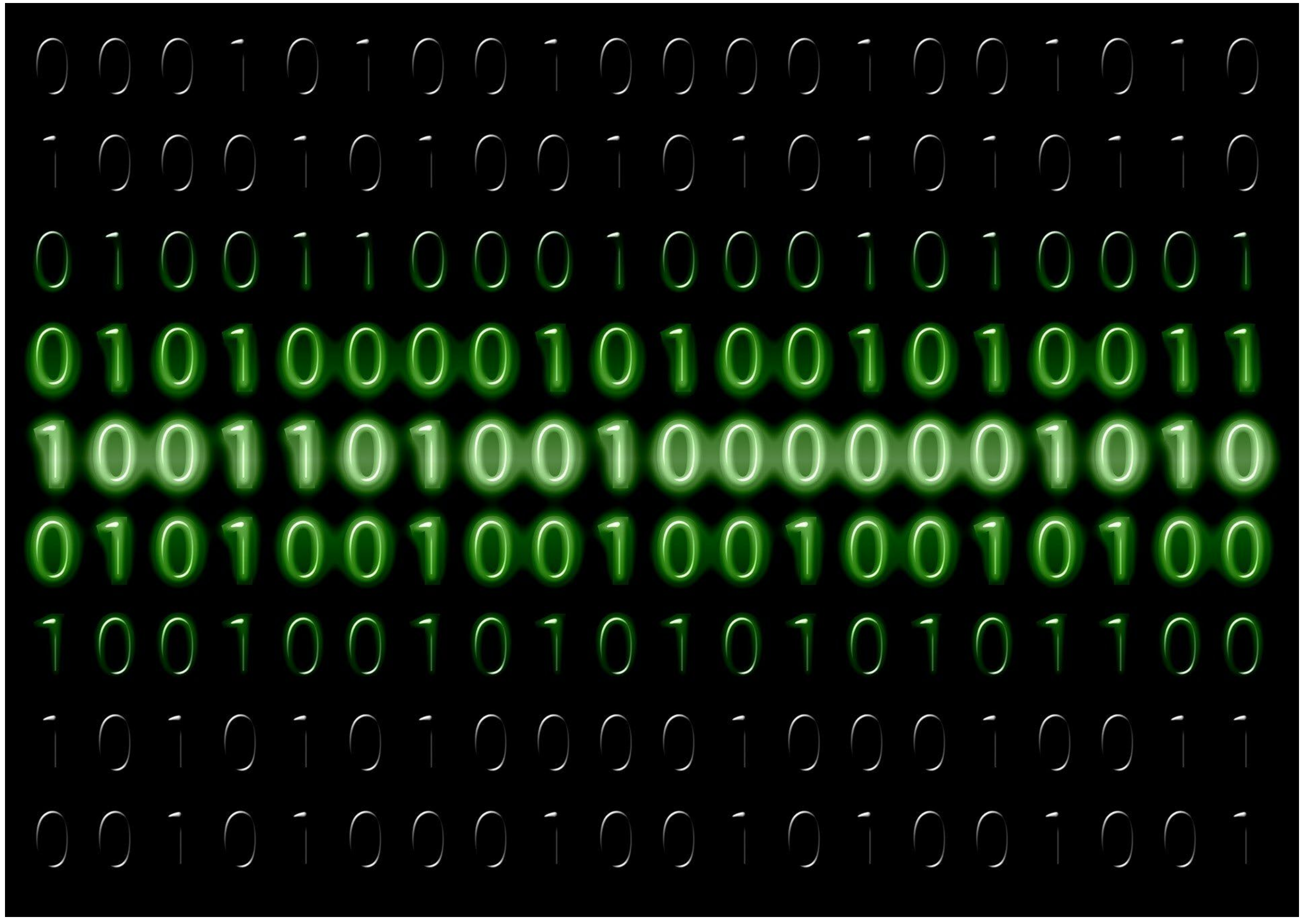
P524: Survey of Instrumentation and Laboratory Techniques

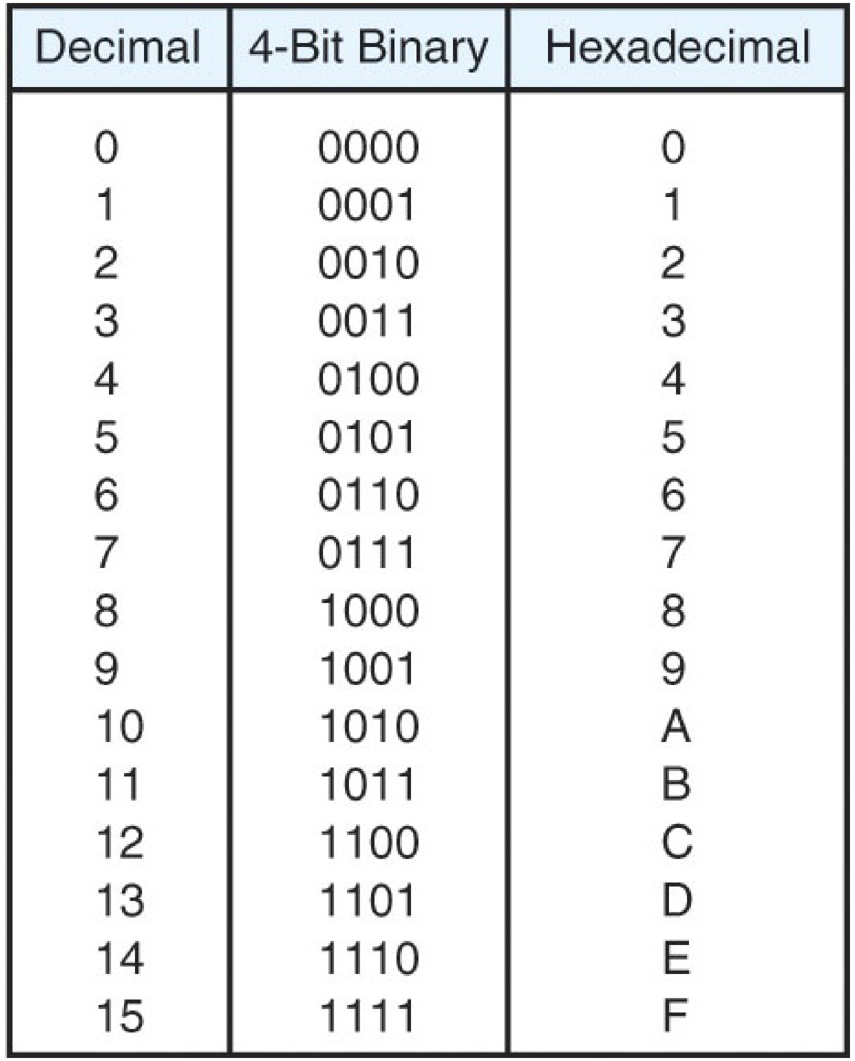
Week 2 (1b):Python programming

Digital Computer



- Digital electronics devices store and process bits electronically.
  - A ***bit*** represents data using 1s and 0s
  - Eight bits is a ***byte*** – the standard grouping in digital electronics
  - 64-bit machines (your laptop computer), corresponding to eight-byte words.

Number Representation



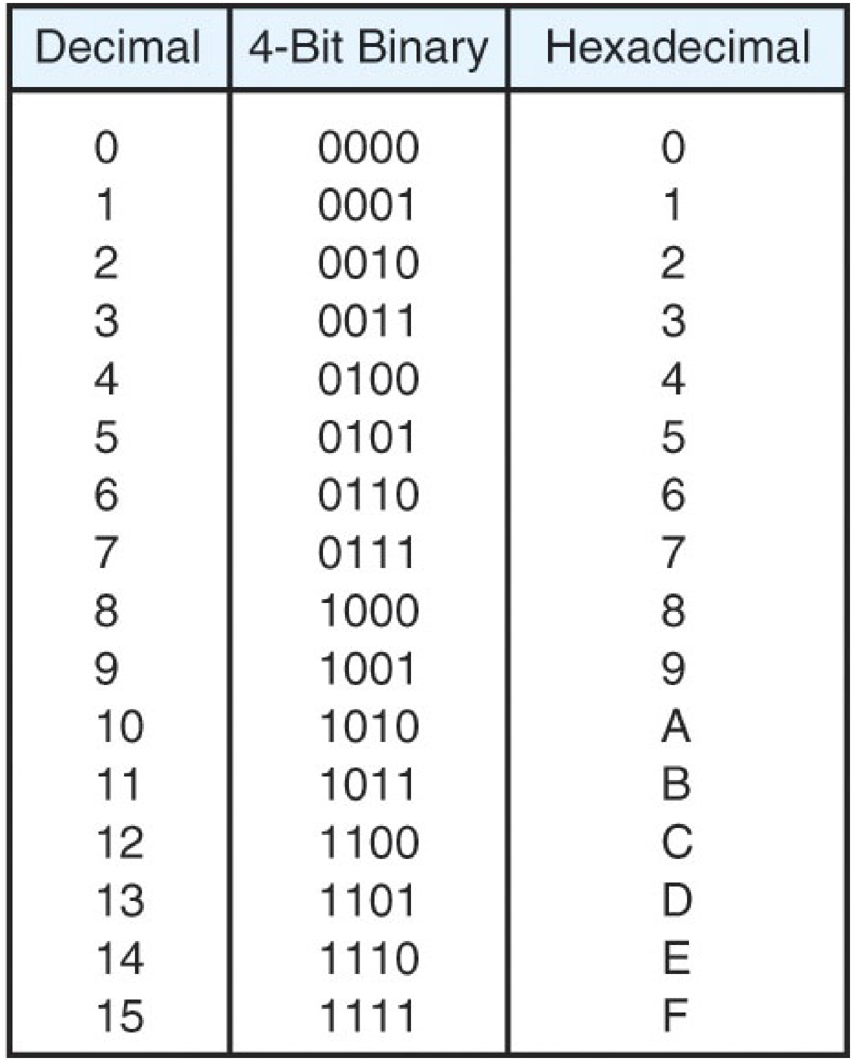
Decimal	4-Bit Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Decimal representation:

Place:	4th	3rd	2nd	1st
Place value:	10^3	10^2	10^1	10^0
Data:	0	0	1	3

Value: 0x1000+0x100+ 1x10+3x1= 13

Number Representation



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14	1110	E
15	1111	F

Binary representation:

Place:	4th	3rd	2nd	1st	
Place value:	2^3	2^2	2^1	2^0	
Data:	1	1	0	1	
Value:	1x8	+ 1x4	+ 0x2	+ 1x1	= 13

Bit, bytes, and words

- Digital electronics devices store and process bits electronically.
  - A bit represents data using 1s and 0s
  - Eight bits is a byte – the standard grouping in digital electronics
  - Hexadecimal representation of a number by preceding the hex digits with 0x

  e.g. Show that the number 63 can be represented as follows:
  0x3F = 0b00111111 = 0d63

- bytes are grouped together to form words. The number of bytes per word depends on the architecture of a particular memory or processor chip; common values are two, four, and eight bytes per word.
  - Most of your laptops are 64-bit machines, corresponding to eight-byte words.

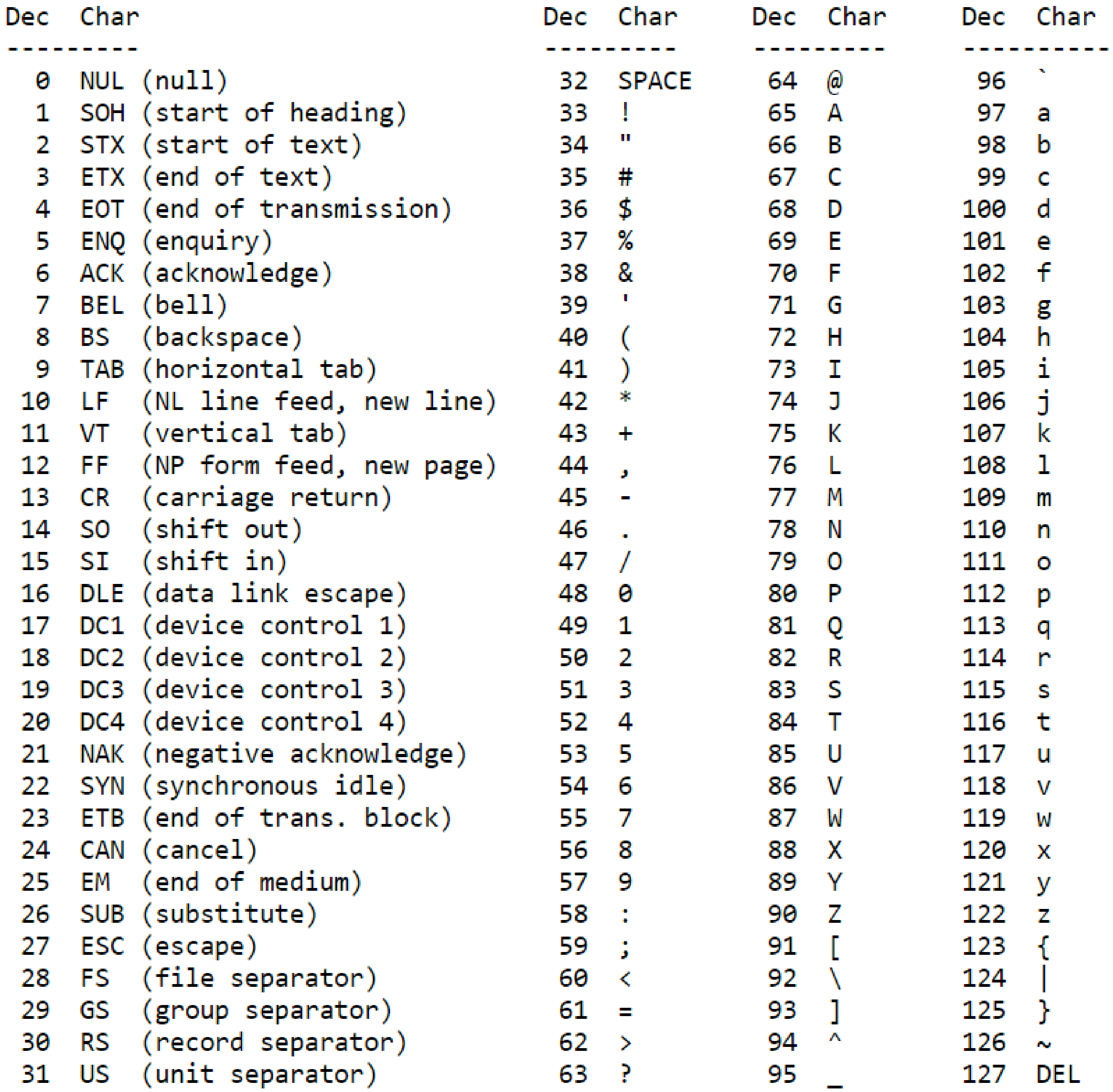
ASCII table

ASCII stands for American Standard Code for Information Interchange.

On the right is the ASCII character table, including descriptions of the first 32 characters.

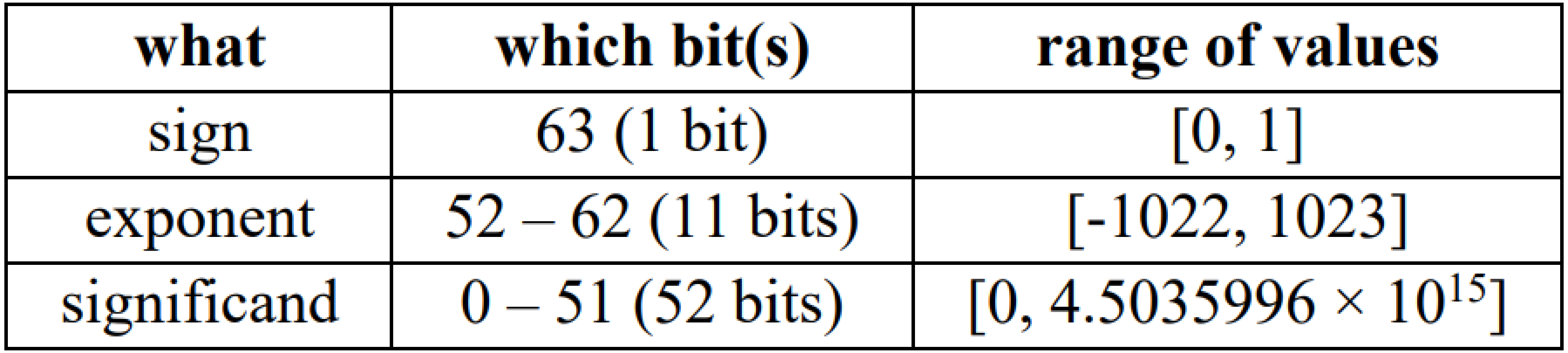
ASCII was originally designed for use with teletypes, and so the descriptions are somewhat obscure and their use is frequently not as intended.

Java actually uses Unicode, which includes ASCII and other characters from languages around the world.



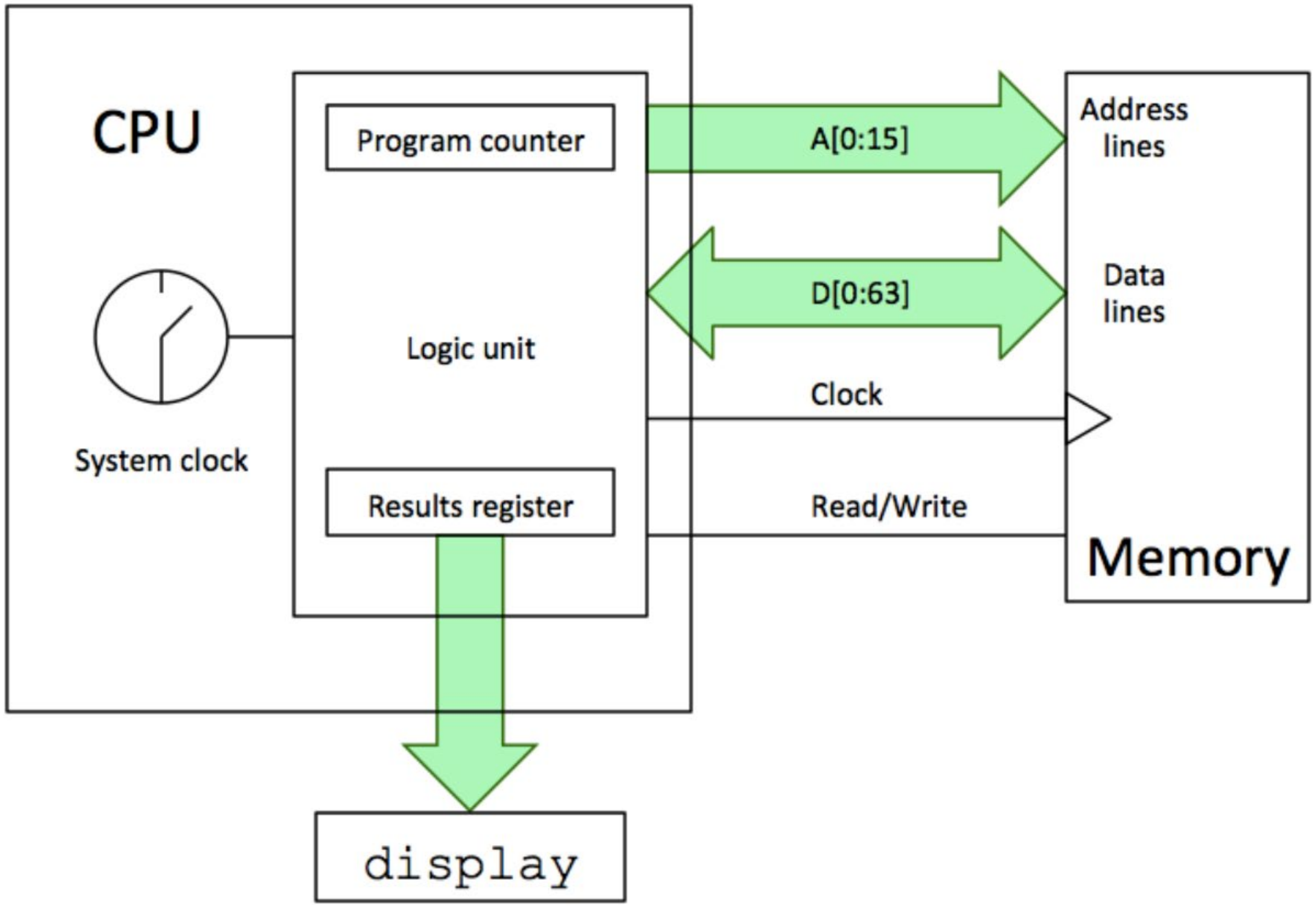
Dec	Char	Dec	Char	Dec	Char	Dec	Char
0	NUL (null)	32	SPACE	64	@	96	`
1	SOH (start of heading)	33	!	65	A	97	a
2	STX (start of text)	34	"	66	B	98	b
3	ETX (end of text)	35	#	67	C	99	c
4	EOT (end of transmission)	36	$	68	D	100	d
5	ENQ (enquiry)	37	%	69	E	101	e
6	ACK (acknowledge)	38	&	70	F	102	f
7	BEL (bell)	39	'	71	G	103	g
8	BS (backspace)	40	(	72	H	104	h
9	TAB (horizontal tab)	41	)	73	I	105	i
10	LF (NL line feed, new line)	42	*	74	J	106	j
11	VT (vertical tab)	43	+	75	K	107	k
12	FF (NP form feed, new page)	44	,	76	L	108	l
13	CR (carriage return)	45	-	77	M	109	m
14	SO (shift out)	46	.	78	N	110	n
15	SI (shift in)	47	/	79	O	111	o
16	DLE (data link escape)	48	0	80	P	112	p
17	DC1 (device control 1)	49	1	81	Q	113	q
18	DC2 (device control 2)	50	2	82	R	114	r
19	DC3 (device control 3)	51	3	83	S	115	s
20	DC4 (device control 4)	52	4	84	T	116	t
21	NAK (negative acknowledge)	53	5	85	U	117	u
22	SYN (synchronous idle)	54	6	86	V	118	v
23	ETB (end of trans. block)	55	7	87	W	119	w
24	CAN (cancel)	56	8	88	X	120	x
25	EM (end of medium)	57	9	89	Y	121	y
26	SUB (substitute)	58	:	90	Z	122	z
27	ESC (escape)	59	;	91	[	123	{
28	FS (file separator)	60	<	92	\	124	|
29	GS (group separator)	61	=	93	]	125	}
30	RS (record separator)	62	>	94	^	126	~
31	US (unit separator)	63	?	95	_	127	DEL

A floating point number (64-bit, or 8 byte)



what	**which bit(s)**	**range of values**
sign	63 (1 bit)	[0, 1]
exponent	52 – 62 (11 bits)	[-1022, 1023]
significand	0 – 51 (52 bits)	[0, 4.5035996×10^{15}]

A simple model of a computer



- The model of a computer includes a simple CPU, including its communication lines and one register, a part of the CPU that communicates with the outside world.

- Each time the system clock “ticks,” the Logic unit fetches, then executes an instruction from the memory address specified in the Program counter.

- Instructions for our toy computer might contain three fields: *an operation code* (op code) and *a pair of addresses a1 and a2*. To add the contents of a1 to the contents of a2, storing the result in a2, we’d have the operating system load an instruction into memory with the appropriate op code and address values.

In-class assignment and Homework (due 9/11)

- Download and install Anaconda Scientific Python (https://www.anaconda.com/download)

- Write a Python script that calculates an approximation to π using the arctan series (see 1b write-up, p.22), and compare its accuracy after the *n* = 10 term, 100 term, 10,000 term, and 1,000,000 term. (Use a conditional statement to print something after the appropriate terms.)

- (email finished programs to jcl11@illinois.edu)