Program Name : **Diploma in Artificial Intelligence and Machine Learning**

Program Code : **AN**

Semester : **Fourth**

Course Title : **Mathematics for Machine Learning - II**

Course Code : **22480**

1. RATIONALE

Machine learning is important because it gives enterprises a view of trends in customer behavior and operational business patterns, as well as supports the development of new products. This course represents an important evolution in computer science and data processing that is quickly transforming a vast array of industries. Artificial intelligence generally refers to processes and algorithms that are able to simulate human intelligence, including cognitive functions such as perception, learning and problem solving. Machine learning and deep learning (DL) are subsets of AI.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Analyze the required data and apply appropriate mathematical solutions.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented in **Python / R programming language**, so that the student demonstrates the following ***industry oriented*** COs associated with the above mentioned competency.

a. Implement the given problem based on calculus.
b. Implement real life problems using matrices concepts.
c. Build programs to implement basic operations based on vectors and tensors.
d. Implement methods based on the interpolation concept.
e. Evaluate numerical integration and differentiation functions.
f. Apply the linear programming problem concept to obtain optimal solution.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme				Examination Scheme													
				Theory						Practical							
L	T	P	Credits (L+T+P)	Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	1	2	6	3	70	28	30*	0	100	40	25@	10	25	10	50	20	

(*): Under the theory PA; Out of 30 marks, 10 marks of theory PA are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *-Credit,* ***ESE*** *-End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

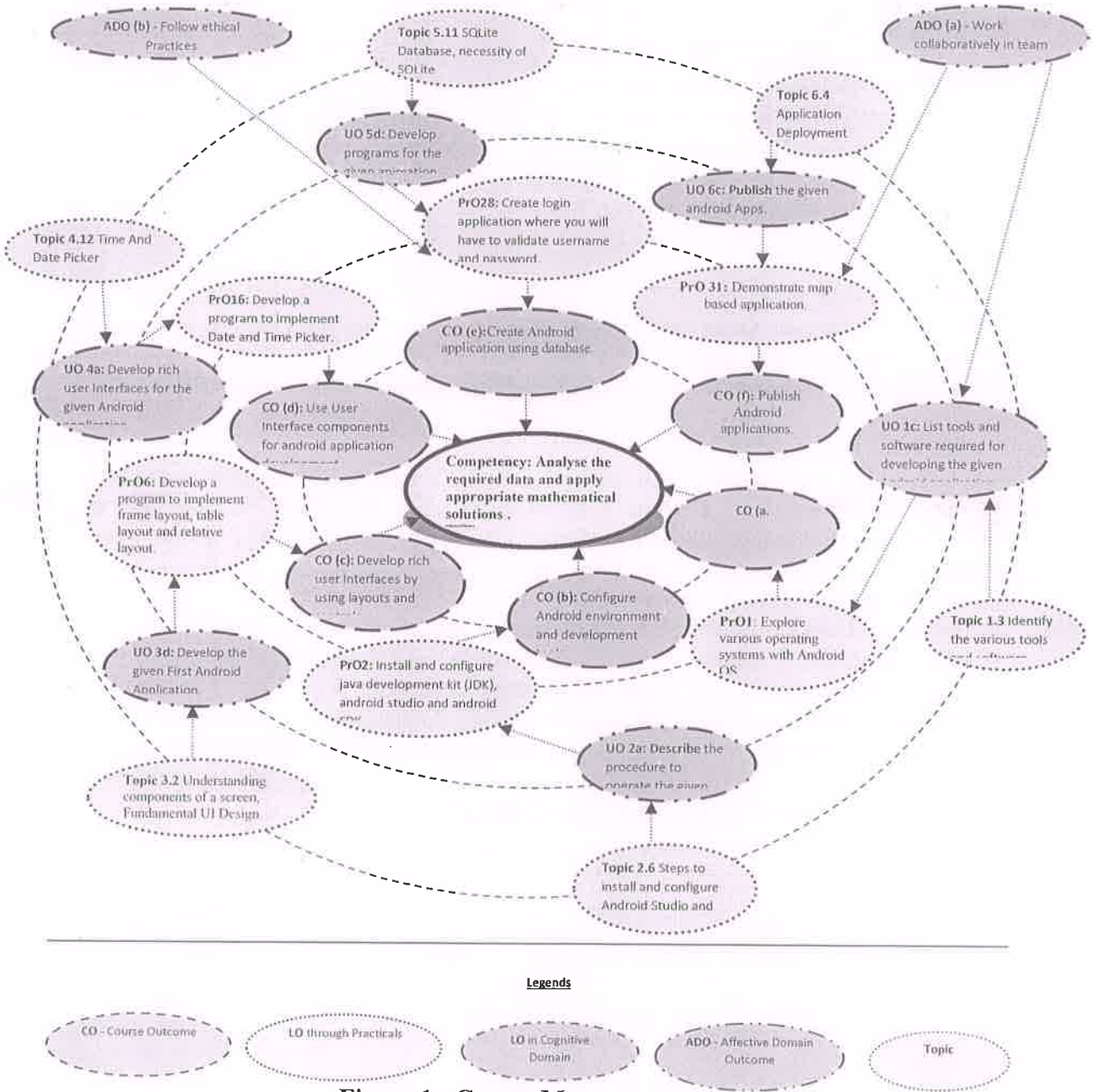

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals/exercises/tutorials in this section are psychomotor domain LOs (i.e. sub-components of the COs) are to be developed and assessed in the student to lead to the attainment of the competency.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Write a program to compute partial derivatives eg: package Deriv, part_deriv (),	I	2*
2	Write a program to find the maxima and minima for two variables.	I	2*
3	Write a program based on Elementary Row and column transformation using R/Python loops.	II	2*
4	Write a program to find rank of a matrix.	II	2*
5	Write a program to solve system of linear equations.	II	2*
6	Write a program to calculate Eigen values for given matrix of order 2 & 3 and Eigen vector for given matrix of order 2.	II	2*
7	Write a program to implement Algebra of vectors like addition, subtraction, scalar multiplication, dot product, cross product, scalar triple product.	III	2*
8	Write a program to implement basic algebraic operations on Tensors like addition, subtraction and rank of Tensors.	III	2*
9	Write a Program to interpolate using newton forward interpolation.	IV	2*
10	Write a Program to interpolate using newton backward interpolation.	IV	2
11	Write a program for the implementation of Linear extrapolation using extrapolate().	IV	4*
12	Write a program to evaluate numerical differentiation and for the given data.	V	2*
13	Write a program to evaluate numerical integration using Trapezoidal rule/ Simpson's one third Rule for the given data.	V	2
14	Write a program to build Mathematical formulation of LPP for the given data.	VI	2*
15	Write a program to implement corner point method / Simplex method for 2 equations in 2 variables and represent it graphically.	VI	2
Total			**32**

Note:

- *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. The practicals marked as '*' are compulsory, so that the student reaches the 'Application Level' of Bloom's Taxonomy' as generally required by the industry.*
- *The 'Process' and 'Product' related skills associated with each PrO are to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
a	Correctness of analyzing the problem statement	30
b	Correctness of building the logic	40
c	Debugging ability	10
d	Correctness of evaluation of the mathematical problems	10
e	On time submission	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

- Work collaboratively in team
- Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year and
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

Sr. No.	Equipment Name with Broad Specifications	Exp. Sr. No.
•	Computer system (Any computer system which is available in laboratory with minimum 2GB RAM)	All
•	Any compatible open source tools (e.g. RStudio, Eclipse, PyCharm, Eric etc.)	

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I **Calculus**	1a. Calculate partial derivative of first order, second order and mixed order. 1b. Calculate maximum and minimum value of the function. 1c. Find maximum and minimum value of the function subject to given	1.1 Introduction to Derivative and Integration 1.2 Partial derivative (Two variables) 1.1.1. Introduction 1.1.2. Partial derivative of first order, second order and mixed order. 1.1.3. Maxima and minima of function (Two variables)

	condition using Lagrange's undermined multipliers .	1.1.4. Lagrange's method of undetermined multipliers with one constraint (Two variables)
Unit– II Matrices	2a. Reduce the matrix to echelon form and normal form. 2b. Find the inverse of matrix by elementary transformation. 2c. Calculate the rank of matrix using determinant of order 2 and 3 2d. Calculate rank of matrix by reducing matrix to echelon form and normal form 2e. Check the Consistency of non-homogenous and homogenous system of linear equation using rank of matrix. 2f. Calculate solution of Non homogeneous and homogenous system of linear equation 2g. Find characteristic polynomial. 2h. Find eigenvalues for the given matrix of order 2 and 3 2i. Find eigenvectors for the given matrix of order two .	2.1 Introduction to types of matrix, algebra of matrix 2.2 Elementary transformation of matrices 2.2.1 Elementary Row and column transformation 2.2.2 Conversion of matrix to echelon form and Normal form 2.3 Inverse of matrix using elementary transformation 2.4 Rank of matrix 2.4.1 Rank of matrix of order two & three 2.4.2 Rank of matrix by reducing matrix to echelon form & normal form. 2.5 Consistency of linear equation and their solution 2.5.1 System of Linear equation a) Non Homogeneous b) Homogeneous 2.5.2 Consistency of system of linear equation using rank of matrices. 2.5.3 Solution of non-Homogeneous system of equation having a) unique solution b) infinite number of solution 2.5.4 Solution of Homogeneous system of equation having a) unique or trivial solution b) infinite number of non trivial solution 2.6 Eigen values 2.6.1 Eigen values and characteristics of Eigen values of matrix. 2.6.2 Eigen-value of matrix of order 2 and 3 a) Characteristic polynomial b) Characteristic Equation c) Characteristic Root 2.7 Eigen-vector matrix of order two
Unit– III Vectors and Tensors	3a. Calculate the magnitude, unit vector, direction ratio, direction cosines of given vector 3b. Find the position vector of	3.1. Introduction 3.2. Definition of scalar and vector quantity 3.3. Some basic concept: Representation of vector, Magnitude of vector.

	point which divide the joining of two point – internally and externally 3c. Find dot product, angle between two vectors, projection of one vector on another vector. 3d. Find cross product, scalar triple product. 3e. State types of tensor 3f. Find order, rank and solve algebraic operations on Tensor	Component of vector, Direction ratio, Direction cosines 3.4. Types of vectors –zero vector, Unit vector, Position vector, Equal vector, Negative vector. Parallel vector, Co-initial vector, Collinear vector 3.5. Algebra of vector: 3.5.1 Addition of vector a) Triangle law of vector addition b) Parallelogram law of vector addition. 3.5.1 Subtraction of vector. 3.5.2 Multiplication of vector by scalar 3.6 Product of two vector 3.6.1 Scalar (dot) product of Two Vector, Projection of one vector on another vector. Angle between two vector 3.6.2 Vector (cross)product of two Vector 3.6.3 Scalar triple product of vector 3.7 Tensor 3.7.1 Definition of tensors 3.7.2 Types of tensors 3.7.3 Rank of tensors 3.7.4 Algebra of tensors
Unit-IV Interpolation	4a. Solve problems using Lagrange's interpolation formula 4b. Construction of forward and backward difference table 4c. Solve examples on different types of operators. 4d. Solve problems on forward and backward interpolation 4e. Find problems on extrapolation.	4.1.Introduction 4.2.Lagrange's interpolation formula for missing values 4.3.Finite differences 4.3.1. Forward difference 4.3.2. Backward difference 4.3.3. Shift operator 4.3.4. Inverse shift operator 4.3.5. Relation between forward, backward, shift and inverse shift operator 4.4. Newton's forward and backward difference Interpolation Formula. 4.5. Concept of Extrapolation
Unit –V Numerical Differentiation and Integration	5a. Find first order derivative using forward and backward interpolation 5b. Find the area Using Trapezoidal and Simpson's one third rule.	5.1.Introduction to numerical differentiation and integration. 5.2.Derivative using forward and backward interpolation 5.3 Numerical integration 5.3.1 Trapezoidal rule 5.3.2 Simpson's one third Rule Formula

Unit –VI Linear programming Problems	6.a. Formulate given problems in LPP 6.b. Find optimal solution of LPP Using point corner method 6.c. Find optimal solution of LPP Using Simplex method	6.1 Introduction 6.2 Mathematical formulation of LPP 6.3 Graphical method to solving LPP problems- Corner point method (Two equation in two variable) 6.4 Optimal solution for LPP using simplex method (Two equation in two variable)

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Partial Derivatives	08	02	04	04	10
II	Matrices	14	02	02	16	20
III	Vectors and Tensors	10	02	04	08	14
IV	Interpolation	08	02	04	04	10
V	Numerical differentiation and integration	04	00	04	04	08
VI	Linear programming problems (LPP)	04	00	04	04	08
	Total	**48**	**08**	**22**	**40**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- Prepare journal of practical.
- Undertake micro-projects.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
- ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.

- About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
- With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
- Use different Audio Visual media for Concept understanding.
- Guide student(s) in undertaking micro-projects.
- Demonstrate students thoroughly before they start doing the practice.
- Ensure use of latest version of tools.
- Encourage students to refer various web sites to have detail understanding of JSP and related concepts.
- Encourage students to refer different web-applications to have deeper understanding of web-applications.
- Observe continuously the performance of students in laboratory.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Develop a Tensor Flow.
b. Develop Sales Forecasting with any mart (Megamart. walmart etc.)
c. Stock price predictions.
d. Time Series Forecasting

GUIDELINES FOR DEVELOPING MICRO PROJECTS:

(Implement following relevant guidelines for micro projects)

- Must implement concepts of Python / R.
- Must evaluate the mathematical operations studied in the theory lectures.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Higher Engineering Mathematics	H.K.Dass, Er.RajnishVerma	S. Chand Technical ISBN: 9788121938907 9788121938907

2	Higher Engineering Mathematics	B .V .Ramana	Tata Mcgraw Hill Education private limited , New Delhi ISBN : 9780070634190
3	Higher Engineering Mathematics	B. S Grewal	Tata Mcgraw Hill Education private limited , New Delhi ISBN : 9789386173522
4	Advance Engineering Mathematics	ERWIN KREYSZIG	Wiley India Pvt Ltd ISBN : 0470458364
5	Engineering Mathematics Tutorial Approach	Ravish R singh Mukul Bhatt	Tata Mcgraw Hill Education private limited , New Delhi ISBN : 9780070146150
6	Engineering Mathematics	Babu Ram	Pearson ISBN : 8131726916, 9788131726914
7	Introduction to R Programming	Hicham and Mohamed Ibnalkadi	(202 Non Fiction Book 4) Kindle Edition
8	R Programming For Dummies	Andrie de Vries, Joris Meys	Wiley india ISBN: 9788126562183

14. SOFTWARE/LEARNING WEBSITES

a. https://www.datacamp.com/tutorial/machine-learning-in-r
b. https://steelkiwi.com/blog/python-for-ai-and-machine-learning
c. https://gwthomas.github.io/docs
d. https://course.ccs.neu.edu
e. https://www.freecodecamp.org