



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Computer Engineering (Artificial Intelligence And Data Science)

Course / Subject Code : ME01095051

Subject Name: Mathematical Foundation for Computing

WEF Academic Year :	2024-25
Semester :	1 st Semester
Category of the Course :	PEC

Prerequisite :	Basics of Probability and Statistics
Rationale :	<p>Mathematical Foundations of Computing (<i>MFC</i>), provides an interdisciplinary forum to promote interaction among mathematicians, computer scientists and statisticians as well as engineers to exchange new ideas and techniques for attacking the pressing challenges in data analysis.</p> <p>Probability theory and statistics are used to model uncertainty and make inferences about data, allowing for robust decision-making in uncertain environments.</p> <p>It aims to provide a place for more understanding how functions can approximate complex mappings is crucial for developing deep learning models.</p> <p>Information theory principles are essential for tasks like model compression and understanding the trade-offs between model complexity and performance.</p> <p>Knowledge of convergence theorems helps in ensuring that algorithms reach an optimal solution reliably.</p>

Course Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Practical		
				ESE (E)	PA(M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate	7	15



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Computer Engineering (Artificial Intelligence And Data Science)

Course / Subject Code : ME01095051

Subject Name: Mathematical Foundation for Computing

	Central Limit Theorem, Probabilistic inequalities, Markov chains		
2	Random samples, sampling distributions of estimators, Maximum likelihood estimation (MLE) in Binomial, Multinomial, Gaussian, models in exponential family.	7	15
3	Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment Time Series Analysis Time series forecasting models, Model evaluation, Applications in data science	8	16
4	Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems, Application of graph theory in neural networks and data science Information Theory Entropy: Understanding uncertainty and its implications in data science. Cross-Entropy: Common loss function in classification problems.	10	20
5	Convex functions and sets, Convex Optimization, Optimization Formulations of Data Analysis Problems, Regularization, Lasso, Gradient and Sub-gradient descent for non-smooth functions e.g.: SVM, Online Gradient Descent e.g.: Stochastic Gradient Descent and its applications (NN), Duality and its examples, Accelerating Gradient Descent Advanced Optimization Methods: Techniques like Adam, RMSprop, and momentum.	9	17
6	Mathematics for machine learning- Expectation Maximization (EM) based learning in Mixture models, Hidden Markov Model, Dirichlet processes (Clustering). Bayesian Machine Learning, estimating decisions using posterior distributions, Model selection: Variational Inference.	8	17
	Total	45	100



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Computer Engineering (Artificial Intelligence And Data Science)

Course / Subject Code : ME01095051

Subject Name: Mathematical Foundation for Computing

Reference Book :

1. John Vince, Foundation Mathematics for Computer Science, Springer
2. K. Trivedi. Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
- 2-3. "Numerical Optimization" by Jorge Nocedal, Stephen J. Wright
- 3-4. "Mathematics for machine learning" by Marc Peter Deisenroth A. Aldo Faisal Cheng Soon Ong
- 4-5. M. Mitzenmacher and E. Upfal. Probability and Computing: Randomized Algorithms and Probabilistic Analysis
- 5-6. Alan Tucker, Applied Combinatorics, Wiley

Course Outcome :

After Completion of the Course, Student will able to :

No	Course Outcomes	RBT Level*
01	To understand the mathematical fundamentals that is prerequisites for a variety of courses like neural networks, deep learning, machine learning.	UN
02	To study various sampling and classification problems.	UN
03	To implement the mathematical concepts in programming language.	AP
04	to analyze and measure the amount of information processed by AI systems, as well as to study how efficiently they can transmit and process data.	AP
05	To optimize the solution using different optimization techniques.	CR
06	To apply advance statistics concepts in data science.	AP

*RM: Remember, UN: Understand, AP: Apply, AN: Analyse, EL: Evaluate, CR: Create

Suggested Course Practical List:

1. Analyze the concept of randomization. Implement a program in a language that supports graphics to Push the balls from left and right allowing random movement and then let them fall in rectangle bins. Show graphically how they form curve
2. Consider that there are two parties party1 and party2 contesting for elections. Consider candidate from either party1 or party2. Consider voting population and ask them about their likelihood to vote for the candidate from party1. Now Ask the population again to show their likelihood for candidate after candidate gives speech. Now again rate the candidate



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Computer Engineering (Artificial Intelligence And Data Science)

Course / Subject Code : ME01095051

Subject Name: Mathematical Foundation for Computing

through voting population. Implement a program to do this. Use WEKA tool to simulate this.

3. Write a program that takes two inputs- size of the house(no of rooms) and location of the house and accordingly give price of the house. Classify the house as very costly, costly, affordable, cheap.
4. Consider website of your institute. Represent the link structure by directed graph. Apply and implement algorithm to traverse the graph and to reach a faculty's web page in your department.
5. Graph theory problem – there are k aircrafts and have to be assigned n flights. The time interval of ith flight is (t_{i1}, t_{i2}) . If the time interval overlaps for the flights the same aircraft cannot be assigned to both the flights. Vertices of the graph are flights. Two vertices are connected if the corresponding time intervals overlap. Simulate the problem by applying graph theory. Use simulation tool to simulate or programming language to implement graph

* * * * *