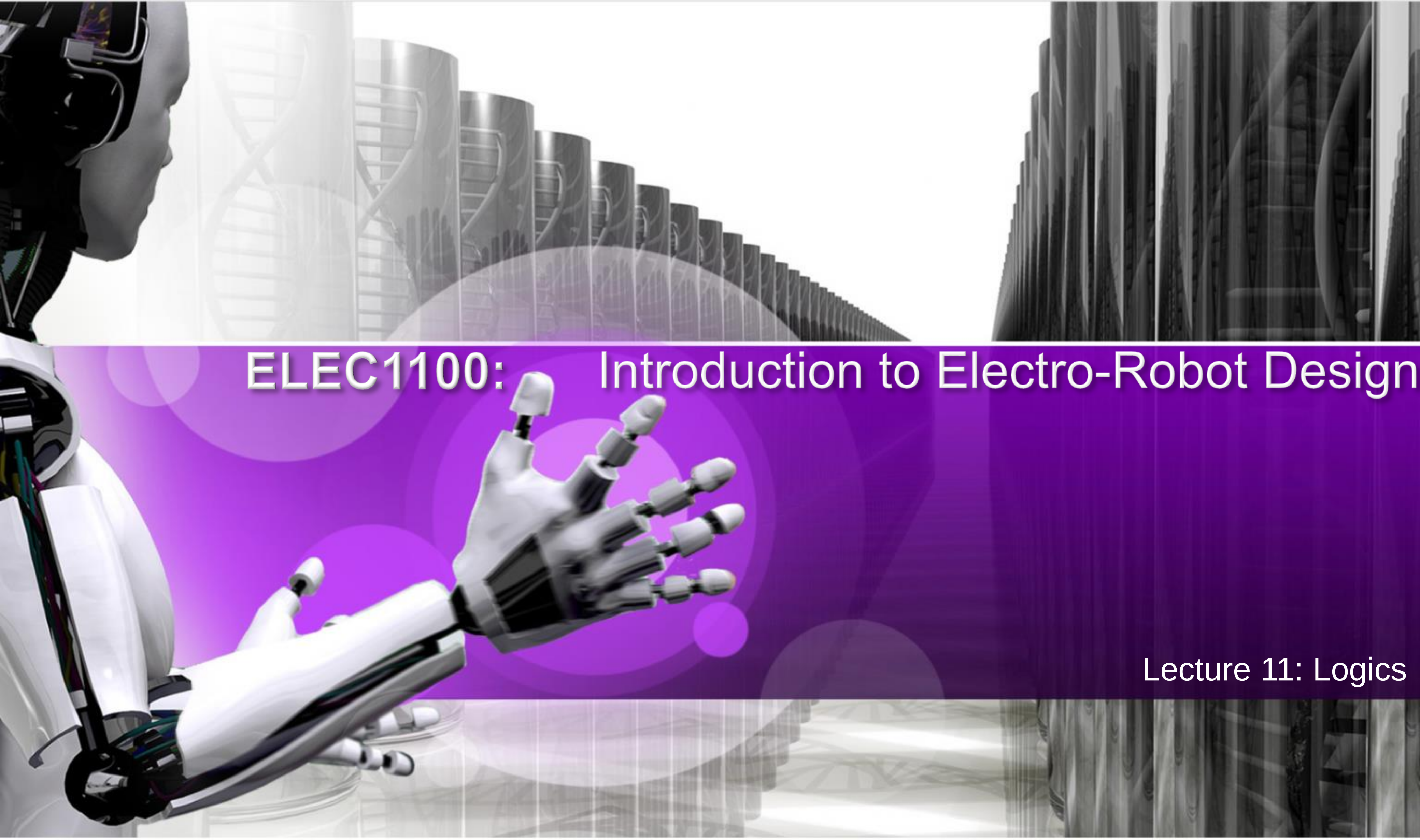

ELEC1100: Introduction to Electro-Robot Design

Lecture 11: Logics

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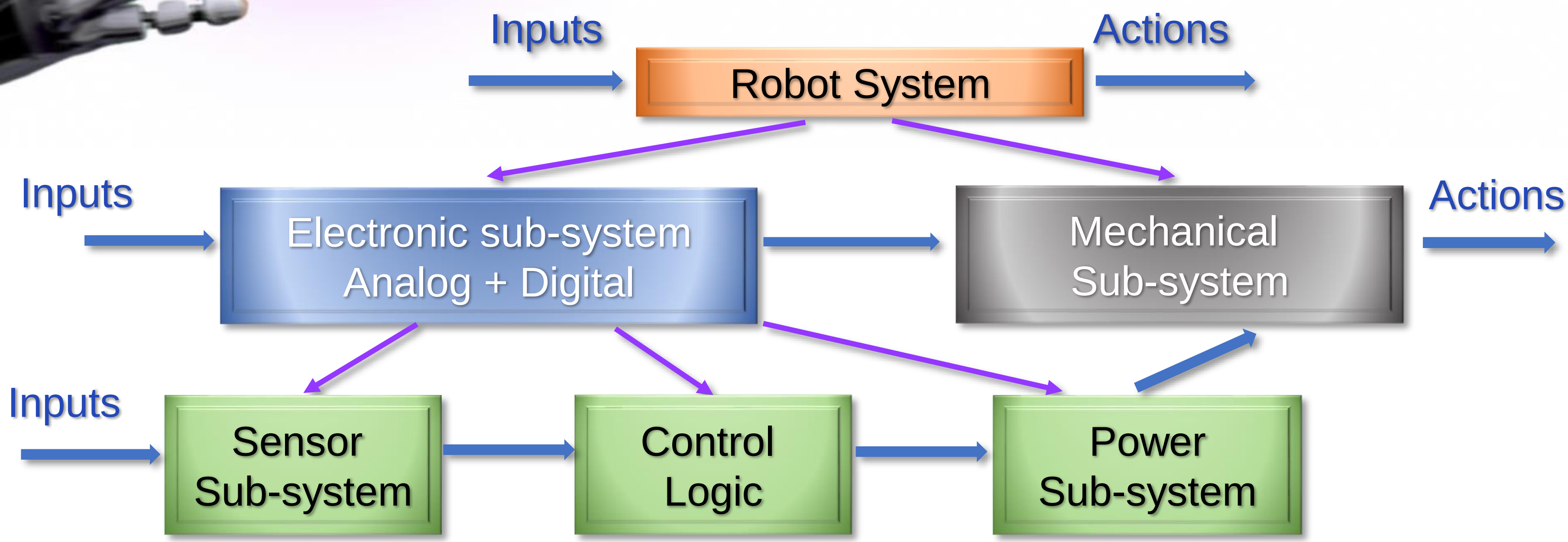
ELEC1100 ROADMAP



Sensor Basics:

Wk5: Sensor Basic – Sensor/Line/ADC

Combinational/Sequential Logic:

Wk6: Robot Brain: Logic Gate and Logic Operation

Basic electronics:

Wk1: Basic Electronics - Charge/Current/Voltage/Resistor

Wk2: Energy/Power and DC Sources

Motor Power Supply:

Wk3: Pulse Signal and PWM Control

Wk4: Transistor and H-Bridge

BINARY NUMBER

- Decimal number system – base 10, each digital is selected from the set {0,1,2,3,4,5,6,7,8,9}

- Binary number system – base 2, each digital is selected from the set {0,1}

Base 10	Base 2
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010

Multiplication and addition of binary number

+	0	1		*	0	1
0	0	1		0	0	0
1	1	0		1	0	1

BINARY NUMBER OPERATION

❖ Addition

Decimal	Binary
7	0111
+ 5	+ 0101
12	1100

❖ Multiplication

Decimal	Binary
7	0111
× 5	× 0101
35	0111
	0111
	100011

❖ Binary digit: 0 and 1 can be represented by logic (True or False)

- 0 is equivalent to False
- 1 is equivalent to True

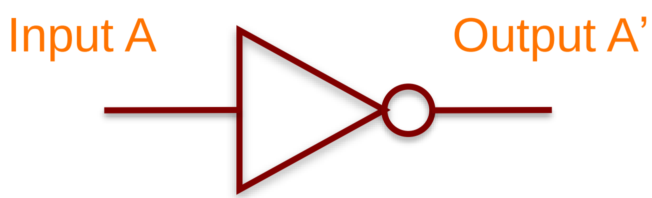
❖ Use Boolean Algebra (which operates on {T,F}) to manipulate the binary digit operation

LOGIC GATES

- Two values for logic: True (“T”) and False (“F”)
- A logic input can be combined with another logic input in different ways to form a new logic output. We call this combination of the inputs as logic gates.
- There are seven fundamental logic gates:
  - Inverter (Not) – 1 input, 1 output
  - AND – 2 or more inputs, 1 output
  - NAND – 2 or more inputs, 1 output
  - OR – 2 or more inputs, 1 output
  - NOR – 2 or more inputs, 1 output
  - XOR – 2 or more inputs, 1 output
  - XNOR – 2 or more inputs, 1 output

TRUTH TABLE

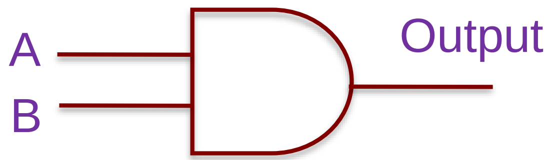
- A tabular summary for all the possible outputs of a logic gate, given all the possible input values
- For a logic gate that has n inputs, how many possible input combinations do we have?
- Sometimes we use 0 to represent F and 1 to represent T
- Truth table of an inverter



Input A	Output A’
0	1
1	0

AND/OR GATES

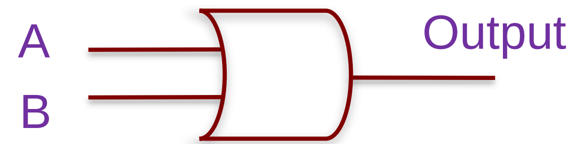
- AND gate: Output = A•B



A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

e.g. if tmr is sunny and I finish ELEC 1100 hw, I'll go hiking.

- OR gate: Output = A+B

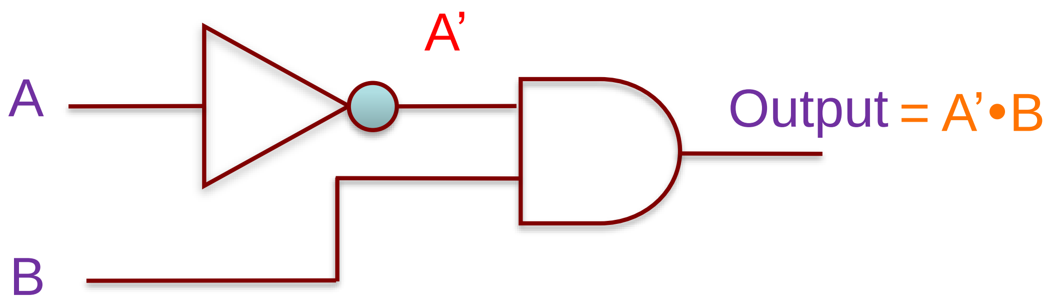


A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

e.g. if it rains tmr or I cannot finish ELEC 1100 hw, I'll stay home.

EXAMPLE OF CIRCUIT WITH AND GATE

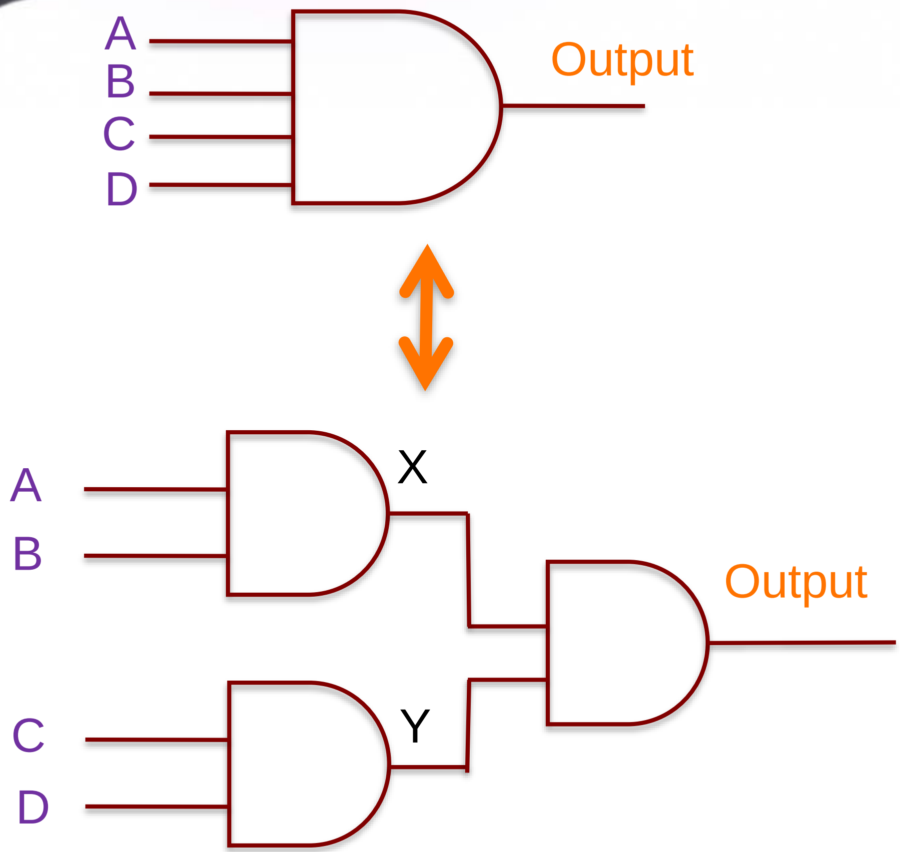
❖ What is the output logic expression for the circuit below?



❖ Complete the truth table

A	B	A'	Output
0	0	1	0
0	1	1	1
1	0	0	0
1	1	0	0

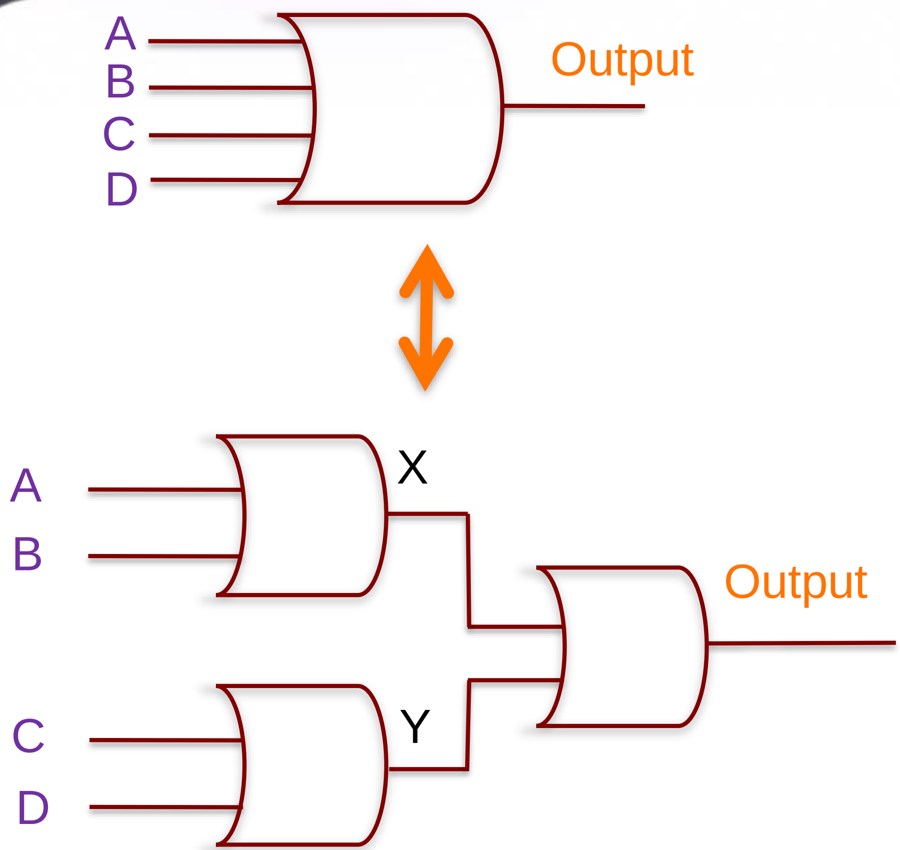
MORE EXAMPLE (AND GATE)



4-input AND gate

A	B	C	D	Output
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

MORE EXAMPLE (OR GATE)

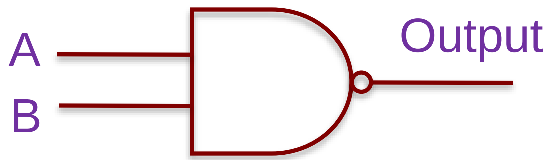


4-input OR gate

A	B	C	D	Output
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

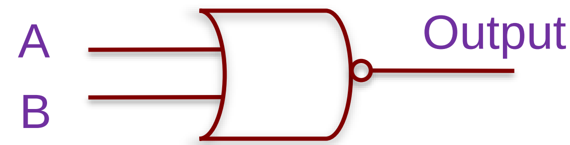
NAND/NOR GATES

- NAND gate: Output = $\overline{A \bullet B}$



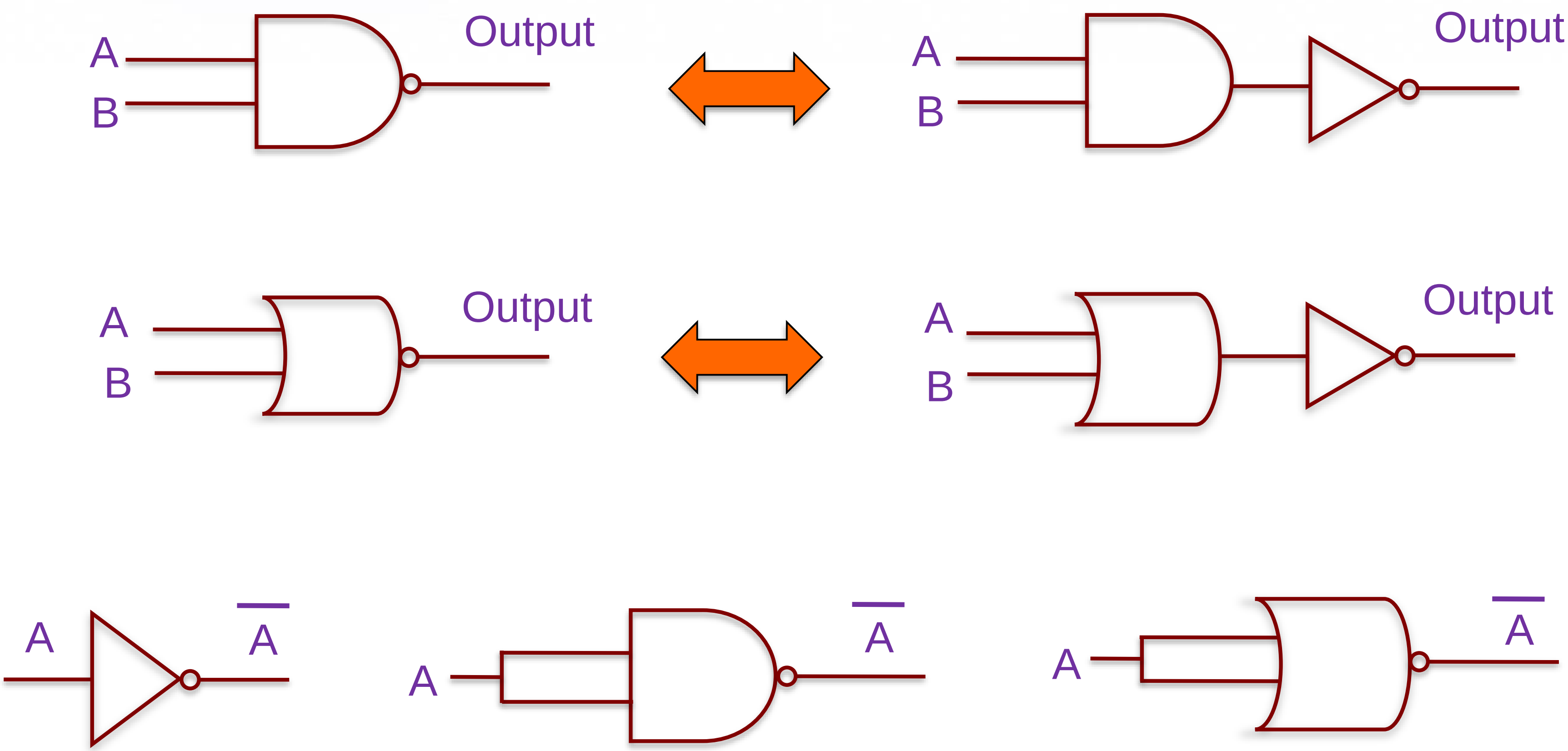
A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

- NOR gate: Output = $\overline{A+B}$



A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

SOME EQUIVALENT GATES

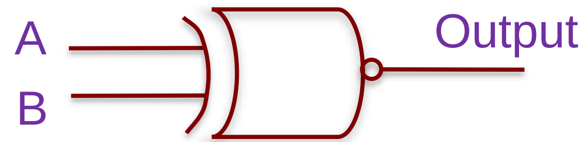


XOR/XNOR GATES

- XOR gate: Output = $A \oplus B$

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

- XNOR gate: Output = $\overline{A \oplus B}$



A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1

LAW OF BOOLEAN ALBEGRA

- $0+X = X$
- $1+X = 1$
- $X'+X = 1$
- $0 \bullet X = 0$
- $1 \bullet X = X$
- $X \bullet X = X$
- $X \bullet X' = 0$
- $(X')' = X$

Exchange:

- $X+Y = Y+X$
- $X \bullet Y = Y \bullet X$

Associativity:

- $X+(Y+Z) = (X+Y)+Z$
- $X \bullet (Y \bullet Z) = (X \bullet Y) \bullet Z$

Distributivity

- $X \bullet (Y+Z) = X \bullet Y + X \bullet Z$

DeMorgan's Law

- $(X+Y)' = X' \bullet Y'$
- $(XY)' = X'+Y'$

LOGIC SIMPLIFICATION

- $X+X\bullet Z = X$

  $X+X\bullet Z = X\bullet(1+Z) = X$

- $X\bullet(X+Y) = X$

  $X\bullet(X+Y) = X\bullet X+X\bullet Y = X\bullet(1+Y) = X$

- $(X+Y)\bullet(X+Z) = X+Y\bullet Z$

  $(X+Y)\bullet(X+Z) = X\bullet X+X\bullet Z+Y\bullet X+Y\bullet Z = X\bullet(1+Z+Y)+Y\bullet Z = X+Y\bullet Z$

- $X'+XY = X'+Y$

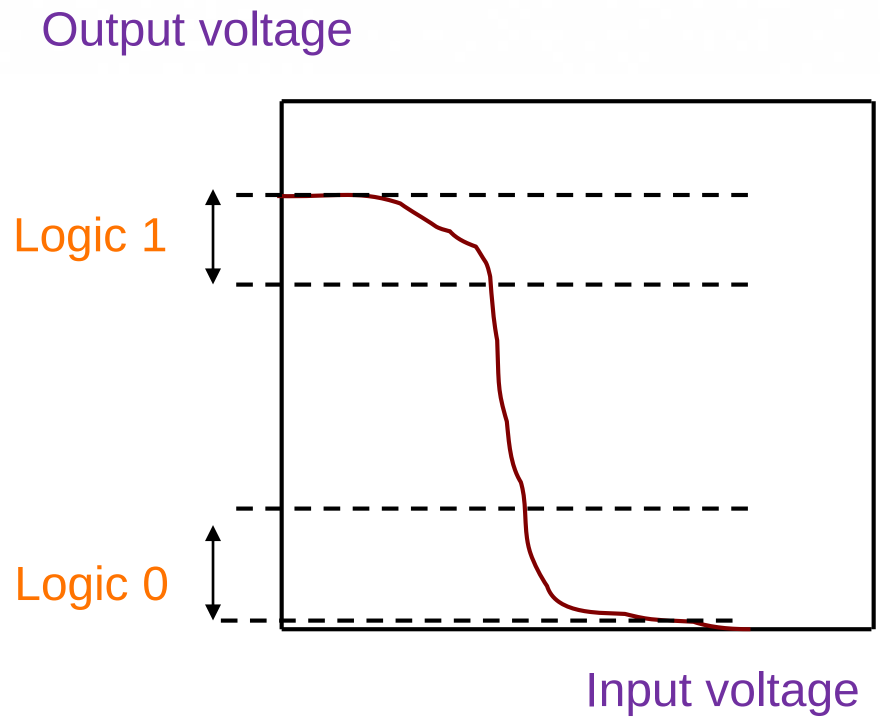
  $X'+XY = (X\bullet(XY)')' = (X\bullet(X'+Y'))' = (X\bullet Y')' = X'+Y$

- $(XY)'+(YZ)'+(XZ)' = (XY)'+(XZ)'$

  $(XY)'+(YZ)'+(XZ)' = (X'+Y') + (Y'+Z') + (X'+Z') = (XY)'+(XZ)'$

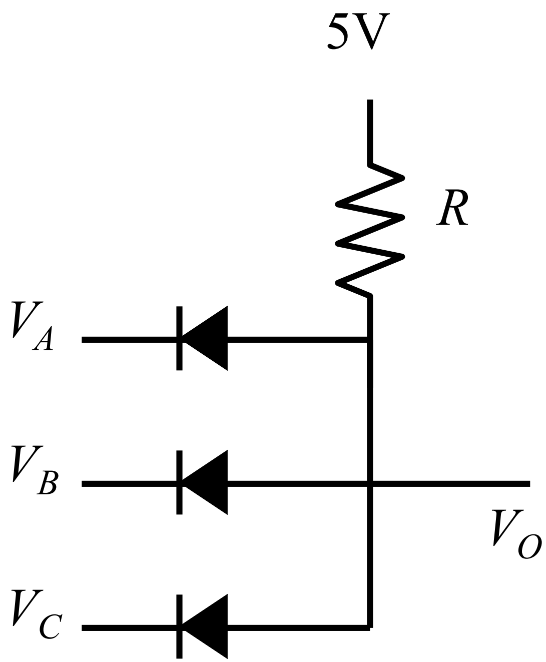
VOLTAGE AND LOGIC VALUE

- How do we represent binary digital signals?
- We can use a range of voltage values to represent logic 0 or 1
- Sometimes we just use high voltage to represent 1 and low voltage to represent 0



LOGIC GATE CONSTRUCTION WITH DIODES [1]

- AND gate



Input/Output Table

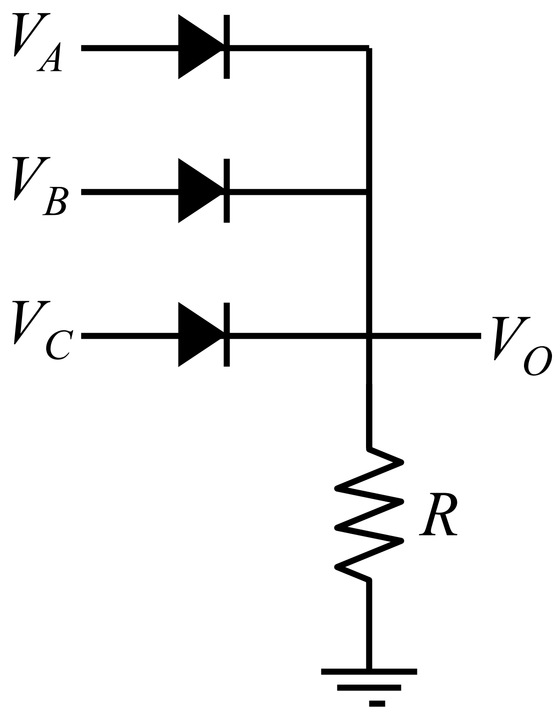
V_A	V_B	V_C	V_O
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

1 = 5V

0 = 0V

LOGIC GATE CONSTRUCTION WITH DIODES [2]

❖ OR gate



Input/Output Table

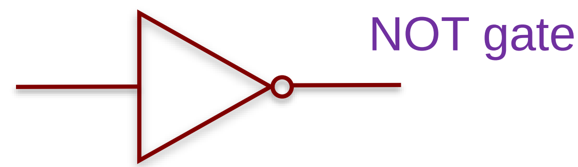
V_A	V_B	V_C	V_O
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

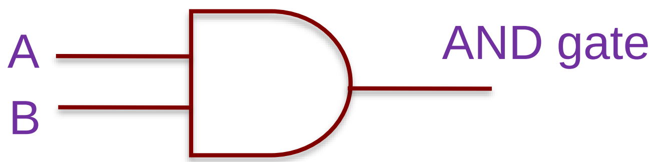
1 = 5V

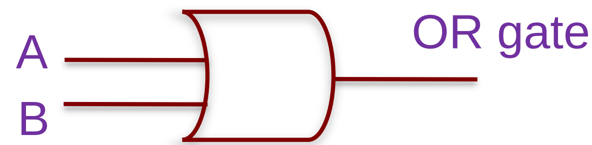
0 = 0V

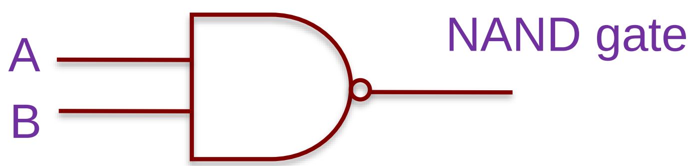
LECTURE SUMMARY

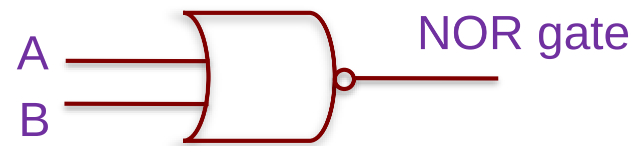
- Binary digit: 0 and 1 can be represented by logic (True or False)
  - 0 is equivalent to False
  - 1 is equivalent to True

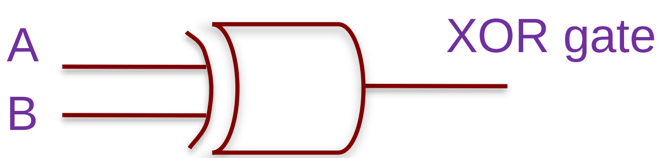


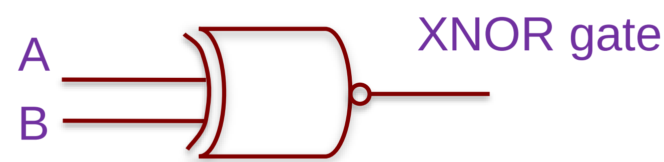












NEXT LECTURE

- K-map
- K-map simplification

QUESTIONS?