Ministry of Higher Education

Al-Zahrawi University

Faculty of Science

Department of Artificial Intelligence Sciences

MODULE DESCRIPTION FORM

نموذج وصف المادة الدراسية

Module Information معلومات المادة الدراسية					
Module Title	**Math for AI (I)**			**Module Delivery**	
Module Type	**S**			☒ **Theory** ☒ **Lecture** ☐ **Lab** ☒ **Tutorial** ☐ **Practical** ☐ **Seminar**	
Module Code	ZU-SC-AI-1A-MATH				
ECTS Credits	**4**				
SWL (hr/sem)	**125**				
Module Level		UG – Year 1	**Semester of Delivery**		First Semester
Administering Department		Artificial Intelligence	**College**	College of Science	
Module Leader	م.م عبدالله شعلان نفنف		**e-mail**	Abdulah.shaalan@alzahu.edu.iq	
Module Leader's Acad. Title		Assistant teacher	**Module Leader's Qualification**		
Module Tutor			**e-mail**		
Peer Reviewer Name			**e-mail**		
Scientific Committee Approval Date			**Version Number**	1.0	

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 Objectives أهداف المادة الدراسية	This module aims to: 1. Provide students with a strong mathematical foundation tailored to AI applications. 2. Develop understanding of vectors, matrices, and linear transformations used in data representation. 3. Introduce calculus concepts essential for optimization and learning algorithms. 4. Build logical and discrete reasoning skills for knowledge representation and reasoning systems. 5. Introduce numerical methods relevant to computational AI algorithms. 6. Bridge abstract mathematical concepts with real AI and machine learning applications.
Module Learning Outcomes مخرجات التعلم للمادة الدراسية	Upon successful completion of this module, students will be able to: **LO1:** Explain sets, functions, vectors, and matrices and describe their role in representing AI data. **LO2:** Apply vector operations, norms, and orthogonality to analyze and compare AI data representations. **LO3:** Use matrix operations and linear transformations to model data transformations in AI systems. **LO4:** Solve systems of linear equations and analyze matrix properties used in AI model formulation. **LO5:** Explain eigenvalues, eigenvectors, and Principal Component Analysis (PCA) for dimensionality reduction in AI. **LO6:** Apply limits and derivatives to analyze change and learning behavior in AI models. **LO7:** Compute partial derivatives and gradient vectors for multivariable functions in AI and machine learning. **LO8:** Apply gradient descent and optimization techniques to train simple AI and machine learning models. **LO9:** Use integrals to model accumulation, continuous quantities, and cost functions in AI systems. **LO10:** Apply propositional and predicate logic to represent knowledge and reasoning in AI systems. **LO11:** Use sets, relations, and discrete structures to organize and analyze AI data. **LO12:** Apply graph theory concepts to model decision trees, networks, and relationships in AI.

	LO13: Use numerical differentiation and integration to approximate and analyze AI model behavior.
Indicative Contents المحتويات الإرشادية	**Part A – Mathematical Foundations (8 hours)** – Sets, functions, and basic mathematical notation – Scalars, vectors, and matrices – Mathematical abstraction and representation – Importance of mathematics in Artificial Intelligence – AI context: data as vectors, models as functions **Part B – Linear Algebra for Artificial Intelligence (28 hours)** – Vector operations and vector spaces – Norms, distances, and orthogonality – Matrix operations and matrix multiplication – Linear transformations and geometric interpretation – Solving linear systems (Ax = b) – Rank, linear independence, and inverse matrices – Eigenvalues and eigenvectors – Diagonalization and Principal Component Analysis (conceptual) – AI context: embeddings, transformations, model parameters, dimensionality reduction **Part C – Calculus for AI (18 hours)** – Limits and continuity – Tangent lines and rates of change – Definition and interpretation of derivatives – Partial derivatives and gradient vectors – Chain rule and multivariable differentiation – Optimization concepts and gradient descent – Learning rate and convergence behavior – AI context: loss functions and model optimization **Part D – Integrals and Continuous Models (8 hours)** – Indefinite integrals and antiderivatives – Definite integrals and area under curves – Fundamental Theorem of Calculus – Conceptual introduction to numerical integration – AI context: cumulative measures and continuous cost functions **Part E – Logic, Discrete Mathematics, and Numerical Methods (16 hours)** – Propositional and predicate logic – Truth tables, quantifiers, and logical inference – Sets, relations, and counting principles – Graph theory fundamentals (nodes, edges, trees, connectivity) – Numerical differentiation and approximation of derivatives – Error analysis and computational considerations – Numerical integration concepts and stability – AI context: reasoning systems, decision trees, networks, numerical gradients

Learning and Teaching Strategies استراتيجيات التعلم والتعليم	
Strategies	The course is delivered through structured lectures combined with problem-solving sessions. Teaching strategies include: – Conceptual explanations with visual intuition – Step-by-step mathematical derivations – AI-motivated examples – Guided problem solving – Continuous formative feedback These strategies aim to strengthen analytical thinking and prepare students for advanced AI coursework.

Student Workload (SWL) الحمل الدراسي للطالب محسوب لـ ١٥ اسبوعا			
Structured SWL (h/sem) الحمل الدراسي المنتظم للطالب خلال الفصل	78	**Structured SWL (h/w)** الحمل الدراسي المنتظم للطالب أسبوعيا	5.2
Unstructured SWL (h/sem) الحمل الدراسي غير المنتظم للطالب خلال الفصل	72	**Unstructured SWL (h/w)** الحمل الدراسي غير المنتظم للطالب أسبوعيا	4.8
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	5% (10)	4 and 10	LO1–LO3, LO7–LO9
	Assignments	2	5% (10)	7 and 12	LO1–LO6, LO7-10
	Projects	2	5% (10)	14	L1-L7 , L8-L13
	Report	1	10% (10)	14	LO11–LO13
Summative assessment	**Midterm Exam**	1 hrs	10% (10)	8	LO1–LO7
	Final Exam	3 hrs	50% (50)	16	All
Total assessment			100% (100 Marks)		

Delivery Plan (Weekly Syllabus) المنهاج الاسبوعي النظري	
	Material Covered
Week 1	**Mathematical Foundations** • Sets, functions, and basic notation • Scalars, vectors, and matrices • Why mathematics is the core of AI • **AI connection:** data as vectors, models as functions
Week 2	**Linear Algebra for AI: Vectors and Spaces** • Vector operations • Norms and distances • Orthogonality • **AI example:** image and text embeddings
Week 3	**Linear Algebra for AI: Matrices and Transformations** • Matrix multiplication • Geometric transformations • Linear mappings • **AI example:** pixel transformations, data rotation
Week 4	**Linear Algebra for AI: Linear Systems and Matrix Properties** • Solving linear systems (Ax = b) • Rank and linear independence • Inverse matrices • **AI example:** solving model weights
Week 5	**Linear Algebra for AI: Eigenvalues and Eigenvectors** • Eigen-decomposition • Diagonalization • Principal Component Analysis (conceptual) • **AI example:** dimensionality reduction
Week 6	**Introduction to Calculus: Foundations of Calculus** • Limits and continuity • Tangent lines and instantaneous change • Definition of the derivative • **AI application:** change in model error over time
Week 7	**Mid-term Exam**
Week 8	**Derivatives and Their Applications: Derivatives in Multiple Dimensions** • Partial derivatives • Gradient vectors • Directional derivatives • Chain rule • **AI application:** gradients in neural networks (conceptual)
Week 9	**Derivatives and Their Applications: Optimization Using Derivatives** • Critical points • Gradient descent • Learning rate • Convex vs. non-convex functions • **AI application:** training simple models
Week 10	**Integrals and Their Applications: Integrals** • Indefinite integrals (antiderivatives) • Definite integrals and area under curves

	• Fundamental Theorem of Calculus • Numerical integration (conceptual) • **AI application:** continuous cost functions, cumulative measures
Week 11	**Logic: Propositional and Predicate Logic** • Statements, connectives, truth tables • Quantifiers • Logical implications • **AI application:** reasoning systems, knowledge bases
Week 12	**Discrete Mathematics: Sets and Structures** • Set operations • Functions and relations • Counting principles • **AI application:** data structures and model relationships
Week 13	**Discrete Mathematics: Introduction to Graph Theory** • Nodes, edges, and paths • Trees • Connectivity • **AI application:** decision trees, networks
Week 14	**Numerical Methods for AI: Numerical Differentiation** • Approximating derivatives • Error analysis • **AI application:** how computers approximate gradients **Numerical Methods for AI: Numerical Integration** • Approximation methods (trapezoid rule, Simpson's rule – conceptual) • Stability and computational limits
Week 15	**General Review**
Week 16	**Preparatory week before the final Exam**

Learning and Teaching Resources
مصادر التعلم والتدريس

	Text	Available in the Library?
Required Texts	Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong. *Mathematics for machine learning*. Cambridge University Press, 2020.	Yes
Recommended Texts	Hartmann, Peter. *Mathematics for Computer Scientists: A Practice-Oriented Approach*. Springer Nature, 2023.	Yes
Websites	https://www.khanacademy.org/math/	

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.