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MATHEMATICS FOR MACHINE LEARNING **Course Code : 314320**

Programme Name/s : **Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Data Sciences**

Programme Code : **AI/ AN/ DS**

Semester : **Fourth**

Course Title : **MATHEMATICS FOR MACHINE LEARNING**

Course Code : **314320**

I. RATIONALE

Mathematics plays a crucial role in Artificial Intelligence(AI) and Machine Learning(ML). This course is included in curriculum as Mathematics which is foundation for Artificial Intelligence and Machine Learning. It provides the theoretical framework, algorithms and tools necessary for understanding, developing and deploying AI and ML system effectively. This course will enable students to implement mathematical concepts using Python programming which will enhance the knowledge and methodology to solve AI/ML based engineering problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Apply mathematics to solve real-world problems using AI/ML concepts and principles to enhance decision-making, design and innovation with precision and efficiency.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use partial differentiation concept to obtain optimal solution.
- CO2 - Implement matrix concept to solve real life problems.
- CO3 - Build programs to implement basic operations based on vectors and tensors.
- CO4 - Evaluate numerical differentiation and integration functions.
- CO5 - Apply the linear programming problem concept to obtain optimal solution.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314320	MATHEMATICS FOR MACHINE LEARNING	MML	AEC	4	-	2	-	6	3	3	30	70	100	40	25	10	25@	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

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V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Calculate partial derivative of first order, second order and mixed order. TLO 1.2 Verify Euler's theorem for the homogeneous function. TLO 1.3 Calculate maximum and minimum value of the function. TLO 1.4 Find maximum and minimum value of the function subject to the given condition using Lagrange's undetermined multipliers.	**Unit - I Partial Differentiation** 1.1 Introduction to Derivative 1.2 Partial derivative (Two variables): Introduction, Partial derivative of first order, second order and mixed order 1.3 Homogeneous Function 1.4 Euler's theorem on homogeneous function (Two variables) 1.5 Maxima and minima of function (Two variables) 1.6 Lagrange's method of undetermined multipliers with one constraint (Two variables)	Lecture Using Chalk-Board Flipped Classroom Demonstration
2	TLO 2.1 Reduce the matrix to echelon form and normal form. TLO 2.2 Find the inverse of matrix by elementary transformation. TLO 2.3 Calculate the rank of matrix using determinant of order 2 and 3. TLO 2.4 Calculate the rank of matrix by reducing matrix to echelon form of order 2 and 3. TLO 2.5 Calculate the rank of matrix by reducing matrix to normal form of order 2 and 3. TLO 2.6 Check the consistency of non-homogenous system of linear equation using rank of matrix. TLO 2.7 Check the consistency of homogenous system of linear equation using rank of matrix. TLO 2.8 Find solution of non-homogeneous system of linear equations. TLO 2.9 Find solution of homogenous system of linear equations. TLO 2.10 Find eigen-values and eigen-vectors for the given matrix of order 2.	**Unit - II Matrices** 2.1 Review of types of matrices and algebra of matrices 2.2 Elementary row and column transformation of matrices 2.3 Conversion of matrix to echelon and normal form 2.4 Inverse of matrix using elementary transformation 2.5 Rank of matrix using determinant of order two & three, Rank of matrix by reducing matrix to echelon and normal form 2.6 Non-Homogeneous and Homogeneous system of linear equations 2.7 Consistency of system of linear equations using rank of matrices 2.8 Non-Homogeneous system of linear equation: Unique solution, Infinite number of solutions 2.9 Homogeneous system of linear equation: Unique or trivial solution, Infinite number of non-trivial solutions 2.10 Eigen values and Eigen-vector: Basic Definition, Characteristic Polynomial, Characteristic Equation, Eigen-value and Eigen-vector of a matrix of order 2	Lecture Using Chalk-Board Flipped Classroom Presentations

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Calculate the magnitude of given vector and unit vector perpendicular to given vector. TLO 3.2 Calculate direction ratio and direction cosines of a vector. TLO 3.3 Find scalar(dot) product of two vectors. TLO 3.4 Find angle between two vectors using scalar(dot) product. TLO 3.5 Find projection of one vector on another vector. TLO 3.6 Find vector(cross) product of two vectors. TLO 3.7 Find angle between two vectors using vector(cross) product. TLO 3.8 Find scalar triple product of the vectors. TLO 3.9 Define different types of tensors.	**Unit - III Vectors and Tensors** 3.1 Introduction, Definition of scalar and vector quantity, Representation of vector, Magnitude of vector, Component of vector, Direction ratio, Direction cosines 3.2 Types of vectors: Zero vector, Unit vector, Position vector, Equal vector, Negative vector. Parallel vector, Co-initial vector, Collinear vector 3.3 Algebra of vectors: Addition of vectors, Triangle law of vectors addition, Parallelogram law of vectors addition, Subtraction of vectors, Multiplication of vectors by scalar 3.4 Product of two vectors: Scalar (dot) product of two vectors, Projection of one vector on another vector, Angle between two vectors using scalar(dot) product, Properties of scalar(dot) product 3.5 Vector (cross)product of two vectors, Angle between two vectors using vector(cross) product, Properties of vector(cross) product 3.6 Scalar triple product of vectors 3.7 Tensor: Definition of tensors, Types of tensors, Rank of tensors, Algebra of tensors	Lecture Using Chalk-Board Demonstration Flipped Classroom
4	TLO 4.1 Find first order derivative using forward and backward interpolation. TLO 4.2 Evaluate numerical integration using Trapezoidal rule. TLO 4.3 Evaluate numerical integration using Simpson’s one third rule. TLO 4.4 Evaluate numerical integration using Simpson’s three eight rule.	**Unit - IV Numerical Differentiation and Integration** 4.1 Introduction to numerical differentiation and integration 4.2 Derivative using forward and backward interpolation 4.3 Numerical integration using Trapezoidal rule 4.4 Numerical integration using Simpson’s one third rule 4.5 Numerical integration using Simpson’s three eight rule	Lecture Using Chalk-Board Flipped Classroom Presentations
5	TLO 5.1 Formulate given problem in Linear Programming Problems. TLO 5.2 Find optimal solution of Linear Programming Problems using graphical (corner point) method. TLO 5.3 Find optimal solution of Linear Programming Problems using simplex method.	**Unit - V Linear Programming Problems** 5.1 Introduction, Basic terms in Linear Programming Problems 5.2 Mathematical formulation of Linear Programming Problems 5.3 Method of solving Linear Programming Problems (Two equations in two variables): Graphical (corner point) method, Simplex method	Lecture Using Chalk-Board Flipped Classroom Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Find partial derivative of first order, second order and mixed order using Python programming.	1	Write a program to compute partial derivative.	2	CO1

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 2.1 Find maximum and minimum value of the function for two variables using Python programming.	2	* Write a program to find maximum and minimum value of the function for two variables.	2	CO1
LLO 3.1 Find maximum and minimum value of the function for three variables using Python programming.	3	Write a program to find maximum and minimum value of the function for three variables.	2	CO1
LLO 4.1 Calculate the rank of a matrix by elementary transformation using Python programming.	4	Write a program to find a) Elementary row and column transformations using Python loops. b) Rank of a matrix.	2	CO2
LLO 5.1 Calculate the inverse of a matrix by elementary transformation using Python programming.	5	* Write a program to find inverse of a matrix by elementary transformation.	2	CO2
LLO 6.1 Solve system of linear equations using Python programming.	6	* Write a program to solve system of linear equations.	2	CO2
LLO 7.1 Calculate eigen-values and eigen-vectors for the given matrix of order 2 using Python programming.	7	Write a program to calculate eigen values and eigen vector for given matrix of order 2.	2	CO2
LLO 8.1 Calculate eigen-values and eigen-vectors for the given matrix of order 3 using Python programming.	8	Write a program to calculate eigen values and eigen vector for given matrix of order 3.	2	CO2
LLO 9.1 Implement algebra of vectors using Python programming.	9	* Write a program to implement algebra of vectors like addition, subtraction and scalar multiplication.	2	CO3
LLO 10.1 Implement vectors operations using Python programming.	10	* Write a program to implement vectors operations like dot product, cross product and scalar triple product.	2	CO3
LLO 11.1 Implement basic algebraic operations on tensors using Python programming.	11	Write a program to implement basic algebraic operations on tensors like addition, subtraction.	2	CO3
LLO 12.1 Find numerical differentiation for the given data using Python programming.	12	* Write a program to evaluate numerical differentiation for the given data.	2	CO4
LLO 13.1 Find numerical integration using Trapezoidal rule for the given data using Python programming.	13	Write a program to evaluate numerical integration using Trapezoidal rule for the given data.	2	CO4
LLO 14.1 Find numerical integration using Simpson's one third rule for the given data using Python programming.	14	* Write a program to evaluate numerical integration using Simpson's one third rule for the given data.	2	CO4
LLO 15.1 Find optimal solution of linear programming problems by applying simplex method using Python programming.	15	* Write a program to implement simplex method for 2 equations in 2 variables.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

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- Collect five linear programming problems that can be solved graphically. Draw graph, identify the feasible region and determine the optimal solution.
- Collect data set of different types of functions such as polynomial, trigonometric, logarithmic, exponential function of two variables. Calculate the partial derivatives of first order, second order and mixed order for each function.
- Solve five examples to find addition, subtraction, scalar product and cross product of given vectors.
- Solve five examples to find the eigen values and eigen vector of matrix of order two and three.
- Solve five examples on numerical differentiation and integration.

Micro project

- Not Applicable

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computer System with Modern Operating System, Intel Core i3/i5 Processor or equivalent, RAM minimum 4 GB onwards.	All
2	Python Interpreter/ IDE like Jupyter Notebook, PyCharm, Spyder etc.	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Partial Differentiation	CO1	10	4	4	6	14
2	II	Matrices	CO2	18	2	6	12	20
3	III	Vectors and Tensors	CO3	14	2	4	8	14
4	IV	Numerical Differentiation and Integration	CO4	10	2	4	6	12
5	V	Linear Programming Problems	CO5	8	0	4	6	10
Grand Total				**60**	**10**	**22**	**38**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Laboratory Performance, Unit Tests , Midterm Exam, Term Work, Seminar/Presentations.
- Continuous assessment based on process and product related performance indicators.
- Each practical will be assessed considering 60% weightage to process and 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End Semester Exam, Practical exam, viva voce.

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XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	2	1	1	-	1			
CO2	2	2	2	1	1	-	1			
CO3	2	2	2	1	1	-	2			
CO4	2	2	2	1	1	-	1			
CO5	2	3	3	1	1	-	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	H. K. Dass, Er. Rajnish Verma	Higher Engineering Mathematics	S. Chand Technical, ISBN: 9788121938907
2	K.Nageswara Rao, Shaikh Akbar	Python Programming	Scitech Publication(India) Pvt. Ltd. ISBN:9789385983450
3	Grewal B. S.	Higher Engineering Mathematics	Tata McGraw Hill Education, New Delhi, ISBN : 9789386173522
4	A. C. Shrivastava, P. K. Shrivastava	Engineering Mathematics	PHI Learning, New Delhi, ISBN:9788120342934
5	Mark Lutz	Learning Python	O'Reilly Publication ISBN-13: 9780672329784

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://atozmath.com/default.aspx	Online Learning Initiative for Mathematics Problems with Solutions
2	https://www.w3schools.com/ai/ai_mathematics.asp	Machine Learning Mathematics
3	https://www.geeksforgeeks.org/machine-learning-mathematics/	Machine Learning Mathematics
4	https://docs.python.org/3/tutorial/index.html	The Python Tutorial
5	https://onlinecourses.nptel.ac.in/noc21_ma38/preview	NPTEL Course
6	https://www.purplemath.com/index.htm	Foundational Mathematics to improve learning
7	https://mathworld.wolfram.com/	Extensive mathematical resource with detailed explanations
8	https://www.khanacademy.org/math	Mathematical concepts through video lectures

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

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MSBTE Approval Dt. 21/11/2024 **Semester - 4, K Scheme**