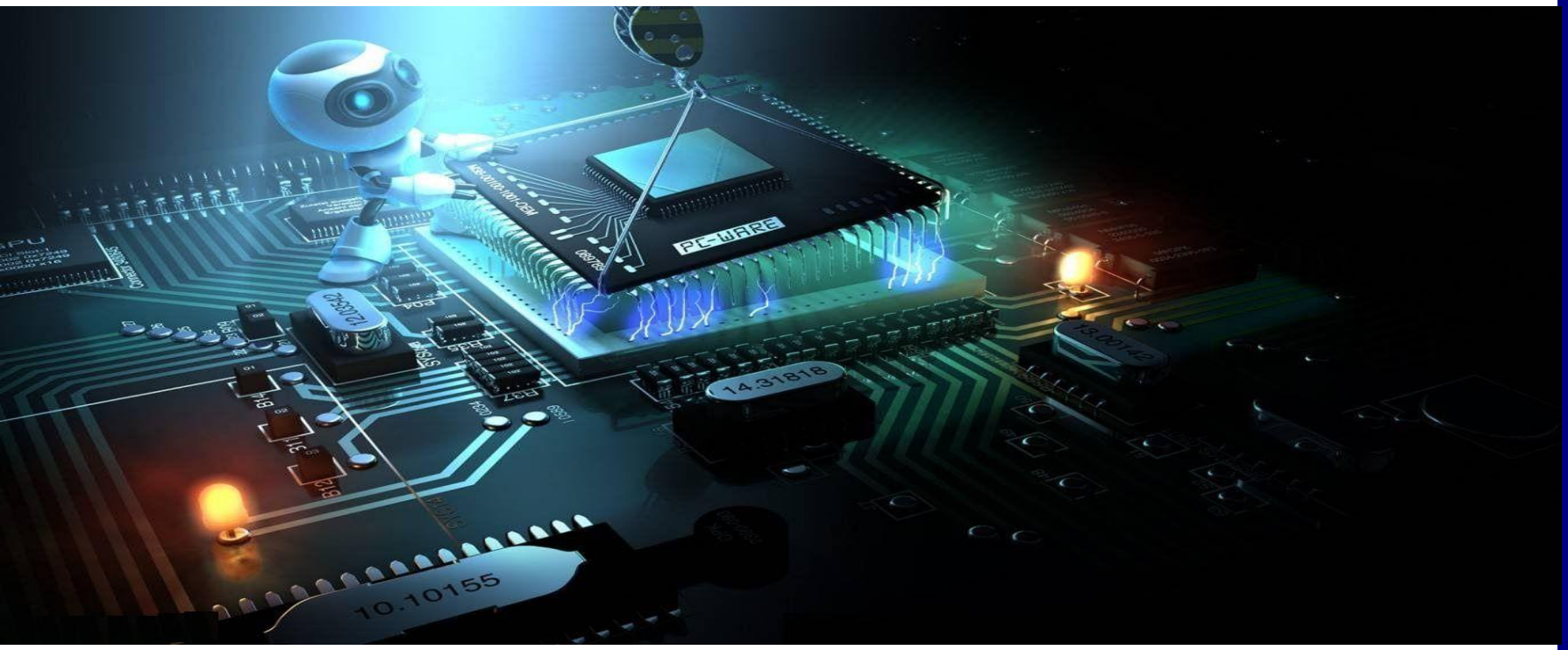
جامعة القاهرة الجديدة التكنولوجية

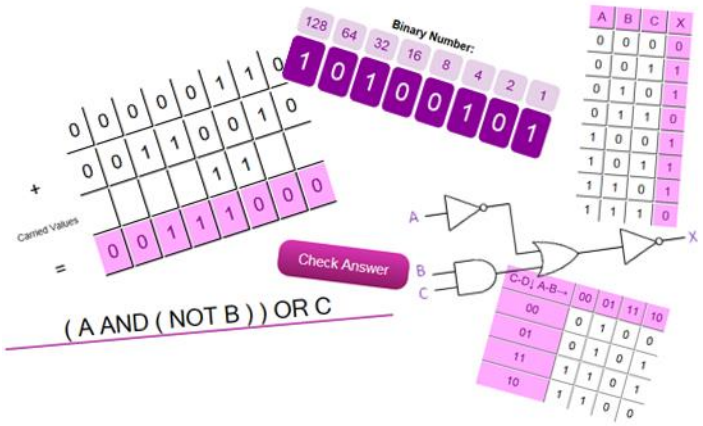
Fall 2023



Digital Engineering

Dr. Hatem Yousry

Agenda



- Course Overview.
- Learning Outcomes.
- Introduction.

Digital Engineering

- This course introduces students to the basic concepts of **digital systems,** including analysis and design.
- Both combinational and sequential logic will be covered. Students will gain experience with several levels of digital systems, from simple logic circuits to programmable logic devices.

Unit Title	Digital Engineering					
Unit Code		Total	Lec.	Tut	Lab/WS	Practice
Credit hours	3	5	2	0	3	0

Digital Engineering

- **Binary number systems, number representations, and codes**
- **Boolean algebra Boolean functions**
- **Logic gates and circuits**
- **Logic simplification using Boolean algebra and Karnaugh maps**
- **Combinational logic design and building blocks**
- **Synchronous sequential logic design and state machines**
- **Latches, flip-flops, registers and counters**

Course Overview

- Perform **arithmetic operations** in many number systems.
- Manipulate **Boolean algebraic** structures. (Counters).
- **Simplify the Boolean expressions** using Karnaugh Map.
- Implement the **Boolean Functions** using NAND and NOR gates.
- Analyze and design various **combinational logic circuits**.
- Understand the basic functions of **Delays and flip-flops**.

Learning Outcomes

1. Understand the operation of logic function at the gate level.
2. Express and simplify logic functions using Boolean rules and logic simplification methods.
3. Understand combinational and sequential digital systems.

Learning Outcomes

- **LO1 Understand the operation of logic function at the gate level.**
- Reviewing the Data & Number Systems.
- Understanding Codes and different types of Conversions.
- Boolean Algebra & Logic Gates.
- Understanding the fundamental concepts of logic design.

Learning Outcomes

- **LO2 Express and simplify logic expressions using the theorems of Boolean algebra.**
- Fundamental properties for Boolean algebra, Implementing Circuits form Truth table, XOR gate, Demorgan's Law, Logical expression, simplification using Fundamental properties, Demorgan ,and Karnaugh map.

Learning Outcomes

- **LO3 Understand combinational and sequential digital systems.**
- Analyze and explore the uses of Logic Functions for Building Digital Logic Circuits. Combinational circuits: Analysis and Design Procedure, Binary Adder and Subtractors, Carry Look-a-head Adder, Binary Multiplier, Magnitude comparator, BCD Adder, Decoders, Encoders, Multiplexers, Demultiplexer. Combinational versus Sequential circuits, Latches, Flip Flops: RS Flip Flop, JK Flip Flop, T Flip Flop, D Flip Flop, Master-Slave Flip Flop, Flip Flops Excitation Functions.

Objectives

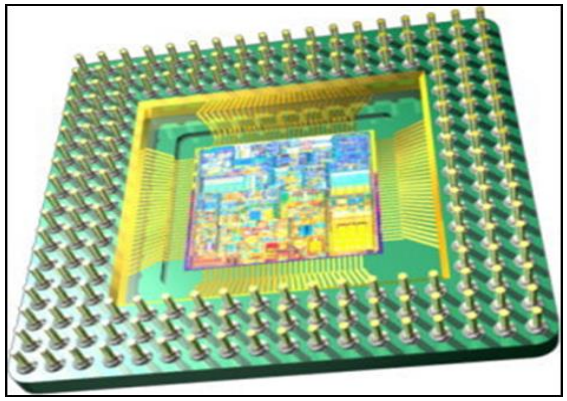
- **An ability to apply knowledge of mathematics, science, and engineering.**
- **An ability to design and conduct experiments, as well as to analyze and interpret data.**
- **An ability to design a system, component , or process to meet desired needs within realistic constraints.**
- **An ability to identify, formulate, and solve engineering problems.**
- **An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**

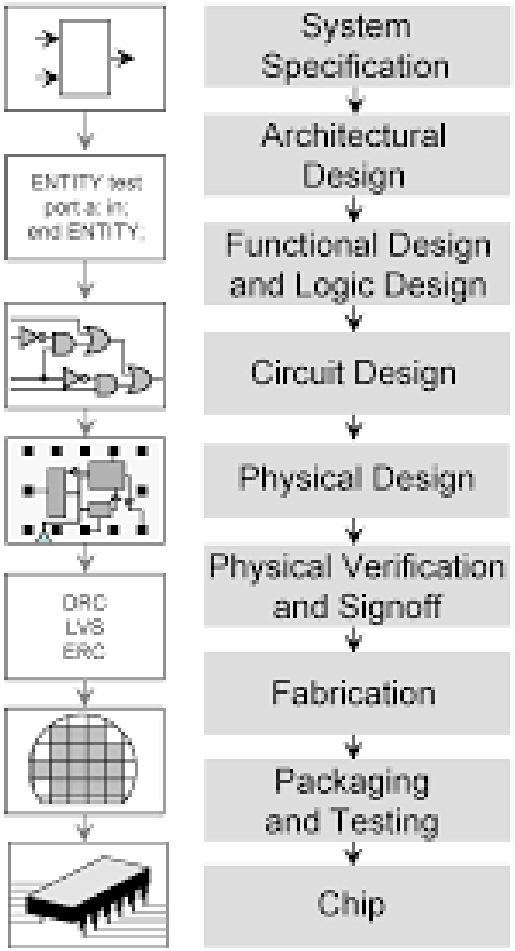
Introduction

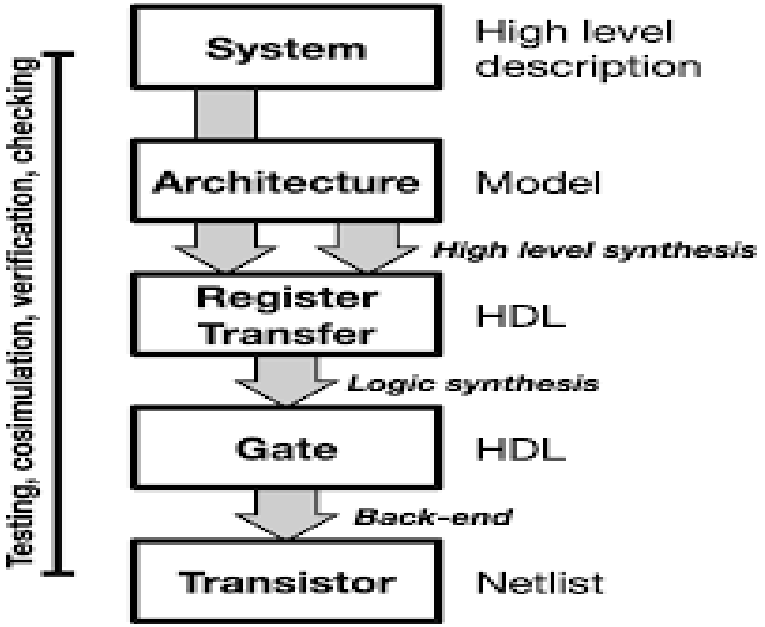
- This is the fundamental course in electrical and computer engineering. This course will provide the fundamental background needed to understand **how digital systems work and how to design digital circuits.**
- We begin by covering the mathematical concepts necessary in the study of digital systems. We will then move onto studying **digital gates** and how they work. We will design and analyze **combinational circuits,** and show how to construct the minimal (least number of gates) circuit necessary to implement a specific function.
- We will then move on to **sequential circuits** which add a **concept of memory or feedback** to the combinational design. We will analyze and design these circuits.

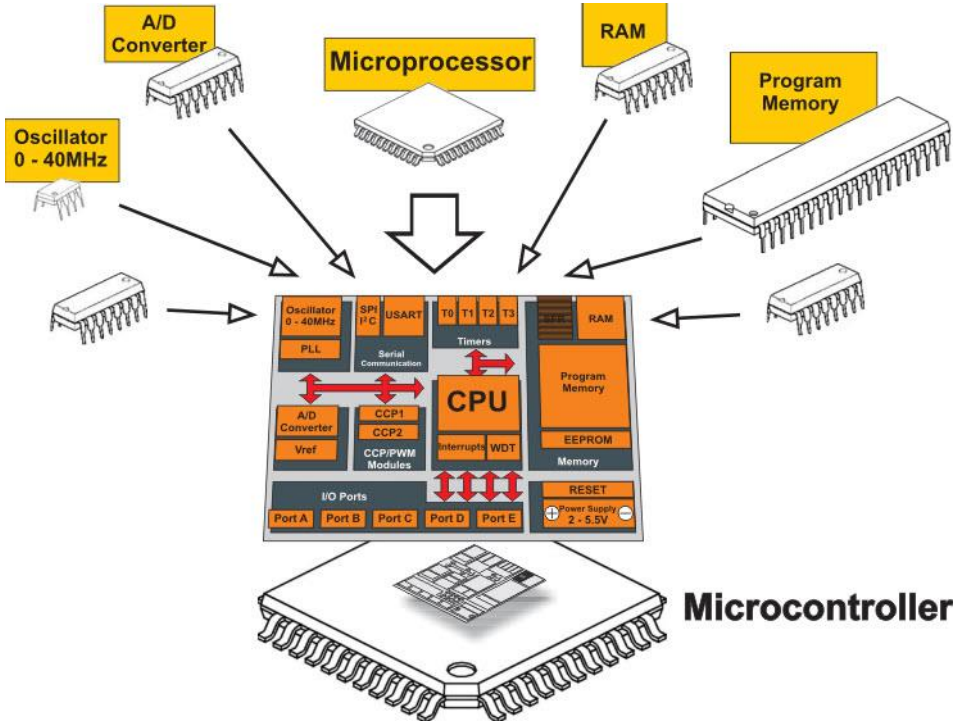
Introduction

- Finally, we will look at common electronic components (such as counters and shift registers) and then look into programmable logic devices. This course will stress fundamentals. We will pay particular attention to design principles and techniques, timing analysis, and finite state machines. The concepts covering in this class are needed in other courses in electrical and computer engineering. It is imperative that these concepts are well understood.

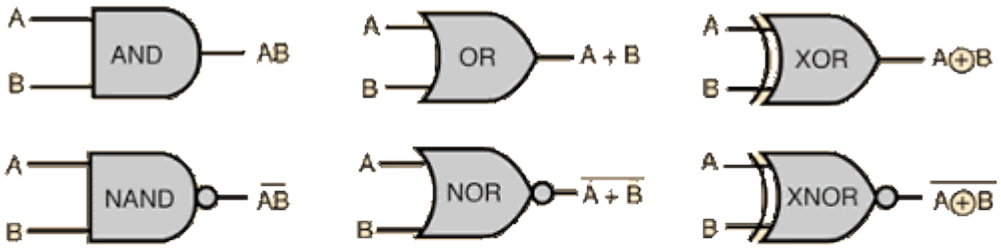


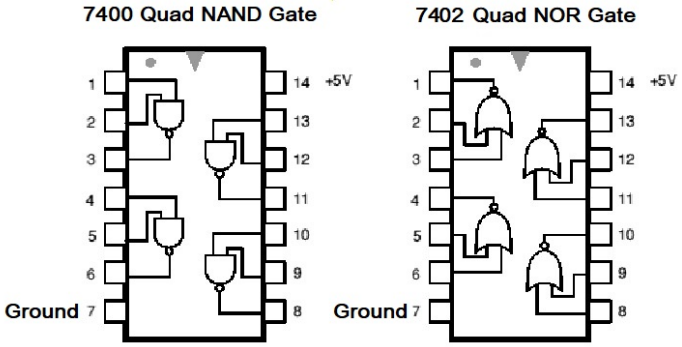

System Specification
Architectural Design
Functional Design and Logic Design
Circuit Design
Physical Design
Physical Verification and Signoff
Fabrication
Packaging and Testing
Chip
ENTITY test
port a: in;
end ENTITY;
DRC
LVS
ERC

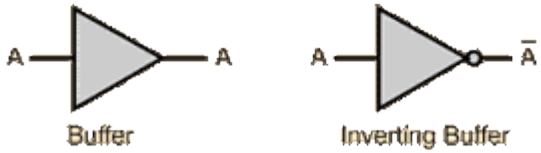

System
High level description
Architecture
Model
High level synthesis
Register Transfer
HDL
Logic synthesis
Gate
HDL
Back-end
Transistor
Netlist
Testing, cosimulation, verification, checking

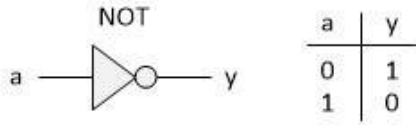

A/D Converter
Microprocessor
RAM
Program Memory
Oscillator 0 - 40MHz
CPU
Microcontroller

Digital Engineering (Logic)

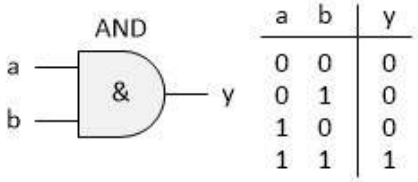




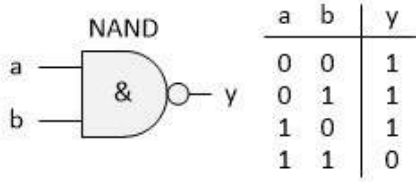




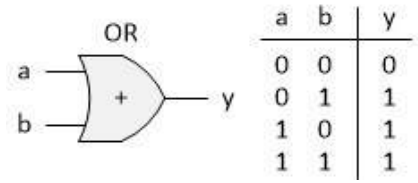
a	y
0	1
1	0



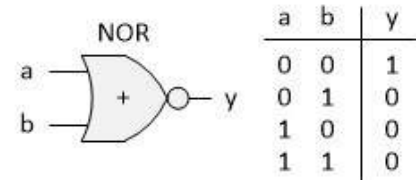
a	b	y
0	0	0
0	1	0
1	0	0
1	1	1



a	b	y
0	0	1
0	1	1
1	0	1
1	1	0



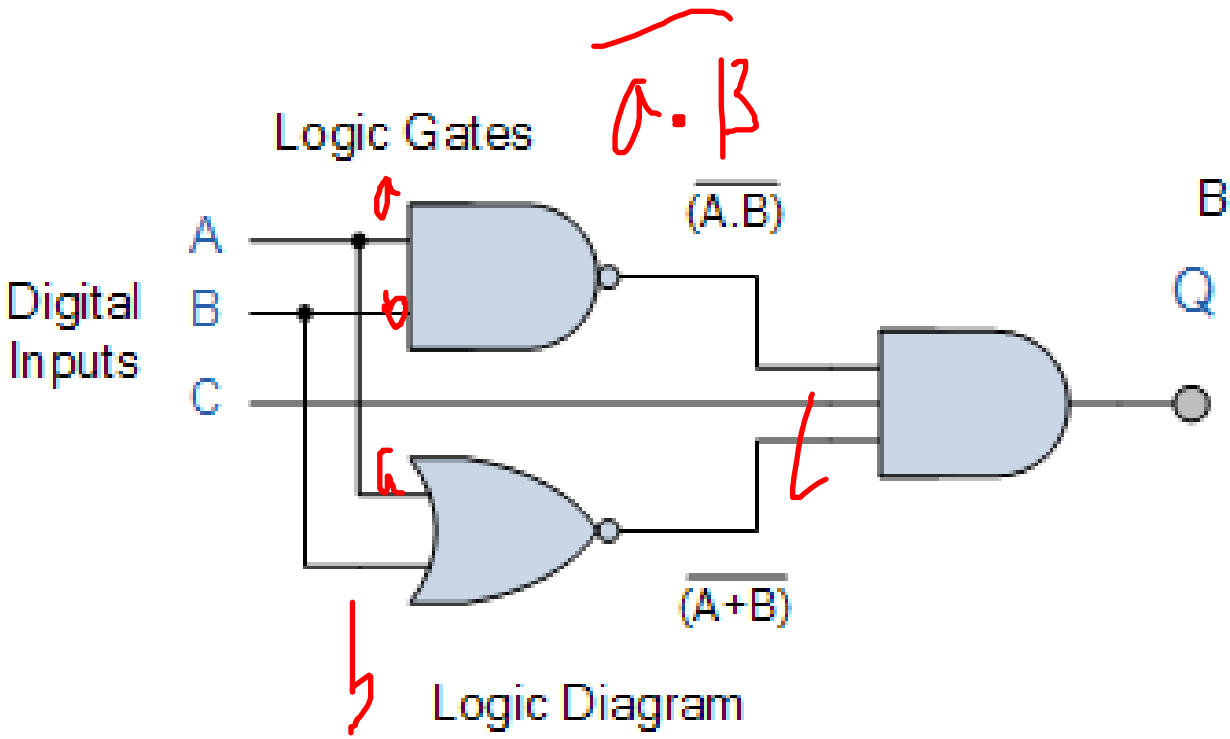
a	b	y
0	0	0
0	1	1
1	0	1
1	1	1



a	b	y
0	0	1
0	1	0
1	0	0
1	1	0

Digital Engineering (Logic)

1. **Boolean Algebra –** This forms the algebraic expression showing the operation of the logic circuit for each input variable either True or False that results in a logic “1” output.
2. **Truth Table –** A truth table defines the function of a logic gate by providing a concise list that shows all the output states in tabular form for each possible combination of input variable that the gate could encounter.
3. **Logic Diagram –** This is a graphical representation of a logic circuit that shows the wiring and connections of each individual logic gate, represented by a specific graphical symbol, that implements the logic circuit.



Boolean Expression

$$Q = \overline{(A.B)}.\overline{(A+B)}.C$$

Typical Truth Table

C	B	A	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

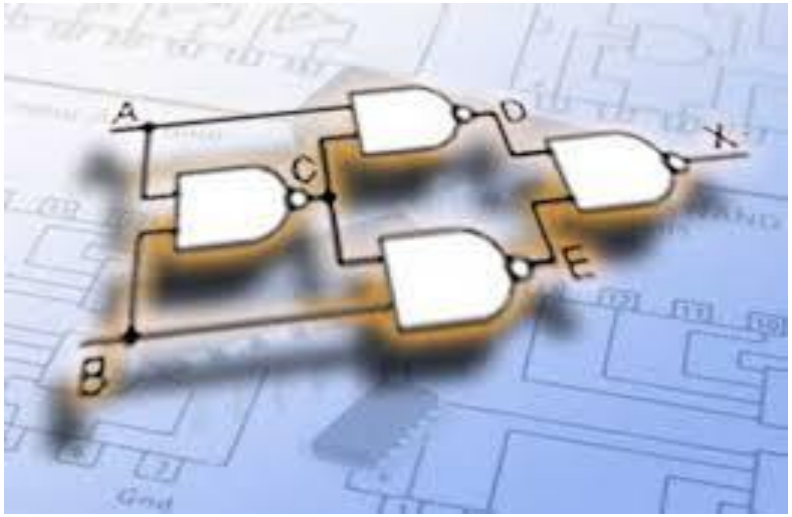
Recommended Resources

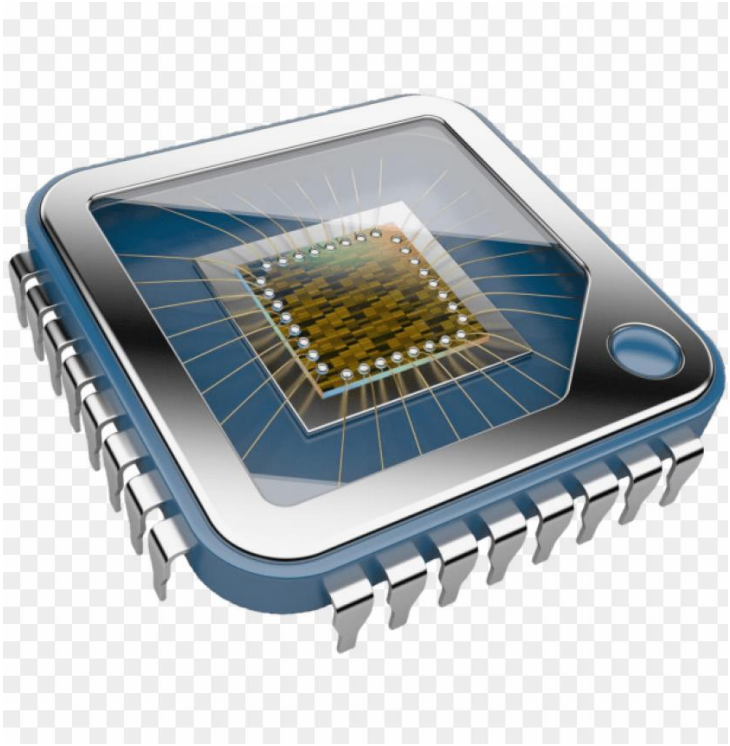
- **M. Morris R. Mano, Charles R. Kime. Logic and Computer Design Fundamentals, 4th Edition Year: 2008. ISBN-10: 013198926X.**
- **Arijit Saha , Nilotpal Manna. Digital Principles and Logic Design. ISBN-10: 1934015032.**

Portfolio

- Selective Lecture Slides.
- Your Private Notes from Lectures , Sections, Trips, Reports, Labs, and Recommendations.
- Complete answers Tasks and Assignments.
- Complete answers to Quizzes, Midterm.
- Final Project Paper.
- In addition to, any related Course martials.

Thank You





Dr. Hatem Yousry
E-mail: Hyousry@nctu.edu.eg