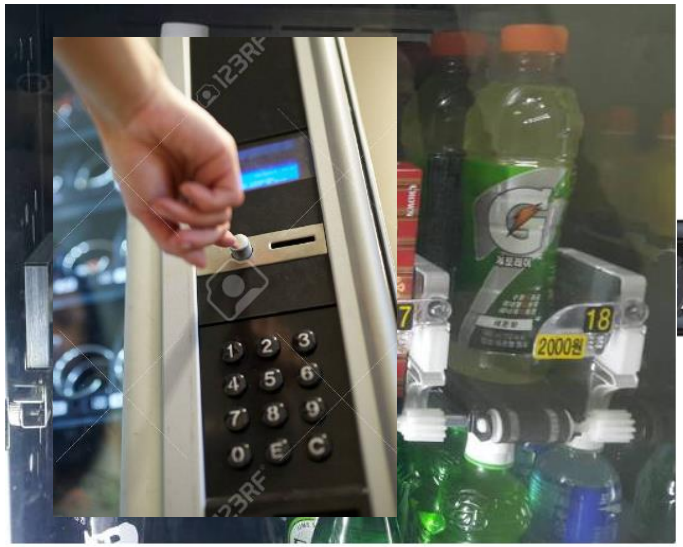
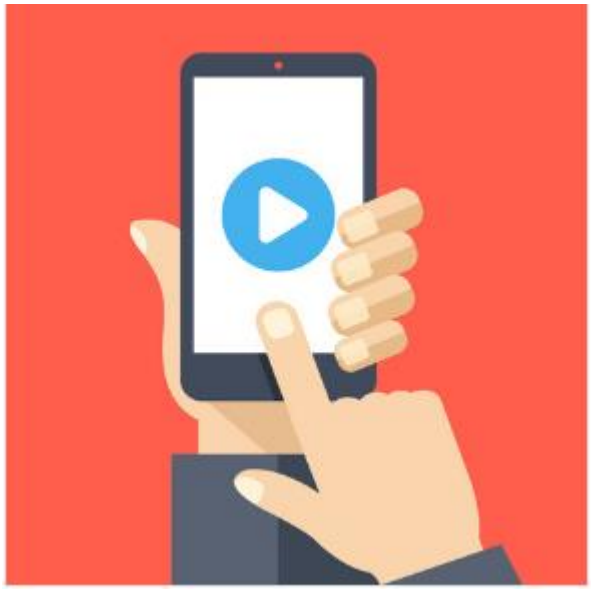
See a Vending Machine







More Friendly,



- How is it realized inside the smartphone? By what procedure?

➔ This course gives a guide & insight for this question.

Chap 1
Digital Systems and Binary Numbers

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Digital System

- Definition: System designed to store, process, and communicate information in digital form.
- Information in digital form?
- It represents & manipulates information with binary number
- Examples of digital systems
  - Smartphone, Personal Computer, …
  - Almost all electronic devices you can imagine!
- Consider your smartphone or simply, vending machine

What We Will Learn in This Course

- All forms of information are converted or mapped into digital signals represented by binary codes

➔ **Why?**

- To operate a target function, the digital system will convert the binary coded inputs into the binary coded outputs

➔ **How?**

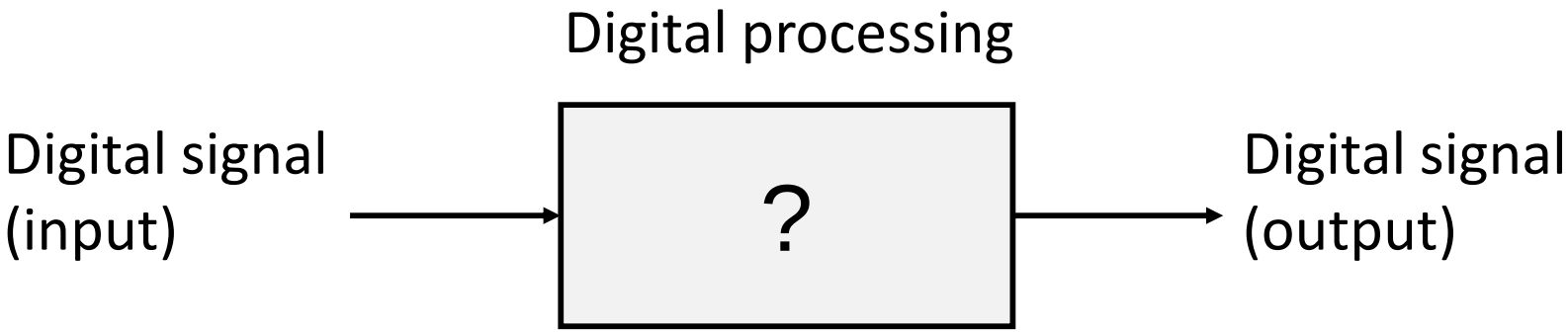
- A digital system is an interconnection of digital modules, and a digital module is designed with digital circuit

➔ **How can you design a digital circuit *accurately* and *efficiently*?**

What is Binary Number?

- 53 vs. $(110101)_2$

Who Does The Following?



We Will Use Electrical Signal!

- There are various kinds of information

➔ Anyway we should differentiate this information in "electrical" way

- With supplying electrical energy, imagine what we can do for achieving such goal.
- Utilizing bits, we can represent infinite kinds of information.

Revisit Vending Machine

- Consider a traditional one which only accepts cash
- Information is represented with **Binary code**



Example: ASCII Character Code

- American Standard Code for Information Interchange (ASCII), which uses seven bits to code 128 characters.

	$b_7b_6b_5$							
$b_4b_3b_2b_1$	000	001	010	011	100	101	110	111
0000	NUL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	“	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	‘	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	–	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	–	o	DEL

Error Detecting Code

- A parity bit is an extra bit included with a message to make the total number of 1's either even or odd

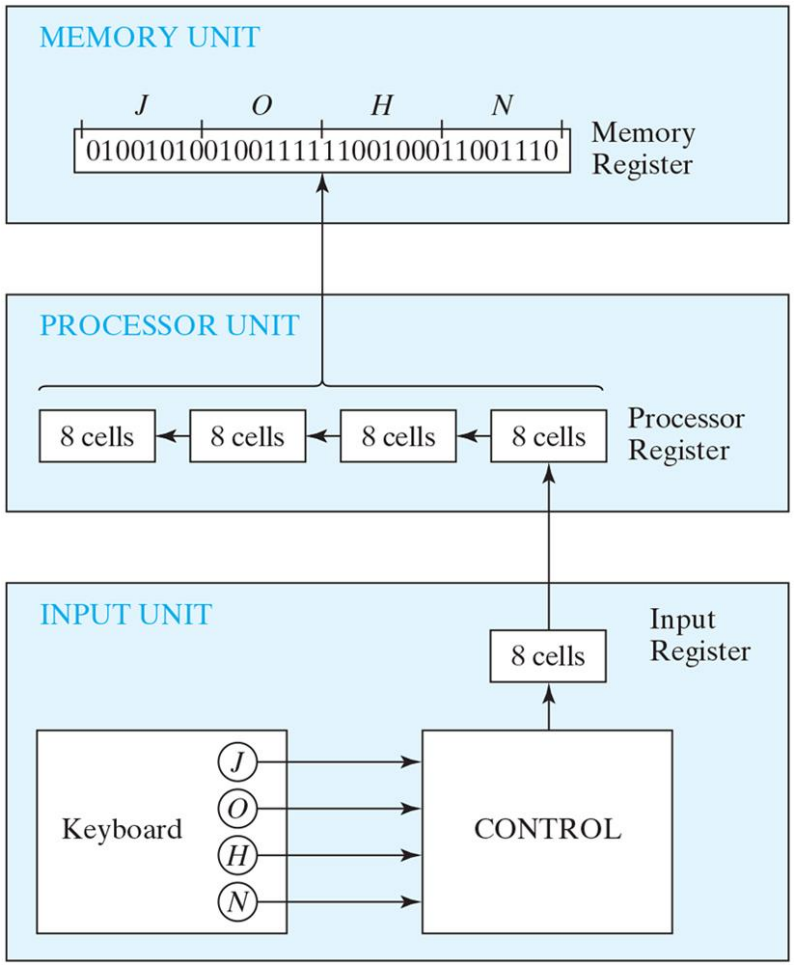
	With even parity	With odd parity
ASCII A = 1000001	01000001	11000001
ASCII T = 1010100	11010100	01010100

Where Can We Store Information?

- There must be a physical existence in some medium for storing individual bits
- A binary cell is a device that possesses two stable states and is capable of storing one bit (0 or 1) of information.
- We need a group of binary cells – **registers** - to represent many kinds of information
  - Ex) 16-bit register can have binary content of 1100001111001001

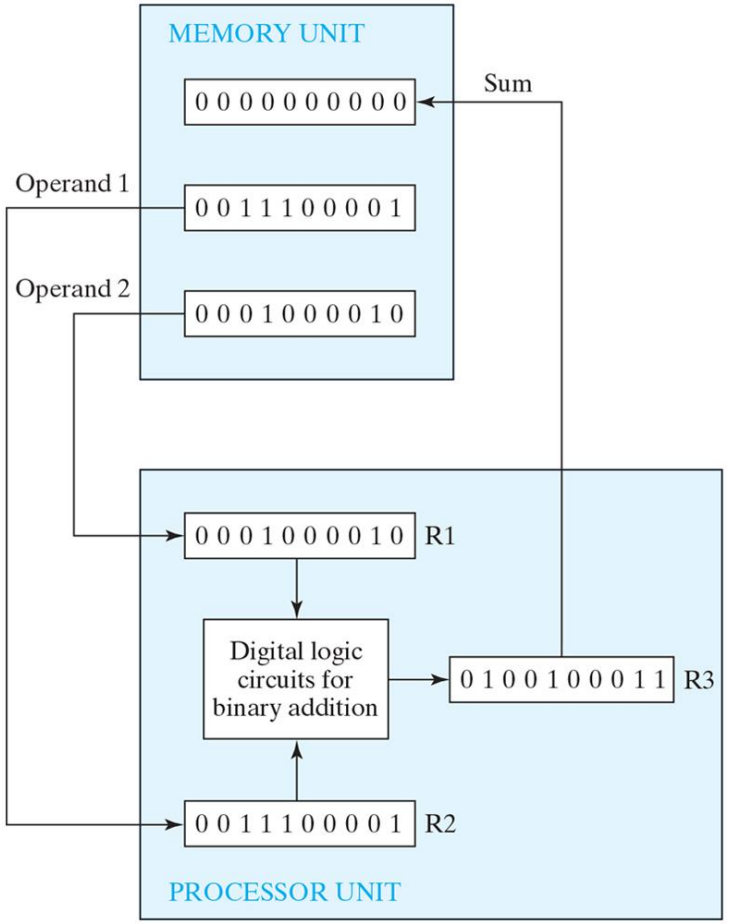
Register Transform

- Transferring of binary information from one set of registers into another set of registers
- ASCII code with odd-parity



Binary Information Processing

- To process binary formed info, a computer must be provided with devices holding the data to be processed ➔ **Register**
- Two data are summed in the figure



Binary Logic (Operation)

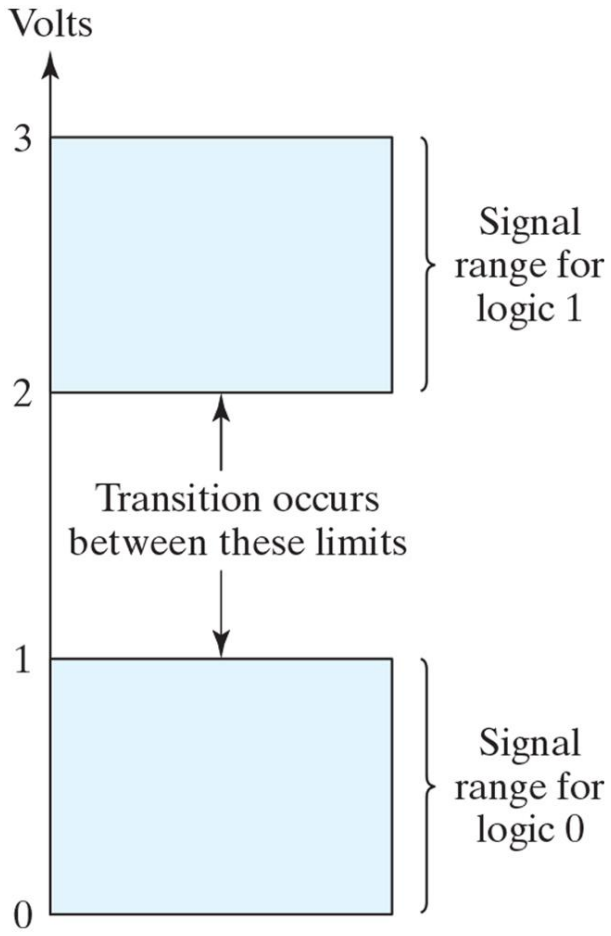
- Why logic? You shall know.
- There are three representative logic operation expressed in **truth tables**.

AND			OR			NOT	
x	y	$x \cdot y$	x	y	$x + y$	x	x'
0	0	0	0	0	0	0	1
0	1	0	0	1	1	1	0
1	0	0	1	0	1		
1	1	1	1	1	1		

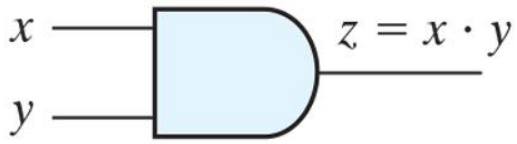
- Don’t confuse binary logic with binary arithmetic

Logic Gates

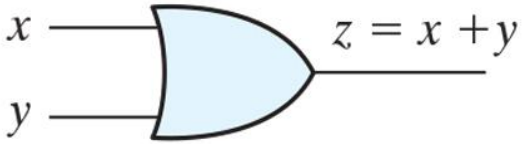
- Logic gates are electronic circuits accepting physical input signals to yield output signal
  ➔ Signals here are actually voltage whose values are over certain given range, ex) 0-3V.
- In the case of 0-3V range, logic 0 is defined as 0V and logic 1 is defined as 3V, typically.



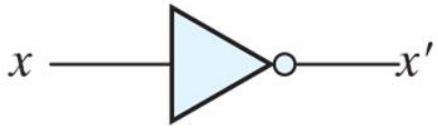
Symbols of the Digital Logic Circuits



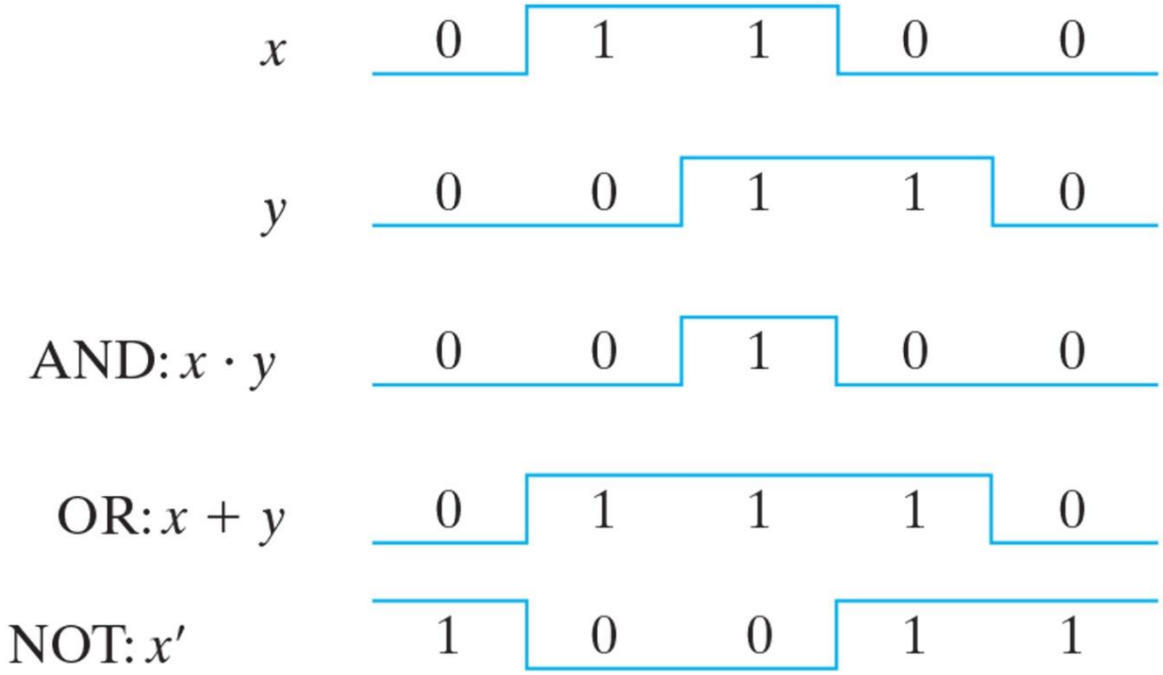
(a) Two-input AND gate



(b) Two-input OR gate

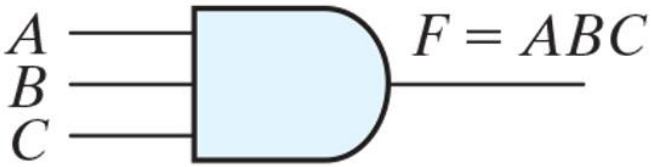


(c) NOT gate or inverter

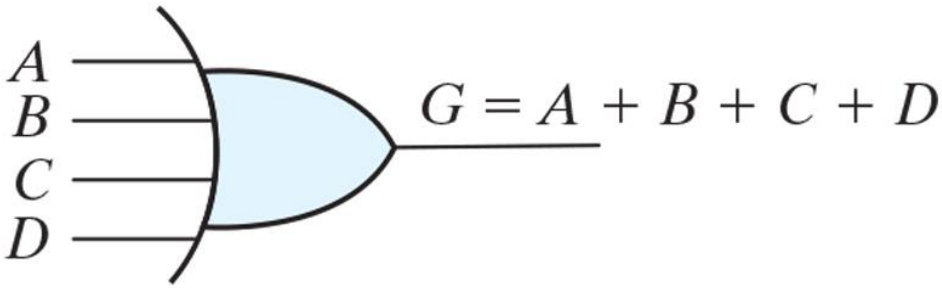


Gates with Multiple Inputs

- What do their truth tables look like?



(a) Three-input AND gate



(b) Four-input OR gate