	Ministry of Higher Education and Scientific Research - Iraq **Al-Naji University** **College of Engineering** **AI Engineering Department**	

MODULE DESCRIPTION FORM

نموذج وصف المادة الدراسية

Module Information معلومات المادة الدراسية					
Module Title	**Discrete logic**			**Module Delivery**	
Module Type	**Basic**			☒ **Theory** ☐ **Lecture** ☒ **Lab** ☐ **Tutorial** ☐ **Practical** ☐ **Seminar**	
Module Code	**AIA1107**				
ECTS Credits	**6**				
SWL (hr/sem)	150				
Module Level			**Semester of Delivery**	1	
Administering Department	AI Engineering		**College**	Engineering	
Module Leader	Dr. Maher Faik Esmaile		**e-mail**	maherfaik3@alnaji-uni.edu.iq	
Module Leader's Acad. Title	Lecturer		**Module Leader's Qualification**	Ph.D	
Module Tutor			**e-mail**		
Peer Reviewer Name			**e-mail**		
Scientific Committee Approval Date			**Version Number**	1	

Relation with other Modules العلاقة مع المواد الدراسية الأخرى			
Prerequisite module	None	**Semester**	
Co-requisites module	None	**Semester**	

Module Aims, Learning Outcomes and Indicative Contents أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية	
Module Aims أهداف المادة الدراسية	This module aims to : 1. To introduce students to the fundamental principles of digital systems and their applications. 2. To distinguish between analog and digital signals and understand the advantages of digital systems. 3. To develop proficiency in number systems, binary arithmetic, and data representation. 4. To teach the design and simplification of logic circuits using Boolean algebra and Karnaugh maps. 5. To explain combinational logic circuits and their real-world applications. 6. To introduce sequential logic circuits, including flip-flops, counters, and registers. 7. To enhance problem-solving and design skills for digital systems in AI, robotics, and automation. 8. To prepare students for advanced courses in digital electronics, computer architecture, and embedded systems.
Module Learning Outcomes مخرجات التعلم للمادة الدراسية	1. Explain the difference between analog and digital signals and describe the role of digital systems in modern engineering. 2. Convert numbers between binary, octal, decimal, and hexadecimal systems, and perform binary arithmetic operations. 3. Construct and interpret truth tables for basic and complex logic gates. 4. Apply Boolean algebra laws and theorems to simplify logic expressions and circuits. 5. Use Karnaugh maps to minimize logic functions and design optimized circuits. 6. Design basic combinational logic circuits, including adders, subtractors, multiplexers, demultiplexers, encoders, and decoders. 7. Explain the principles of sequential circuits, including latches, flip-flops, and memory elements. 8. Design counters, registers, and sequential systems using flip-flops and timing diagrams. 9. Apply digital logic concepts to real-world problems in robotics, AI, and automated control systems. 10. Demonstrate systematic problem-solving and circuit design skills in digital logic projects.
Indicative Contents المحتويات الإرشادية	Introduction to Digital and Analog Systems This section covers the basic distinction between analog and digital signals, their advantages and limitations, and practical applications in AI and robotics. Students

	explore how digital systems form the backbone of modern computational and control technologies. [5 hrs] Number Systems and Binary Arithmetic Students study binary, octal, decimal, and hexadecimal systems, including number conversions and binary arithmetic operations. Exercises emphasize accuracy in representation and computation, preparing students for circuit design and digital data manipulation. [8 hrs] Logic Gates and Truth Tables This section introduces the basic logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR), their symbols, truth tables, and practical applications. Students learn to represent logical functions using gates and analyze simple logic circuits. [6 hrs] Boolean Algebra and Karnaugh Map Simplification Students learn Boolean algebra laws and theorems to simplify expressions. Karnaugh maps are used to minimize logic functions efficiently, enabling optimized circuit design for real-world engineering problems. [9 hrs] Combinational Logic Circuits Topics include the design of half and full adders, subtractors, multiplexers, demultiplexers, encoders, and decoders. Students practice constructing combinational circuits for practical applications in AI, robotics, and automated systems. [9 hrs] Sequential Logic Circuits Introduction to sequential logic, including memory concepts, latches, flip-flops (SR, JK, D, T), edge-triggering, and clock behavior. Students learn to design counters, registers, and sequence-generating circuits using flip-flops and timing diagrams. [9 hrs] Applications of Combinational and Sequential Logic This section focuses on implementing control logic and decision-making circuits in robotics and automation. Case studies demonstrate how digital logic solves real-world engineering problems, bridging theory and practice. [9 hrs] Revision and Problem-Solving Comprehensive exercises cover all topics, reinforcing problem-solving, circuit design, and analytical reasoning. Students consolidate their knowledge and prepare for exams and project applications. [8 hrs]

Learning and Teaching Strategies استراتيجيات التعلم والتعليم	
Strategies	1. Interactive Lectures: Provide theoretical knowledge on core concepts such as number systems, Boolean algebra, and the operation of combinational and sequential logic circuits. 2. Hands-on Laboratory Sessions: Allow students to build and test logic circuits using hardware (like breadboards and ICs) or simulation software (e.g., Logisim). This develops practical skills in circuit implementation, analysis, and troubleshooting. 3. Problem-Solving Exercises: Focus on applying Boolean algebra and Karnaugh maps to simplify logic expressions and design optimized circuits. 4. Case Studies and Applications: Analyze real-world examples of how digital logic is used in robotics, AI, and automated control systems, bridging theory and practice. 5. Group Discussions and Collaborative Projects: Encourage teamwork in designing and implementing digital logic projects, fostering a deeper understanding and shared problem-solving skills. 6. Assessments: Use quizzes, assignments, lab reports, a mid-term exam, and a final exam to evaluate students' understanding of theoretical concepts and their ability to apply design techniques.

Student Workload (SWL) الحمل الدراسي للطالب			
Structured SWL (h/sem) الحمل الدراسي المنتظم للطالب خلال الفصل	78	**Structured SWL (h/w)** الحمل الدراسي المنتظم للطالب أسبوعيا	4
Unstructured SWL (h/sem) الحمل الدراسي غير المنتظم للطالب خلال الفصل	72	**Unstructured SWL (h/w)** الحمل الدراسي غير المنتظم للطالب أسبوعيا	4
Total SWL (h/sem) الحمل الدراسي الكلي للطالب خلال الفصل	150		

Module Evaluation تقييم المادة الدراسية					
		Time/Number	**Weight (Marks)**	**Week Due**	**Relevant Learning Outcome**
Formative assessment	**Quizzes**	2	10% (10)	5 and 10	LO #1- #5 and #6-#10
	Assignments	2	10% (10)	Continuous	LO #5 and #10
	Projects / Lab.	1	10% (10)	Continuous	All
	Report	1	10% (10)	13	All
Summative assessment	**Midterm Exam**	2 hr	10% (10)	7	LO #1 - #7
	Final Exam	3hr	50% (50)	15	All
Total assessment			100% (100 Marks)		

Delivery Plan (Weekly Syllabus) المنهاج الاسبوعي النظري	
	Material Covered
Week 1	**Introduction to Digital and Analog Systems** • Difference between analog and digital signals. • Role of digital systems in AI and robotics.
Week 2	**Number Systems and Binary Arithmetic** • Binary, octal, decimal, and hexadecimal systems. • Number conversions and binary operations.
Week 3	**Logic Gates and Truth Tables** • Basic logic operations (AND, OR, NOT, NAND, NOR, XOR, XNOR). • Circuit representation and practical examples.
Week 4	**Boolean Algebra** • Laws and theorems of Boolean algebra. • Simplifying digital circuits using Boolean expressions.
Week 5	**Karnaugh Map (K-Map) Simplification** • Logic function minimization using K-Maps. • Designing optimized logic circuits.
Week 6	**Combinational Logic Circuits – Part 1** • Half and full adders, subtractors. •Basic combinational circuit design.
Week 7	**Mid-term Exam**
Week 8	**Combinational Logic Circuits – Part 2** • Multiplexers, demultiplexers, encoders, and decoders.

	Practical Applications of Combinational Logic • Designing control and decision circuits. • Real-world examples in robotics and AI.
Week 9	**Introduction to Sequential Logic Circuits** • Basic concepts of memory and timing. • Introduction to latches and flip-flops. •
Week 11	**Flip-Flop Types and Applications** • SR, JK, D, and T flip-flops. • Edge-triggering and clock behavior. •
Week 12	**Sequential Circuits Design** • Using flip-flops to design counters and registers. • Timing diagrams and sequence generation. •
Week 13	**Counters and Shift Registers** • Asynchronous and synchronous counters. • Shift register operation and applications. •
Week 14	**Sequential Circuits – Applications** • Implementing control logic using sequential circuits. • Case studies in robotics and automation. •
Week 15	**Review and Final Exam Preparation** • Comprehensive course review and practical revision. •

Delivery Plan (Weekly Lab. Syllabus) المنهاج الاسبوعي للمختبر	
	Material Covered
Week 1	• Introduction to the Digital Laboratory Familiarization with lab equipment (breadboard, power supply, logic probes); safety instructions and introduction to digital signals.
Week 2	• Number Systems and Logic Levels Practice binary-to-decimal conversion and verify digital HIGH/LOW levels using simple LED circuits.
Week 3	• Logic Gates – Basic Operations Build and test basic logic gates (AND, OR, NOT, NAND, NOR) using ICs; verify truth tables.
Week 4	• Logic Gates – Combined Circuits Construct compound logic expressions; analyze and test outputs using logic probes or simulation.
Week 5	• Boolean Algebra and Simplification Apply Boolean simplification on given circuits and implement simplified versions using hardware or simulation software (e.g., Logisim).
Week 6	• Karnaugh Map Practice Simplify logic functions using K-map methods and compare complexity before and after reduction.
Week 7	• Midterm Lab Evaluation Assessment on experiments from Weeks 1–6 (circuit building, analysis, and documentation).
Week 8	• Combinational Logic Circuits – Adders/Subtractors Design and implement half adder and full adder/subtractor circuits; verify functionality.
Week 9	• Combinational Circuits – MUX and DEMUX Build multiplexer and demultiplexer circuits and explore their data-routing applications.
Week 10	• Encoders and Decoders Construct simple encoder and decoder circuits and test their operation using binary inputs.
Week 11	• Introduction to Sequential Logic Observe latch and flip-flop behavior using LEDs; understand SR, D, and JK flip-flops.
Week 12	• Flip-Flop Timing and Triggering Explore clock signals and triggering (edge vs. level); measure response using oscilloscopes or simulation.

Week 13	• Counters Design and test asynchronous and synchronous counters using flip-flops or IC counters.
Week 14	• Shift Registers Implement and test serial-in/serial-out and parallel-in/parallel-out shift registers.
Week 15	• Final Lab Assessment and Demonstration

Learning and Teaching Resources مصادر التعلم والتدريس		
	Text	**Available in the Library?**
Required Texts	1. Floyd, T.L., 2011. Digital fundamentals, 10/e. Pearson Education India.	yes
Recommended Texts	1. Shiva, S.G. ed., 2018. Introduction to logic design. CRC Press.FLOYD, Thomas L., and David BUCHLA. 2. Nixon, M.S., 2015. Digital Electronics: A Primer-Introductory Logic Circuit Design (Vol. 1). World Scientific Publishing Company.	yes
Websites	https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/	

Grading Scheme مخطط الدرجات				
Group	**Grade**	التقدير	**Marks (%)**	**Definition**
Success Group (50 - 100)	**A -** Excellent	امتياز	90 - 100	Outstanding Performance
	B - Very Good	جيد جدا	80 - 89	Above average with some errors
	C - Good	جيد	70 - 79	Sound work with notable errors
	D - Satisfactory	متوسط	60 - 69	Fair but with major shortcomings
	E - Sufficient	مقبول	50 - 59	Work meets minimum criteria
Fail Group (0 – 49)	**FX –** Fail	راسب (قيد المعالجة)	(45-49)	More work required but credit awarded
	F – Fail	راسب	(0-44)	Considerable amount of work required

Note: Marks Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above.