

Numbering Systems

Review of Decimal System

Binary Numbering System

⌘ Decimal to binary conversion:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Power of 2
					1	0	1	0	1	0	0	1	1	1	1	
X_{15}	X_{14}	X_{13}	X_{12}	X_{11}	X_{10}	X_9	X_8	X_7	X_6	X_5	X_4	X_3	X_2	X_1	X_0	

Data Organization

0



3 2 1 0



7 6 5 4 3 2 1 0



USASCII code chart

					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b ₃	b ₂	b ₁	b ₀	Column								
				Row	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	\$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0



31 23 15 7 0



31 23 15 7 0



~~High~~. Word
Upper

~~Low~~. Word
Lower

Hexadecimal Numbering System

Binary	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

⌘ Base 16

⌘ Conversion from Hex to Binary

⌘ Representation of values in different bases

Practice

	Binary	Hexadecimal	Decimal
1.	100	_____	_____
2.	10101101	_____	_____
3.	1101110101	_____	_____
4.	11111011110	_____	_____
5.	10000000001	_____	_____
6.	_____	8EF	_____
7.	_____	10	_____
8.	_____	A52E	_____
9.	_____	70C	_____
10.	_____	6BD3	_____
11.	_____	_____	100
12.	_____	_____	527
13.	_____	_____	4128
14.	_____	_____	11947
15.	_____	_____	59020

Practice

Numbering Systems - 2

	Binary	Hexadecimal	Decimal
1.	100	_____	_____
2.	10101101	_____	_____
3.	1101110101	_____	_____
4.	11111011110	_____	_____
5.	10000000001	_____	_____
6.	_____	8EF	_____
7.	_____	10	_____
8.	_____	A52E	_____
9.	_____	70C	_____
10.	_____	6BD3	_____
11.	_____	_____	100
12.	_____	_____	527
13.	_____	_____	4128
14.	_____	_____	11947
15.	_____	_____	59020

$$16^0 = 1$$

$$16^1 = 16$$

$$16^2 = 256$$

$$16^3 = 4096$$

$$16^4 = 65,536$$

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

Practice

	Binary	Hexadecimal	Decimal
1.	100	_____	_____
2.	10101101	_____	_____
3.	1101110101	_____	_____
4.	11111011110	_____	_____
5.	10000000001	_____	_____
6.	_____	8EF	_____
7.	_____	10	_____
8.	_____	A52E	_____
9.	_____	70C	_____
10.	_____	6BD3	_____
11.	_____	_____	100
12.	_____	_____	527
13.	_____	_____	4128
14.	_____	_____	11947
15.	_____	_____	59020

$$16^0 = 1$$

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

Logical and Arithmetic Operations

⌘ Logical Operation

⌘ Arithmetic Operation

Signed and Unsigned Numbers

⌘ Pos -> Neg number Conversion:

How to make out a negative number ?

⌘ Neg -> Pos number Conversion

How to find the value of the number with sign=1 ?

⌘ The range of signed numbers in a given number of bits

$$-2^{n-1} \sim (2^{n-1})$$

$$0 \sim (2^n - 1)$$

	Signed Number Range	Unsigned Number Range
8-bit (Byte)	-128 ~ +127	0 ~ 255
16-bit (Word)	-32,768 ~ + 32,767	0 ~ 65,535
32-bit (DWord)	-2,147,483,648 ~ + 2,147,483,647	0 ~ 4,294,967,295

Practice for Signed Numbers

Answers in Hexadecimal number

⌘ Find the 8-bit expression for each of the following decimal numbers

☒ (a) 23

☒ (b) - 100

⌘ Find the 16-bit expression for each of the following decimal numbers

☒ (a) 15000

☒ (c) -923

⌘ Find the 32-bit expression for each of the following decimal numbers

☒ (a) 3874

☒ (b) - 100

Practice for Signed Numbers

- ⌘ Find the decimal equivalent of each of the following 8-bit hexadecimal numbers
 - ☒ (a) 7C
 - ☒ (b) E1
- ⌘ Find the decimal equivalent of each of the following 16-bit hexadecimal numbers
 - ☒ (a) 6F20
 - ☒ (c) B64A
- ⌘ Find the decimal equivalent of each of the following ~~16~~³²-bit hexadecimal numbers
 - ☒ (a) 98C2417D
 - ☒ (b) FFFFFFF78

Signed and Unsigned Numbers

Computers are nonchalant.

⌘ Why 2's (or 16's) Complement in Signed numbers?

⌘ Assembly Mnemonic

⌘ NOTE



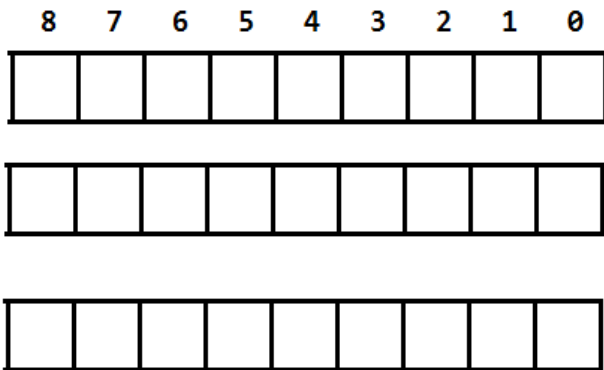
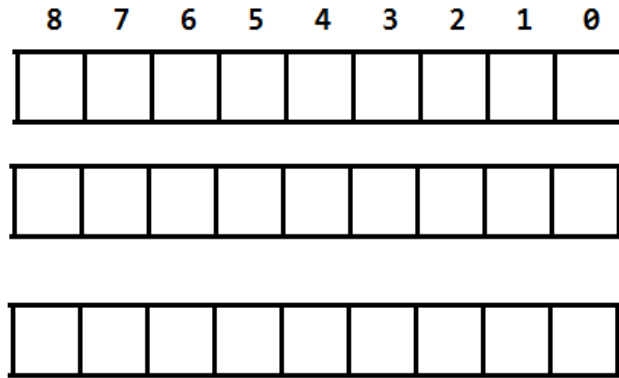
USASCII code chart

Bits					0 0 0 0	0 0 0 1	0 0 1 0	0 0 1 1	0 1 0 0	0 1 0 1	0 1 1 0	0 1 1 1
b ₃	b ₂	b ₁	b ₀	Column	0	1	2	3	4	5	6	7
Row	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
1	0	0	0	1	SOH	DC1	!	1	A	Q	o	q
2	0	0	1	0	STX	DC2	"	2	B	R	0	r
3	0	0	1	1	ETX	DC3	#	3	C	S	1	s
4	0	1	0	0	0	4	D	T	4	T	2	t
5	0	1	0	1	1	5	E	U	5	U	3	u
6	0	1	1	0	2	6	F	V	6	V	4	v
7	0	1	1	1	3	7	G	W	7	W	5	w

Context Example

python

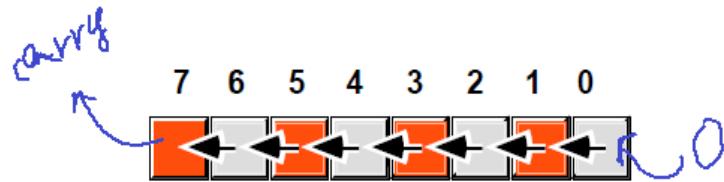
```
>>> 0x8a
138
>>> hex(138)
'0x8a'
>>>
```



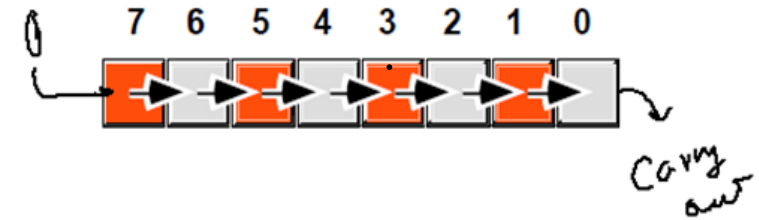
Sign Extension - for Signed Numbers

Zero Extension for Unsigned Numbers

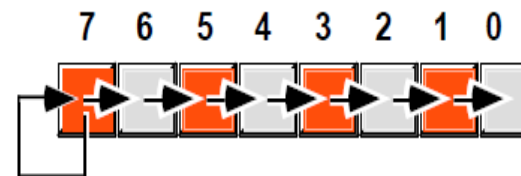
Shift Left - Operation



Shift Right - Operation



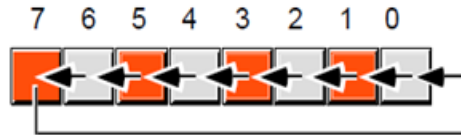
Arithmetic Shift Right - Operation



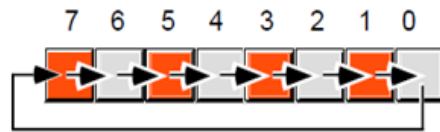
Rotate Operation

Example

Rotate Left:



Rotate Right



USASCII code chart

b ₇ b ₆ b ₅ b ₄ Bits		Column				Row						
		b ₇	b ₆	b ₅	b ₄	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	\$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL