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CSCI 150
Introduction to Digital and Computer System Design
Lecture 1: Digital Information Representations III

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Overview

- Focus: Number Systems
- Architecture: Digital Circuits
- Textbook v4: Ch1 1.4, 1.5, 1.6; v5: Ch1 1.5, 1.6, 1.7
- Core Ideas:

  1. Alphanumeric Codes, ASCII, UTF8, Parity Bit
  2. Lecture 1 Review

P0
Review

Number Systems

- Base N number systems
- Binary, Octal, Hexadecimal systems
- Arithmetics, Conversions
- Signed and Unsigned Integers
- Bit, Byte, Representation ranges

Review

Alphanumeric Codes

Decimal Codes, ASCII, UTF8, Parity Bit

Summary

Binary Coded Decimal

- Decimal numbers, each digit represented in 4bit binary, but separately
- 185 = $(0001\ 1000\ 0101)_{BCD} = (10111001)_2$
- Used in places where using decimals directly is more convenient, such as digital watches etc.

Binary Coded Decimal

			Original Decimal	
Carry		1	1	0
		4	4	8
	+	4	8	9
Sum		9	3	7

Demo

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Alphanumerics

Binary Coded Decimal

In BCD

BCD Carry		1	**1**	1	**1**	0	**0**
		4	**0100**	4	**0100**	8	**1000**
	+	4	**0100**	8	**1000**	9	**1001**
BCD Sum		9	**1001**	3	**0011**	7	**0111**

Demo

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Alphanumerics

Binary Coded Decimal

In BCD

BCD Carry		1	1	1	1	0	0
		4	0100	4	0100	8	1000
	+	4	0100	8	1000	9	1001
BCD Sum		9	1001	3	0011	7	0111

$(0100\ \ 0100\ \ 1000)_{BCD} + (0100\ \ 1000\ \ 1001)_{BCD} = (1001\ \ 0011\ \ 0111)_{BCD}$

Demo

ASCII

- American Standard Code for Information Interchange
- Assign each character with a 8bit binary code (e.g. '0'-'9', 'A'-'Z', 'a'-'z')
- The first bit is always 0

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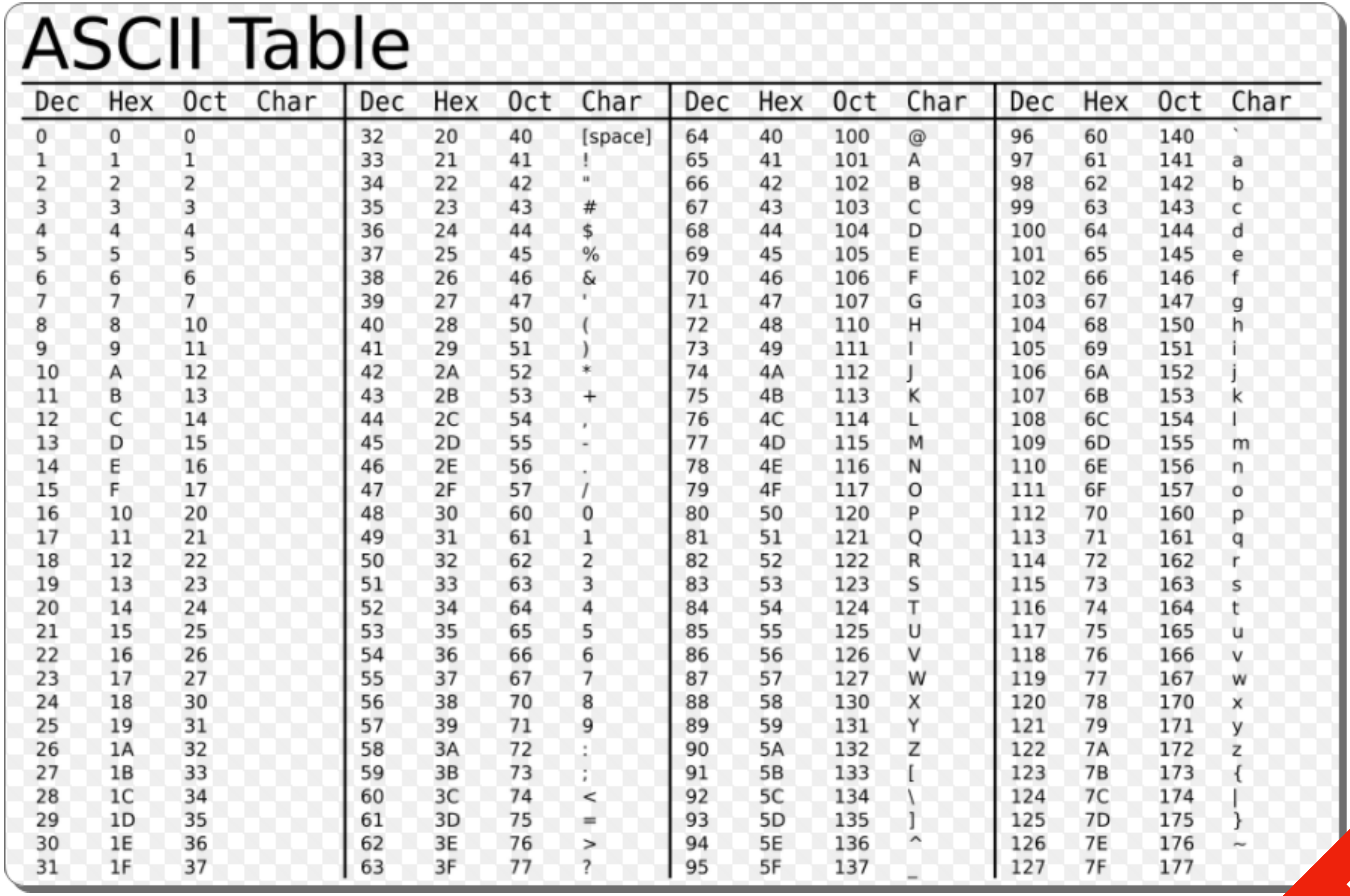
Alphanumerics

ASCII

'0' = 48
'A' = 65
'a' = 97
0-31: control chars



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	

1. https://3.bp.blogspot.com/-EmmXIc6wNRI/WauyBOCusUI/AAAAAAAAAk8/Wodt0iDmaQowu3XuaHcIGCVes-75E7URgCLcBGAs/s1600/ASCII%2Bcode.png

Demo

ASCII

- Content of `1.txt` on your hard disk (if encoded with ASCII)
  - Text: Hello
  - `Hex: 4865 6C6C 6F0A          // 0A is the end of file symbol`
  - `Bin: 01001000 01100101 01101100 01101100 01101111 00001100`

Demo

UTF8

- Unicode Transformation Format
- Extends ASCII with more characters, including accented letters (e.g. ’Ä’, 'Ö', 'Ü'), most languages (e.g. Chinese), and emoji
- Variable width character encoding (8bit to 32bit)
- First 128 characters of Unicode exactly the same as ASCII
  - valid ASCII text is valid UTF-8-encoded Unicode

Demo

UTF8

Number of bytes	Bits for code point	First code point	Last code point	Byte 1	Byte 2	Byte 3	Byte 4
1	7	U+0000	U+007F	0xxxxxxx			
2	11	U+0080	U+07FF	110xxxxx	10xxxxxx		
3	16	U+0800	U+FFFF	1110xxxx	10xxxxxx	10xxxxxx	
4	21	U+10000	U+10FFFF	11110xxx	10xxxxxx	10xxxxxx	10xxxxxx

Demo

Parity Code

- For error detection in data communication
  - e.g. resulting from packet loss or other forms of interference
- One parity bit for n-bits
  - An extra even parity bit: whether the number of 1s is not even
  - An extra odd parity: whether the number of 1s is not odd
  - Can be placed in any fixed position
  - Does it always work?

Demo

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Alphanumerics

Parity Code

Original 7bits	with Even parity	with Odd parity
1000001	01000001	11000001
1010100	11010100	01010100

Demo

Summary

- Digital representation of strings
  - BCD
  - ASCII, UTF8
  - Parity Code

Review

P2
Review

Lecture 1 Review

With exercises!

Summary

P2
Review

Circuits

- Circuits
  - Digital and Analog
- Integrated systems
  - Von Neumann computers
  - Embedded systems

Review

Number Systems

- Number systems of base N
- Binary systems
- Octal and Hexadecimal systems
- Arithmetics

Review

P0
Review

Number Systems in DC

- Bit, Byte, Representation ranges
- Signed and Unsigned Binary Integers
- BCD, ASCII, UTF8
- Parity bit

Review

P2
DA Conversion

Digital to Analog Conversion

- Frequency: number of cycles per second
- Sample rate: number of samples per unit time
- Bitrate: number of bits per second

Review

P2
Review

Exe 0

- All the exercises in the slides, come up with variations on your own and solve them.
  - Especially conversions

Review

P2
Review

Exe 1

- What is the biggest number representable by the following bits of unsigned binary integers?
  - 10 bits; 24 bits
- How about signed?
- How about signed with parity code?
- What if with BCD?

Review

P2
Review

Exe 2

- Recall in analog-to-digital conversion, the two important factors influencing the resulting quality: sampling rate and bitrate
  - What happens if bitrate is constant, and sampling rate is increased?
  - What happens if sampling rate is constant, and bitrate is increased?

Review

P2
Review

Exe 3

- Without compression and any metadata, estimate the file size of a 5 min audio with the following parameters
  - sampling rate: 44100; bitrate: 192 Kbps
- How many bits for each sample?

Review

P2
Review

Exe 4

- Show the bit configuration that represents the decimal number 240 in

A. binary

B. BCD

C. ASCII

D. ASCII with odd parity

Review