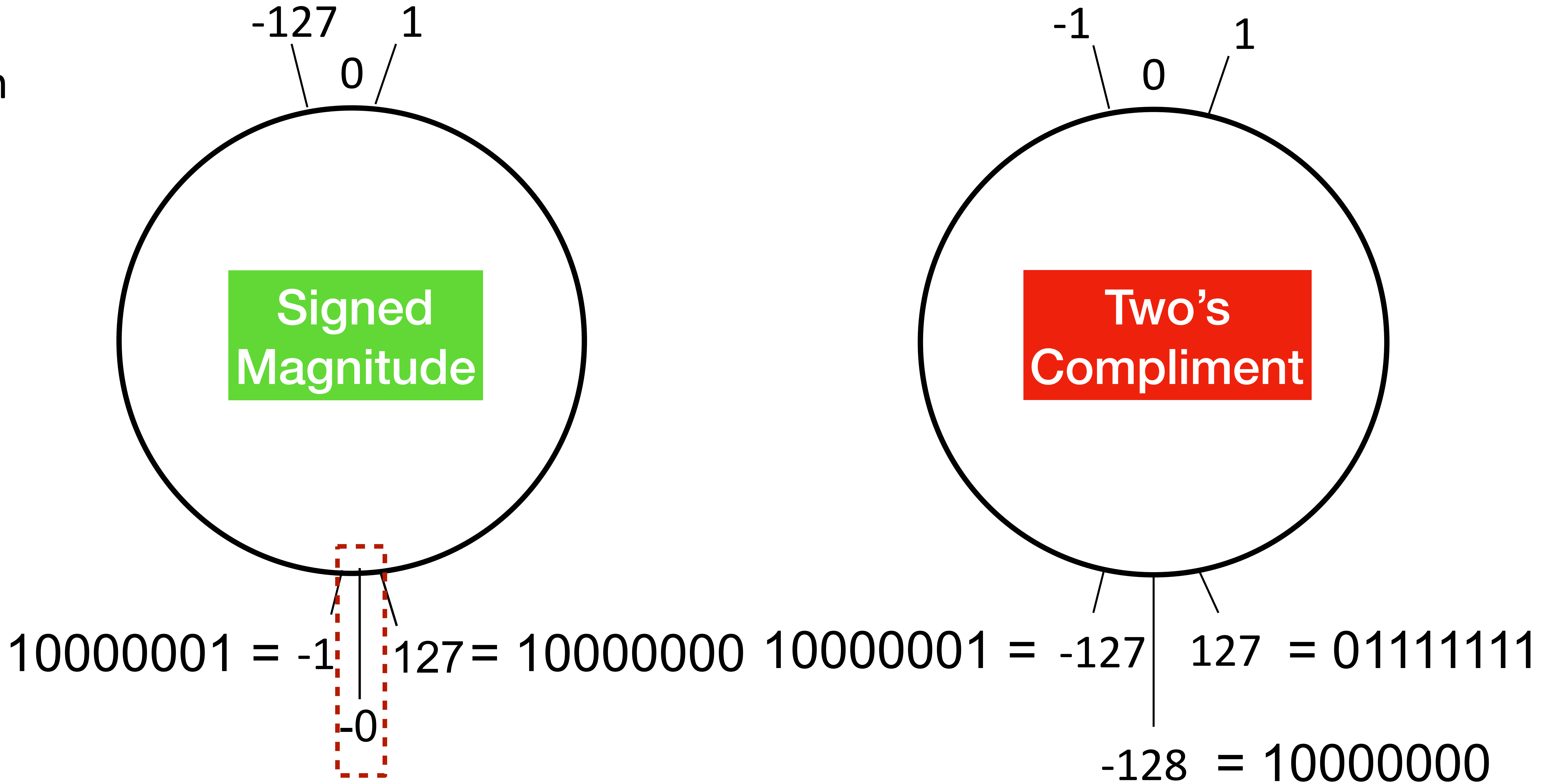

255 (11111111)
0
Addition
Unsigned Numbers
192
64
128
(10000000)

Integers


255 (11111111)
0
Addition
192
Unsigned Numbers
64
128
(10000000)


-127
1
0
Signed Magnitude
10000001 = -1
127 = 10000000
-0

Integers



-127

0

1

Signed Magnitude

10000001 = -1

-0

127= 10000000

-1

0

1

Two's Compliment

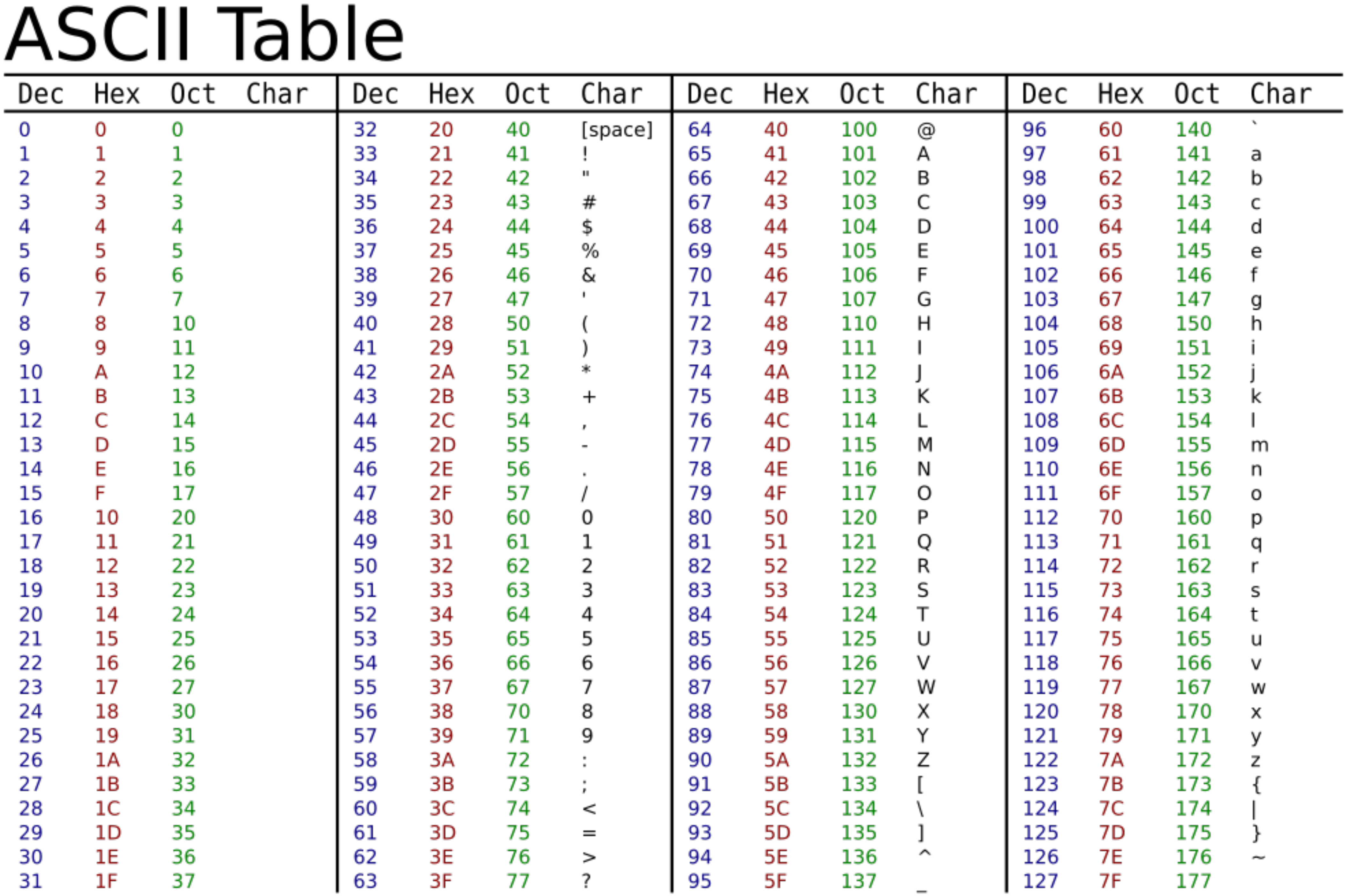
10000001 = -127

127 = 01111111

-128 = 10000000

Floating Point

Text ASCII



ASCII Table

Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char	Dec	Hex	Oct	Char
0	0	0		32	20	40	[space]	64	40	100	@	96	60	140	`
1	1	1		33	21	41	!	65	41	101	A	97	61	141	a
2	2	2		34	22	42	"	66	42	102	B	98	62	142	b
3	3	3		35	23	43	#	67	43	103	C	99	63	143	c
4	4	4		36	24	44	$	68	44	104	D	100	64	144	d
5	5	5		37	25	45	%	69	45	105	E	101	65	145	e
6	6	6		38	26	46	&	70	46	106	F	102	66	146	f
7	7	7		39	27	47	'	71	47	107	G	103	67	147	g
8	8	10		40	28	50	(	72	48	110	H	104	68	150	h
9	9	11		41	29	51	)	73	49	111	I	105	69	151	i
10	A	12		42	2A	52	*	74	4A	112	J	106	6A	152	j
11	B	13		43	2B	53	+	75	4B	113	K	107	6B	153	k
12	C	14		44	2C	54	,	76	4C	114	L	108	6C	154	l
13	D	15		45	2D	55	-	77	4D	115	M	109	6D	155	m
14	E	16		46	2E	56	.	78	4E	116	N	110	6E	156	n
15	F	17		47	2F	57	/	79	4F	117	O	111	6F	157	o
16	10	20		48	30	60	0	80	50	120	P	112	70	160	p
17	11	21		49	31	61	1	81	51	121	Q	113	71	161	q
18	12	22		50	32	62	2	82	52	122	R	114	72	162	r
19	13	23		51	33	63	3	83	53	123	S	115	73	163	s
20	14	24		52	34	64	4	84	54	124	T	116	74	164	t
21	15	25		53	35	65	5	85	55	125	U	117	75	165	u
22	16	26		54	36	66	6	86	56	126	V	118	76	166	v
23	17	27		55	37	67	7	87	57	127	W	119	77	167	w
24	18	30		56	38	70	8	88	58	130	X	120	78	170	x
25	19	31		57	39	71	9	89	59	131	Y	121	79	171	y
26	1A	32		58	3A	72	:	90	5A	132	Z	122	7A	172	z
27	1B	33		59	3B	73	;	91	5B	133	[	123	7B	173	{
28	1C	34		60	3C	74	<	92	5C	134	\	124	7C	174	|
29	1D	35		61	3D	75	=	93	5D	135	]	125	7D	175	}
30	1E	36		62	3E	76	>	94	5E	136	^	126	7E	176	~
31	1F	37		63	3F	77	?	95	5F	137	_	127	7F	177	