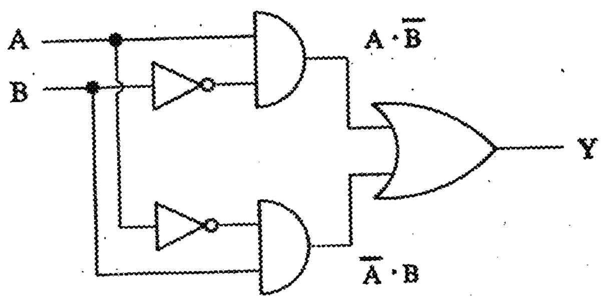
ES 300 H.W. 1 Due Tues. Mar. 8

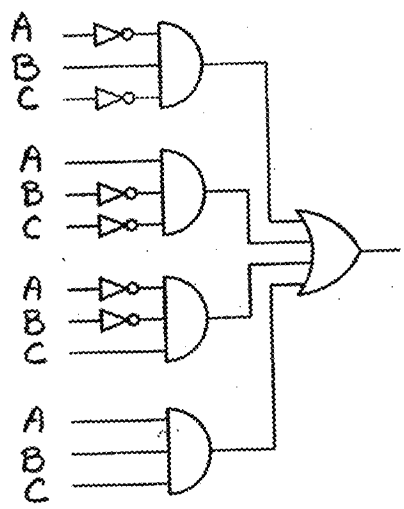
1. Determine the truth table for the following logic circuits:

a)



A	B	Y
0	0	
0	1	
1	0	
1	1	

b)



A	B	C	Y
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

2. Design a combinational logic circuit to control segment "a" of the 7-segment calculator display.

The Digital Information Age

1st Week

This section of ES 300 will describe how & why some common information systems work. Examples will illustrate how engineers think in order to make these systems work reliably & efficiently.

Information commonly exists in digital form.

It appears on
- products - UPC symbol bar codes (universal product code)
- mail - U.S. Postal Service bar codes
- credit & phone cards

Digital information flows over
- wires - facsimile transmission (fax)
- air - cellular telephone, satellite transmission
- internet - email, MP3 (music)

It is stored on: CD's (audio)
DVD's (video)
magnetic disk (computer memory)

The rapid rise of digital information is due largely to advances in digital (i.e. computer) hardware and software.

Hardware includes:
- Integrated circuits which process, store, & retrieve information.
- Sensors which acquire information.
- Converters which digitize analog information.
- Communication channels which transmit information.

Electronic Logic Circuits : the basic building blocks for computer hardware.

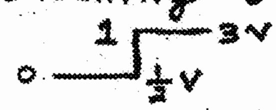
Computers use information in digital form as binary digits or bits, consisting of 0's & 1's.

The binary information is processed with electronic logic circuits.

Electronic Logic Circuits (or Switching Circuits)

Logic circuits can process the binary information from sensors.
For example to control when things turn on or off.
They can also perform the basic operations in a computer.

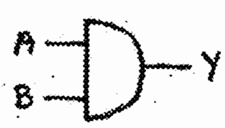
Inputs and outputs of logic circuits are binary, 0 or 1.
Because they are electronic two voltage levels identify 0 or 1.



Gates

The most basic logic circuits are called gates.
They are the AND, OR, and NOT gates.

AND Gate



truth table for the AND gate

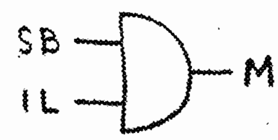
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Y = 1 if A = 1 AND B = 1.

A and B are inputs, Y is the output.

Example : Design a system that prevents a driver from starting a car if his seat belt is not fastened.

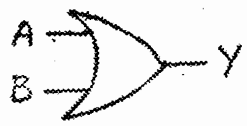
The starter motor, M, operates if the seat belt, SB, is fastened AND the ignition lock, IL, is engaged.



truth table

SB	IL	M
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate



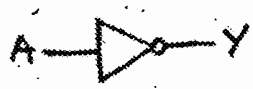
truth table

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

$Y=1$ if $A=1$ OR $B=1$.

Example : The car lamp is ON if one door OR the other is opened.

NOT Gate



Y is the opposite of A (not A).

truth table

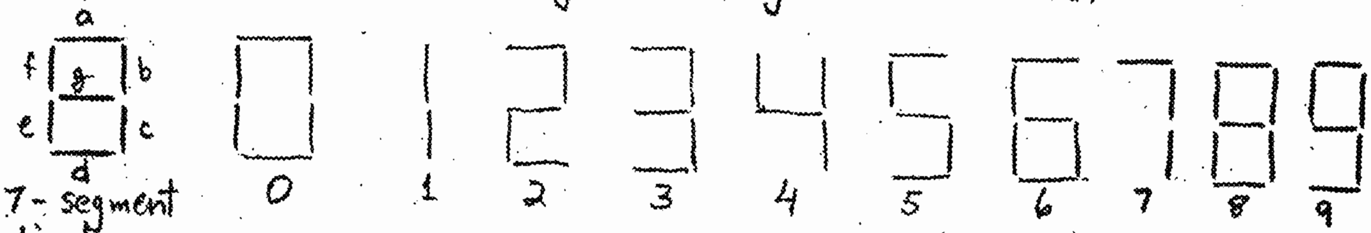
A	Y
0	1
1	0

Example : The starter will NOT operate if the car is in drive.

The AND and OR gates can have more than two inputs.

Combinational Logic Circuit :
a set of interconnected elementary logic gates that implements a truth table.

Project : Let's design a combinational logic circuit to light up the 7-segment displays of calculators.



7-segment display

In calculators (and computers) numbers are represented in binary. The digits 0, 1, 2, ... 9 are represented by 4 bits A B C D.

truth table

digit	A B C D	a	b	c	d	e
0	0000	1	1	1	1	1
1	0001	0	1	1	0	0
2	0010	1	1	0	1	1
3	0011	1	1	1	1	0
4	0100	0	1	1	0	0
5	0101	1	0	1	1	0
6	0110	1	0	1	1	1
7	0111	1	1	1	0	0
8	1000	1	1	1	1	1
9	1001	1	1	1	1	0

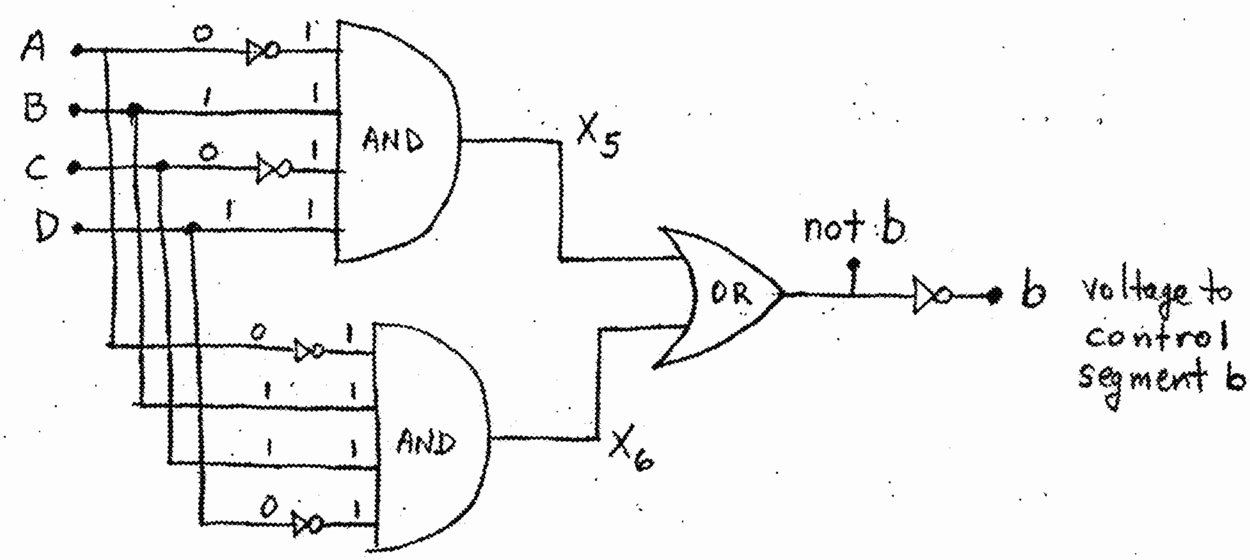
Example: 3 is represented by 0011.
Hence if A=0, B=0, C=1, D=1
then segments a, b, c, d, & g light up.

We need to design 7 separate logic circuits, each one controls when one of the 7 segments light up.

Logic circuit to control segment b:
Segment b is 1 (or lighted) for all digits except 5 and 6.

We will design a logic circuit with output 0 (b is off),
if A=0 and B=1 and C=0 and D=1 (digit 5)
or if A=0 and B=1 and C=1 and D=0 (digit 6)
For any other ABCD the output will be 1 (b is on).

The circuit will have 2 AND gates to recognize 0101 and 0110.



$X_5 = 1$ if $A=0$, $B=1$, $C=0$, and $D=1$.

$X_6 = 1$ if $A=0$, $B=1$, $C=1$, and $D=0$.

not b equals 1 if X_5 or X_6 equal 1.

Hence b equals 0 (off) if X_5 or X_6 equal 1, otherwise b equals 1 (on).

Homework: Design combinational logic circuit to control segment "a".

Combinational logic circuits perform arithmetic operations (addition, multiplication, etc) for computers by implementing a truth table.
Usually there is more than one way of implementing a truth table and the engineer searches for an efficient design which uses few logic gates.

Logic circuit for computer addition: Y = A + B

example: A = 3, B = 6

Express each digit in binary: 3 - 11

6 - 110

Let's do the addition in binary:

	1	0		carry digit
		1	1	A
	1	1	0	B
1	0	1	1	sum

Logic circuit for a column:

3 inputs: A, B, carry digit

2 outputs: Sum & next carry digit

Truth table for column operation:

A	B	carry digit	column sum	next carry digit
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Computer hardware for addition implements this truth table with electronic logic circuits.