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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2025/477 Date: 14.10.2025

CIRCULAR

The University has decided to implement the Curriculum and Credit Framework for the Undergraduate Programme (CCFUP) under the National Education Policy (NEP), 2020 based on All India Council for Technical Education (AICTE) and National Credit Framework (NCrF) Guidelines from the Academic Year 2024-2025 onwards.

The Syllabus of Semester III & IV Courses offered under Specialization **Artificial Intelligence and Machine Learning** of **Bachelor of Engineering in Computer Engineering** Programme is attached.

The Dean, Faculty of Engineering and Principals of affiliated Engineering Colleges are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE Digitally signed by ASHWIN VYAS LAWANDE Date: 2025.10.14 10:36:47 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of affiliated Engineering Colleges.

Copy to,
1. The Director, Directorate of Technical Education, Govt. of Goa
2. The Chairperson, BoS in Computer Engineering.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, Prof. Examinations (Technical and Allied), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Computer Engineering
Specialization: Artificial Intelligence and Machine Learning

Sr. No.	Semester	Course Code	Title of the Course	L	T	P	TCr
1	III	CMP-281	Mathematical Foundation for AI/ML	3	0	0	3
2		CMP-282	Mathematical Foundation for AI/ML Lab	0	0	1	1
3	IV	CMP-283	Applied Machine Learning	3	0	0	3
4		CMP-284	Applied Machine Learning Lab	0	0	1	1
5	V	CMP-381	Data Science and Analytics	3	0	0	3
6		CMP-382	Data Science and Analytics Lab	0	0	1	1
7	VI	CMP-383	Neural Networks and Deep Learning	3	0	0	3
8		CMP-384	Neural Networks and Deep Learning Lab	0	0	1	1
9	VII	CMP-481	Applications of Artificial Intelligence	3	0	0	3
10		CMP-482	Applications of Artificial Intelligence Lab	0	0	1	1
			Total	**15**	**0**	**5**	**20**

SEMESTER III

Name of the Programme	**: Computer Engineering (Artificial Intelligence and Machine Learning)**
Course Code	**: CMP-281**
Title of the Course	**: Mathematical Foundations for Artificial Intelligence and Machine Learning**
Number of Credits	**: 3(3L)**
Effective from AY	**: 2025-26**

Pre- requisites for the Course:	Basic Knowledge of classical definition of probability differentiation and Matrices	
Course Objectives:	This course will enable students to: • Understand probability spaces, discrete and continuous random variables, and special distributions in the context of artificial intelligence and machine learning. • Understand sampling distributions and the Central Limit Theorem's role in estimating means, and explore hypothesis testing concepts and various tests for means, in relation to artificial intelligence and machine learning. • Gain exposure to Vector and Matrix Calculus, which is an essential tool for solving optimization problems in artificial intelligence and machine learning. • Learn unconstrained and constrained optimization methods used in artificial intelligence and machine learning.	
Units	**Contents:**	**No of Hours**
Unit-1	**Probability Distributions:** Probability Space, Discrete and Continuous Random Variables and probability Distributions, Some Special Distributions (Bernoulli, Binomial, Poisson, Geometric, Exponential, Uniform, and Gaussian distributions), Moment Generating Function (computation of first two moments of specific probability distributions).	**11**
Unit-2	**Sampling Distributions:** Definition of Sampling distribution, Sampling distribution of the Mean with variance known, Central Limit Theorem (Sampling distribution of the Mean for a Large Sample when variance is not known). **Confidence Interval Estimation:** Concept, Confidence interval for the mean of a normal population with variance known, Large Sample Confidence interval for a population mean (variance not known). **Tests of Hypotheses:** Statistical Hypotheses, Null Hypothesis, alternative hypothesis, Type I and Type II Errors, Level of Significance, Test on the mean of a normal population with	**12**

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	variance known, Large Sample Test on a Population mean (variance unknown).	
Unit-3	**Vector and Matrix Calculus:** Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices (only scalar valued functions of matrices), Higher-Order Derivatives, Linearization and Multivariate Taylor Series.	**11**
Unit-4	**Unconstrained Optimization:** Gradients and Stationary Points, Second Derivative Test for functions of several variables (up to three variables), Gradient Descent method. **Constrained Optimization:** Lagrange's Multiplier method, Standard form of linear programming problem, Basic Simplex algorithm.	**11**
Pedagogy	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem-solving skills.	
References/ Readings:	Text Books 1. Douglas C. Montgomery, George C. Runger, "Applied Statistics and Probability for Engineers", Fourth Edition, Wiley-India, 2012. 2. E. K. P. Chong and S. H. Zak, "An Introduction to Optimization with applications to machine learning", 4th Edition, John Wiley and Sons Pvt. Ltd., 2013. 3. George B. Thomas, Maurice D. Weir Naval, Joel Hass, Christopher Heil "Thomas' Calculus - Early Transcendentals", Thirteenth Edition, Pearson, 2014. 4. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020. Reference Books 1. Jay Dawani, "Hands-On Mathematics for Deep learning", First Edition, Packt Publishing Ltd., 2020. 2. Jorge Nocedal, Stephen J. Wright, "Numerical optimization", 2nd Edition, Springer, 2006. 3. Richard A. Johnson, Irwin Miller, John Freund, "Miller and Freund's Probability and Statistics for Engineers", Eight Edition, Pearson India Education services Pvt. Ltd., 2018.	
Course Outcomes:	On completion of the course students should be able to: 1. Apply various probability distributions to model uncertainties arising in artificial intelligence and machine learning. 2. Effectively formulate and test statistical hypotheses to validate artificial intelligence and machine learning models.	

	3. Apply vector and matrix calculus techniques to effectively compute gradients required to train modelsarising in artificial intelligence and machine learning, 4. Apply various optimization techniques to solve problems arising in artificial intelligence and machine learning.

Name of the Programme : **Computer Engineering (Artificial Intelligence and Machine Learning)**
Course Code : **CMP-282**
Title of the Course : **Mathematical Foundations for Artificial Intelligence and Machine Learning Lab**
Number of Credits : **1(2P)**
Effective from AY : **2025-26**

Pre- requisites for the Course:	The students should have knowledge on basics of Python programming.	
Course Objectives:	This course will enable students to: 1. Develop the ability to generate and visualize probability distributions using Python constructs. 2. Learn to construct confidence intervals and perform hypothesis testing for population means, using Python. 3. Gain proficiency in computing Jacobian matrices, and calculating higher-order derivatives using symbolic and numerical methods. 4. Gain hands-on experience in implementing optimization algorithms in Python.	
Units		**No of Hours**
Content:	1. Program to generate Binomial random variables and visualize the probability mass function. 2. Program to generate Poisson random variables and visualize the probability mass function. 3. Program to generate and plot the Gaussian distribution. 4. Program to construct a confidence interval for a normally distributed population with known variance. 5. Demonstrate the Central Limit Theorem with large sample sizes from a non-normal population. 6. Perform a hypothesis test on the population mean with known variance 7. Program to numerically compute the Jacobian matrix for a given vector-valued function. 8. Program to compute higher-order derivatives (e.g., second, third derivatives) of univariate and multivariate functions using symbolic differentiation 9. Program to compute and visualise the Taylor series for a function of two variables. Compare it with the original function. 10. Program to implement the Simplex algorithm.	**30**
Pedagogy	Constructive, Collaborative and Creativity Based Learning	

References/ Readings:	Text Books 1. Wes McKinney, "Python for Data Analysis", Second Edition, O'Reilly Media, Inc., 2017. 2. Robert Johansson, "Numerical Python: A Practical Techniques Approach for Industry", First Edition, Apress, 2015. 3. Francois Chollet, "Deep Learning with python", First Edition, Manning, 2017. 4. Rupesh Kumar Tipu, Vandna Batra, Suman Punia, "Efficient Coding with Python Mastering Optimization Techniques", 1st Edition, Lambert Academic Publishing, 2024. Reference Books 1. Samir Madhavan, "Mastering Python for Data Science", 1st Edition, Packt Publishing Ltd., 2015. 2. Dr. R. Nageswara Rao, "Core Python Programming", 3rd Edition, Dreamtech Press, 2018. 3. Kenneth. A. Lambert, "Fundamentals of Python: First Programs", 2nd Edition, Course Technology Cengage Learning, 2019. 4. Vamsi Kurama, "Python Programming: A Modern Approach", 1st Edition, Pearson India, 2017.
Course Outcomes:	On completion of this course students should be able to: 1. Generate and visualize probability distributions using Python. 2. Construct confidence intervals and perform hypothesis testing for population means, for real-world data analysis using Python. 3. Compute Gradients and calculate higher-order derivatives for univariate and multivariate functions using Python. 4. Implement optimization algorithms such as the Simplex algorithm, Lagrange's multiplier method and gradient descent, to solve optimization problems arising in artificial intelligence and machine learning.

Semester IV

Name of the Programme : Computer Engineering (Artificial Intelligence and Machine Learning)
Course Code : CMP-283
Title of the Course : Applied Machine Learning
Number of Credits : 3(3L)
Effective from AY : 2025-26

Pre- requisites for the Course:	Mathematical Foundation of AI/ML	
Course Objectives:	This course aims students to : 1. Understand the basic concepts of Machine learning. 2. Learn various supervised learning algorithms. 3. Understand data clustering, transformation and dimensionality reduction techniques. 4. Apply Decision tree learning algorithms.	
Contents:		**No of Hours**
Unit-1	Well-Posed Machine Learning Problems, Data Representation, Diversity of Data: Structured/Unstructured, Forms of Learning. **Supervised Learning:** Learning from Observations, Bias and Variance, Computational Learning Theory, Occam's Razor Principle and Overfitting Avoidance, Heuristic Search in Inductive Learning, Estimating Generalization Errors, Metrics for Assessing Regression accuracy, Metrics for Assessing Classification accuracy.	**12**
Unit-2	Statistical Learning: Descriptive Statistics in Learning Techniques, Bayesian Reasoning to Inference, k-Nearest Neighbor (k-NN) Classifier, Discriminant Functions and Regression Functions, Linear and Logistic regression. Fisher's Linear Discriminant, Minimum Description Length Principle. Support Vector Machines:	**11**
Unit- 3	**Data Clustering and Data Transformations:** Clustering, Engineering the Data, Different Clustering Methods such as Partitional Clustering, Hierarchical Clustering, Spectral Clustering, Clustering using Self-Organizing Maps, Fuzzy K-Means Clustering, Expectation-Maximization (EM) Algorithm and Gaussian Mixtures Clustering, Data transformation techniques.	**11**
Unit- 4	Decision Tree Learning: Introduction, Example of a Classification Decision Tree, Measures of Impurity for Evaluating Splits in Decision Trees, ID3, C4.5, and CART Decision Trees, Pruning the Tree, Strengths and Weaknesses of Decision-Tree Approach, Random Forest algorithm. Data Warehousing and Online Analytical Processing.	**11**

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Pedagogy:	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem-solving skills.
References/ Readings:	**Text Books** 1. M. Gopal: Applied Machine Learning, 2nd Edition, Mc Graw Hill Publication, 2021. ISBN 9353160251 Reference Books 1. Siddhanta Bhatta: Applied Machine Learning Solutions with Python, 2nd Edition, BPB Publication, 2021, ISBN 9391030432 2. Tom M Mitchell: Machine Learning, Indian edition, McGraw Hill Publication, 1997, ISBN 1259096955 3. Ethem Alpaydin: Introduction to Machine Learning", 4th Edition, MIT Press, Prentice Hall of India, 2020, ISBN 0262043793.
Course Outcomes:	On the successful completion of this course students should be able to: CO 1. Explain concepts of Machine learning. CO 2. Develop solutions to real world applications using supervised learning algorithms. CO 3. Apply data clustering, transformation and dimensionality reduction techniques for various applications CO 4. Demonstrate usage of logic functions, linear and non-linear separability concept and different training rules.

Name of the Programme : **Computer Engineering (Artificial Intelligence and Machine Learning)**
Course Code : **CMP-284**
Title of the Course : **Applied Machine Learning Lab**
Number of Credits : **1(2P)**
Effective from AY : **2025-26**

Pre-requisites for the course:	Familiarity with Python programming.	
Course Objectives:	This course aims to: 1. Understand the concepts of Machine learning and learn about Python libraries. 2. Demonstrate the knowledge of various supervised learning algorithms. 3. Implement Python programs for data clustering, transformation and dimensionality reduction techniques. 4. Illustrate knowledge of logic functions, linear and non-linear separability concept and different training rules.	
Contents:	**List of Programs /Experiments**	**No. of Hours**
	1. Implementation of Linear Regression. 2. Implementation of Logistic Regression. 3. Implementation of KNN classifier. 4. Implementation of Decision tree classifier. 5. Implementation of Random Forest algorithm. 6. Implementation of Naive Bayes Classifier. 7. Implementation of Hierarchical clustering algorithm. 8. Implementation of EM algorithm. 9. Implementation of K-Means clustering. 10. Implementation of PCA.	**30**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. M. Gopal: Applied Machine Learning, 2nd Edition, Mc Graw Hill Publication, 2021. ISBN 9353160251 Reference Books 1. Siddhanta Bhatta: Applied Machine Learning Solutions with Python, 2nd Edition, BPB Publication, 2021, ISBN 9391030432 2. Tom M Mitchell: Machine Learning, Indian edition, McGraw Hill Publication, 1997, ISBN 1259096955	

	3. Ethem Alpaydin: Introduction to Machine Learning", 4th Edition, MIT Press, Prentice Hall of India, 2020, ISBN 0262043793.
Course Outcomes:	On the successful completion of this course students should be able to: CO 1. Demonstrate the knowledge of Machine learning and Python libraries. CO 2. Implement solutions to real world applications using supervised learning algorithms. CO 3. Demonstrate usage of data clustering, transformation and dimensionality reduction techniques for various applications CO 4. Implement logic functions, linear and non-linear separability concept.