DETAILED SYLLABUS

SEMESTER-I

MATHEMATICAL ANALYSIS

Course Code: BMA- 581 **L-T-P-C:** 3-1-0-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Demonstrate basic knowledge of the real number system, its properties, point topology, and various types of real number sets,	Apply
CLO 2	Find limits of real-valued functions, examine continuity and differentiability of the functions and prove related theorems and illustrate their applications,	Analyze & Apply
CLO 3	Investigate the convergence of concrete numerical sequences and series and uniform convergence of sequences and series of functions and prove standard inequalities,	Analyze
CLO 4	Examine the existence and uniform convergence of Riemann-Stieltje's Integral, prove related theorems and carry out convergence analysis of power series and prove related theorems,	Analyze
CLO 5	Explain the fundamental concepts of measure theory and prove related theorems.	Understand

SYLLABUS

Unit I: Real Number System: Real number system and set theory, ordered set, The Real Field, The Extended real number system, Completeness property, Archimedian property, Denseness of rational and irrational, Cardinality, Zorn's lemma, Axiom of choice. Countable and uncountable, Compact Sets, Perfect Sets, Connected Sets.

Unit II: Continuity and Differentiability: Limits of functions, Continuous Functions, Uniform Continuity, Continuity and Compactness, Continuity and Connectedness, Discontinuities, Monotonic Functions, the derivative of a real function, Mean value theorems, The Continuity of Derivatives, L' Hospital's

Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

Rule. Derivatives of Higher Order, Taylor's theorem, Differentiation of Vector-valued Functions.

Unit III: Sequences and Series: Sequence and series of numbers, Sequences and Series of Functions, Uniform Convergence, Uniform Convergence and Continuity, Uniform Convergence and Integration, Functions of bounded variation, L^p spaces, convex functions, Jensen's inequality, Holder and Minkowski inequalities, completeness of L^p.

Unit IV: Integration: Definition and existence of Riemann Integral, Properties of the integral, Integration and differentiation, Fundamental theorem of integral calculus, Uniform convergence of Riemann Integral, Integration of vector-valued function, Rectifiable curves, Weierstrass approximation theorem, Power Series, Uniqueness theorem for power series, Abel's and Tauber's theorems and the generalized form of Riemann Integral.

Unit V: Measure Theory: Measurable sets, Lebesgue outer measure, Regularity, Measurable functions, Borel and Lebesgue measurability, measures and outer measures, an extension of a measure, uniqueness of extension, Completion of measure, Measure spaces, Integration with respect to measuring, Convergence in measure, almost uniform convergence.

Text Book:

1. Rudin, W. (2013) Principles of Mathematical Analysis (3rd Edition), Tata McGraw Hill Education.

Reference books:

1. Apostol, T. (2000) Mathematical Analysis (2nd edition) Narosa Book Distributers Pvt. Ltd.
2. Bartle, R.G. and Sherbert D. R. (2000) Introduction to Real Analysis (3rd edition) John Wiley & Sons, Inc., New York.

Any other text recommended by the instructor.

COMPUTATIONAL LINEAR ALGEBRA WITH MATLAB

Course Code: BMA-583 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	explain the vector space structure with related concepts and use basic algorithms of matrix multiplication	Understand & Apply
CLO 2	discuss basic linear algebraic concepts, norms, the principle underlying SVD, etc., and solve triangular	Understand

Prof. Ram Autar
Dean
School of Basic And Applied Scien
HBTU, Newabganj, Kanpur 208

	systems of linear equations using LU factorization/parallel LU, Gaussian elimination and pivoting strategies,	
CLO 3	apply various methods to solve special linear systems of equations and perform matrix orthogonalization and factorization as well as solve the full–rank and rank–deficient least squares problems,	Apply
CLO 4	solve modified least squares problems and unsymmetric eigenvalue problems by selecting methods/algorithms	Evaluate
CLO 5	utilize select algorithms to solve the symmetric eigenvalue problems and compute SVD and evaluate matrix functions,	Apply

SYLLABUS

Unit-I: Vector Space and Matrix Multiplication: Overview of Vector space, Basic algorithm, and notations, Structure and efficiency, Block matrices and algorithms, Fast matrix-vector products, Vector products, Vectorization and locality, Parallel matrix multiplication.

Unit-II: Matrix Analysis: Basic ideas from linear algebra, Vector norms, Matrix norms, The singular value decomposition, Subspace matrices, The sensitivity of square systems, and Finite precision matrix computation.

General Linear Systems: Triangular systems, The LU factorization, round-off error in Gaussian elimination, Pivoting, Improving and Estimating Accuracy, Parallel LU.

Unit-III: Special Linear Systems: Diagonal Dominance and symmetry, Positive definite systems, Banded systems, Symmetric indefinite systems, Block tri-diagonal systems, Vandermonde systems, classical methods for Toeplitz systems, Circulant and discrete Poisson systems.

Orthogonalization and Least Square: Householder and Givens transformations, The QR factorization, The full–rank least square problem, Other orthogonal factorizations, The rank deficient least square problem, square and undetermined systems.

Unit-IV: Modified Least Square problems and Methods: Weighting and regularization, Constrained least squares, Total least squares, Subspace computations with SVD, Updating matrix factorizations. Un-symmetric Eigen Value Problems: properties and Decomposition, Perturbation theory, Power iterations, The Heisenberg and real Schur Forms, The Practical QR algorithm, Invariant subspace computations, The generalized Eigenvalue problem, Hamiltonian and product Eigenvalue problems, Pseudo spectra.

Unit-V: Symmetric Eigen Value Problems: Properties and decompositions, Power iterations, the symmetric QR algorithm, more methods for tri-diagonal problems, Jacobi methods, Computing the SVD, Generalized Eigenvalue

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

problem with symmetry.
Functions of Matrices: Eigenvalue methods, approximation methods, The matrix exponential, the sign, square root, and Log of a matrix.

LAB WORK: Implementation of any 2-3 techniques from each UNIT (selected by the instructor) using MATLAB.

Text Book:

1. Gene. H. Golub, Charles F. Van Loan, Matrix Computations, Fourth Edition, The Johns Hopkins University Press, Baltimore 2013.

Reference Books:

1. J. W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.
2. P.G. Ciarlet, Introduction to numerical linear algebra and optimization
3. William Ford, Numerical linear algebra with applications, AP
4. Richard Bronson, G.B. Costa, Matrix Methods: Applied Linear Algebra, Third Edition, AP.

Any other text recommended by the instructor.

PRINCIPLES OF DATA SCIENCE WITH PYTHON

Course Code: BMA-585 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	explain concepts of data science and data preprocessing and apply tools to preprocess data, carry out exploratory data analysis and data visualization,	Understand
CLO 2	utilize probability theory in the analysis of data with numeric and categorical attributes,	Apply
CLO 3	investigate graph data and high-dimensional data and apply kernel methods to analyze data,	Analyze
CLO 4	implement select clustering and dimensionality reduction techniques for data preprocessing and data mining,	Apply

Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208

CLO 5	employ select regression algorithms and classifiers to carry out data analysis	Apply

SYLLABUS

Unit-I: Introduction: Data Science and Data Science skills, Big Data and Data Science, Datafication with Examples, Data Science Landscape, Data Science Environment. Data Preprocessing: Data Cleaning, Data Integration, Data Reduction, Data Transformation, and Data Discretization – types/methods/tools, Types of Data, Level of Data, Steps of Data Science, Exploratory Data Analysis, Data Visualization & Descriptive Statistics, Coding, and Tools.

Unit-II: Data Analysis Foundations–I: Numeric Attributes: Univariate Analysis, Bivariate Analysis, Multivariate Analysis, Data Normalization, Normal distribution. Categorical Attributes: Univariate Analysis, Bivariate analysis, Multivariate Analysis, Distance and Angle, Discretization.

Unit-III: Data Analysis Foundations–II: Graph Data: Graph Concepts, Topological Attributes, Centrality Analysis, Graph models. Kernel Methods: Kernel Matrix, Vector Kernels, Basic Kernel Operations in Feature Space, Kernels for Complex Objects, High-dimensional Data: High–dimensional Objects, High–dimensional volumes Hypersphere inscribed within Hypercube, Volume of Thin Hypersphere shell, Diagonals in Hyperspace, Density of Multivariate Normal.

Unit-IV: Dimensional Reduction and Clustering: Dimensionality Reduction: Background, Principal Component Analysis, Singular Value Decomposition Clustering: Definition, Types, K-Means Algorithm, EM Algorithm, Agglomerative Hierarchical Clustering Algorithm.

Unit-V: Regression and Classification: Regression: Simple Linear Regression, Multiple Regression, Decision Trees, Random Forests. Classification: Background, Bayes Classifier, Naive Bayes Classifier, K Nearest Neighbors Classifier, Decision Tree Classifier, Random Forest Classifier.

LAB WORK: Implementation of any 2-3 techniques from each **UNIT** (selected by the instructor) using Python.

Text Books:

1. Cathy O'Neil and Rachel Schutt, "Doing data science, straight talk from the frontline'', O'Reilly,2014,
2. Jiawei Han, Micheline Kamber, and Jian Pei, "Data Mining: Concepts and Techniques", Third Edition. ISBN 0123814790, 2011.
3. Mohammed J. Zaki and Wagner Miera Jr, "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press, 2014.

Autar
23|10|2022
Prof. Ram Autar
Dean
School of Basic And Appliied Sciences
HBTU, Newabganj, Kanpur 208002

4. Matt Harrison, "Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization, O' Reilly, 2016.
5. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media, 2015.
6. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly Media, 2012.

Any other textbook recommended by the instructor.

PROBABILITY AND STATISTICS WITH R

Course Code: BMA-587 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	discuss and apply the concepts of probability, Bayes' theorem, random variables, and their functions, the central limit theorem, and several well-known distributions,	Understand and Apply
CLO 2	derive probability distributions from the normal distribution and use the distributions and explain various types of survey sampling with sample statistics and their applications,	Apply
CLO 3	explain the concepts of various parameter estimation techniques both the point estimation and confidence interval estimation and fit probability distributions to the data,	Understand
CLO 4	analyze and utilize various hypothesis tests and summarize sample data and derive conclusions/decisions,	Apply/ Analyze
CLO 5	compare two samples using parametric and nonparametric methods and the Bayesian approach and perform the analysis of variance by conducting–way two–way layouts and appropriately interpreting results,	Understand/ Apply/ Analyze

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
Uttar Pradesh Rajarshi Tandon Open University, Prayagraj

SYLLABUS

Unit-I: Probability and Distributions: Probability spaces, Conditional probability, Independence, Baye's Rule, Discrete and continuous random variables, Expectation, Distributions: Binomial, Geometric, modified Geometric, multinomial, Hypergeometric, Poisson and Normal, Exponential, Weibull, Beta and Gamma, Functions of random variables, Joint distribution, Conditioning, Law of large numbers, Central limit theorem.

Unit-II: Distributions Derived from the Normal Distribution: Introduction, chi – squared, t, F distributions, The sample Mean and the Sample Variance, Problems.

Survey Sampling: Introduction, Population parameters, simple random Sampling – The Expectation and variance of the Sample Mean, Estimation of the Population Variance, The Normal Approximation to the Sampling Distribution of $\bar{X}$ Estimation of a Ratio, Stratified random sampling.

Unit-III: Estimation of Parameters and Fitting of Probability Distributions: Introduction, fitting the Poisson Distribution to Emissions of Alpha Particles, Parameter Estimation, The Method of Moments, The Method of Maximum Likelihood, Maximum Likelihood Estimates of Multinomial Cell Probabilities, Large sample theory for maximum likelihood estimates, Confidence intervals from Maximum likelihood estimates, Confidence intervals from Maximum likelihood estimates, The Bayesian Approach to Parameter Estimation – Further Remarks on Priors, Large Sample Normal approximation to the Posterior, computational Aspects, Efficiency, and Sufficiency.

Unit-IV: Testing Hypotheses and Assessing goodness of Fit: Introduction, The Neyman-Pearson Paradigm- Specification of the Significance Level and the concept of a p-value The Null Hypothesis, Uniformly Most Powerful Tests, The Duality of Confidence Intervals and Hypothesis Tests, Generalized Likelihood Ratio Test, Likelihood Ratio tests for the Multinomial Distribution, Probability Plots, Tests for Normality.

Summarizing Data: Comparison of Location Estimates, Estimating Variability of Location Estimates by the Bootstrap, Measures of Dispersion, Box plots, Exploring Relationship with Scatter plots.

Unit -V: Comparing Two Samples: Introduction, comparing Two Independent Samples – Methods Based on the Normal distribution, Power, A Nonparametric Method-the Mann Whitney Test, Bayesian Approach, Comparing Paired Samples, Methods Based on the Normal Distribution, A Nonparametric Method-the Signed Rank Test, An Example- Measuring Mercury Levels in Fish.

The analysis of Variance: Introduction, One-way Layout- Normal Theory: the F Test, The Problem of Multiple comparisons, a Nonparametric Method-The Kruskal Wallis Test, Two- way Layout.

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Appliied Sciences
HBTU, Newabganj, Kanpur 208002

LABWORK: Implementation of any 2-3 techniques from each **UNIT** (selected by the instructor) using R.

Text Book:

1. Mathematical Statistics and Data Analysis – John A Rice, CENGAGE Learning, Third Edition

Reference Books

1. Robert I. Kabacoff, R in Action – Data analysis and graphics with R, Dreamtech press.
2. Wasserman, All of Statistics.

Any other textbook recommended by the instructor.

PROGRAMMING (PYTHON & R)

Course Code: BMA- 589 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Explain basic principles of Python programming language and acquire programming skills,	Understand
CLO 2	Articulate object-oriented programming concepts such as encapsulation, inheritance, and polymorphism in Python and implement object-oriented concepts,	Understand
CLO 3	Download, install and utilize well-known Python libraries for data analysis,	Apply
CLO 4	Demonstrate how to install and configure R Studio and apply various concepts to develop programs in R,	Apply
CLO 5	Install, load and deploy select R- packages for the data analysis and visualization and build new packages for sharing and reusability,	Apply

SYLLABUS

UNIT-I: Fundamentals of Python Language-1: Introduction, Features, and uses, Data Types, Variables and Assignments, I/O Operations, Operators, Expressions, Conditional Statements, Loops, Loop Control Statements, Function,

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur

Strings, Lists, Tuples, Sets, Dictionaries with manipulations.

UNIT-II: Fundamentals of Python Language-2: OOPs Concepts: Classes, Objects Methods, Inheritance, Instances, Constructors, Polymorphism, Abstraction, and Sets, Encapsulation, Exception Handling, Working with Files, Regular Expressions, Database Access, Databases, and SQL.

UNIT-III: Python for Data Science: Modules/Packages/ Libraries for Data Science: Introduction, Installation/ Access/ Importing, Features and Applications of IPython, Jupytor, NumPy, SciPy, Matplotlib, Tensor flow, Pytorch, Keras, Pandas, Scikit-Learn, Seaborn, nltk, plotly, sciply. stats, stats models. tsa. stattools, SymPy etc.

UNIT-IV: Fundamentals of R Language: Introduction, Features and uses, Installation of R & R Studio, Identifiers, Constants, Variables, I/O Operations, Operators, Strings, Data Types & Operations: Vectors, Lists, Matrices, Arrays, Factors, Data Frames, Conditional structures, Loops, Functions.

UNIT-V: Data Science with R: Introduction, Installation, Features, and Applications of R packages/Libraries: tidyverse, ggplot2, data.table, tibble, readr, dataframes, dplyr, tidyr, Shiny, plotly, knitr, mlr3, XGBoost, Caret, Lattices, ggvis, ggforce, patchwork, Esquisse, Lubridate, mlr, leaflet, rcrawler, Janitor, modelr, purr, broom, tidymodels, forcats.

LAB WORK: Development and execution of any 3-4 programs from each unit I, II &IV, using programming concepts and implementation of any 4-5 modules/ Libraries/packages from each of units III and V.

Text Books:

1. Michael Urban and Joel Murach, Python Programming, Shroff / Murach 2016.
2. Cotton, R., Learning R: a step-by-step function guide to data Analysis, First edition, O'Reilly Media Inc.

Reference Books:

1. Mark Lutz, Programming Python, O'Reilly, 4th Edition, 2010.
2. Gardener, M., Beginning R: The Statistical Programming Language, Wiley, 2017.

Any other textbook recommended by the instructor.

R.Bala

Autar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

SEMESTER-II

TOPOLOGY

Course Code: BMA- 582 **L-T-P-C:** 3-1-0-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Demonstrate knowledge of the concepts of topological spaces, create new topological spaces using subspace and quotient topological spaces and use homeomorphisms to understand the structure of topological spaces,	Apply
CLO 2	Illustrate the concepts of separability and countability, axioms in topological spaces, prove related theorems and state their applications,	Understand
CLO 3	Define connectedness in a topological space, and other related concepts and prove a section of related theorems,	Understand
CLO 4	Explain the concept of compactness in a topological space and other related concepts and prove important theorems,	Understand
CLO 5	Demonstrate an understanding of concepts of Net and Filters, examine their convergence, and prove important results,	Apply

SYLLABUS

Unit I: Fundamentals of Topology: Definition and examples of topological spaces; Neighborhoods, Limit points, Closure of a set, Interior, Exterior and boundary of a set, Open and closed sets, basis and sub basis; order topology; subspace topology, Weak topologies, Continuity, and related concepts and homeomorphism; product topology; quotient topology; countability axioms; Lindelof spaces and separable spaces. First and second axioms of countability.

Unit II: Separability & Countability: Separation axioms; Regular spaces, completely regular spaces, Normal spaces, Urysohn's lemma; Tietze's extension

R.Bath

Rutar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

theorem; Urysohn's embedding lemma and Urysohn's metrization theorem for second countable spaces.

Unit III: Connectedness: Connected spaces, generation of connected sets; component, path component; local connectedness, local path-connectedness.

Unit IV: Compactness: Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; one point compactification; the finite product of compact spaces, statement of Tychonoff's theorem (Proof of finite product only).

Unit V: Net & Filters: Net & Filters, Topology and convergence of nets, Hausdroffnes and nets, Compactness and Nets, Filters and their Convergence.

Text Book:

1. G.F. Simmon, Introduction to Topology and Modern Analysis, (McGraw Hill Book Company, 1963)

Reference Books:

1. J. Dugundji, Topology, (Allyn and Bacon Inc., 1966)
2. Stephen Willard, General Topology, (Addison-Wesley Publishing Co.,1970)
3. Seymour Lipschutz, General Topology, (Schaum's Outline Series, McGraw Hill Book
   The company, 2004)

Any other textbook recommended by the instructor.

ABSTRACT ALGEBRA

Course Code: BMA- 584 **L-T-P-C:** 3-1-0-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Demonstrate an understanding of the concepts of various types of groups and subgroups with their structure and properties, describe structure maps between the groups, and illustrate applications of Sylow's theorems.	Understand/ Apply
CLO 2	Examine a given set with two binary operations for different types of rings, ideals, and domains by using relevant axioms, proving related theorems, and	Understand/ Apply

Autar 23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

	explaining structure-preserving maps between the rings.	
CLO 3	Have acquaintance with the fundamental concepts of various types of polynomial rings, fields, and their various extensions and analyze them using relevant theorems.	Understand
CLO 4	Explain how to build Galois groups, compute Galois groups for fields and polynomial rings and show confidence in proving important theorems related to Galois groups.	Apply
CLO 5	Explain the concepts of solvable groups, and solvability by radicals with numerous examples and illustrate applications of Jordan Holder theorem and the fundamental theorem of algebra.	Understand Apply

SYLLABUS

Unit I: Group Theory: Brief review of groups, permutation groups, normal subgroups, quotient groups; isomorphism theorems; Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions). Applications of Sylow's theorems, conjugacy classes in Sn and An, simplicity of An. Direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only).

Unit II: Rings: Basic properties and examples of the ring, domain, division ring, and field; direct products of rings; characteristic of a domain; field of fractions of an integral domain; ring homomorphisms (always unitary); ideals; factor rings; prime and maximal ideals, principal ideal domain; Euclidean domain; unique factorization domain.

Unit III: Polynomial Rings: A brief review of polynomial rings over a field; reducible and irreducible polynomials, Gauss' theorem for reducibility of $f(x) \in Z[x]$; Eisenstein's criterion for irreducibility of $f(x) \in Z[x]$ over Q, roots of polynomials; finite fields, Extension fields, finite extensions; algebraic and transcendental elements, Kronecker theorem, algebraic extensions, splitting fields – existence and uniqueness; extension of base field isomorphism to splitting fields, Simple and multiple roots of polynomials, the criterion for simple roots, separable and inseparable polynomials; perfect fields; separable and inseparable extensions, prime fields and their relation to splitting fields, cyclotomic polynomials.

Unit IV: Galois group: Algebraically closed fields and algebraic closures, primitive element theorem; normal extensions; automorphism groups and fixed fields; Galois pairing; determination of Galois groups, fundamental theorem of Galois theory, abelian and cyclic extensions.

Prof. Ram Kumar
Dean
School of Basic and Applied Sciences
RPS, Rewari, Haryana

Unit V: Solvability: Normal and subnormal series, composition series, Jordan-Holder theorem (statement only); solvable groups, Solvability by radicals; solvability of algebraic equations; symmetric functions; ruler and compass constructions, fundamental theorem of algebra.

Text Books:

1. Dummit, D.S. and Foote, R.M (2003) Abstract Algebra, John Wiley & Sons.
2. Bhattacharya, P.B., Jain, S. K. and Nagpal S. R. (2000) Basic Abstract Algebra (3rd edition), Cambridge University Press.

Reference Books:

1. Gallian, J. A. (1999) Contemporary Abstract Algebra (4th edition), Narosa Publishing House, New Delhi.
2. Herstein, I. N. (2003) Topics in Algebra (4th edition), Wiley Eastern Limited, New Delhi.
3. Fraleigh, J. B. (2002) A First Course in Abstract Algebra (4th edition), Narosa Publishing House, New Delhi.

Any other textbook recommended by the instructor.

MACHINE LEARNING

Course Code: BMA- 586 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	Bloom's Level
CLO 1	Explain the Bayesian concepts of and design/implement NBC & GDA as generative classifiers and Bayesian linear and logistic regression as a discriminative model,	Understand/ Apply
CLO 2	Appreciate the importance of exponential family, mixture models, sparse linear models, and kernels in supervised learning and apply EM, SVMS, kernels, and Gaussian processes for regression and classification tasks,	Understand/ Apply
CLO 3	Discuss the theory of and formulate probabilistic graphical models: HMM, MRF, and CRF in order to solve real-life problems.	Understand/ Apply

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

School of Basic And Applied Sciences

CLO 4	Illustrate the mathematical theory of perception models and backpropagation algorithm and implement the models / BPA in Python,	Understand/ Apply
CLO 5	Explain the theory of and implement unsupervised machine learning algorithms: dimensionality reduction and clustering algorithms in Python,	Understand/ Apply

SYLLABUS

Unit-I: Introduction, generative models for discrete data (Bayesian concept learning, Naïve Bayes' classifier), Gaussian discriminant analysis, Inference in jointly Gaussian distributions, Bayesian statistics, Bayesian linear and logistic regression,

Unit-II: General linear models and exponential family. Mixture models and EM algorithm, Sparse linear models, Review of SVM, Multiclass SVM, kernels for building generative models, Multiple kernels, kernels for strings, trees, and graphs, Gaussian Processes.

Unit-III: Graphical models-DIRECTED Graphical models (Bayesian networks), Markov and Hidden Markov Models, Markov Random fields, Conditional Random fields.

Unit-IV: Neural Networks-Perception, MLP, and backpropagation, Methods of acceleration of convergence of BPA.

Unit-V: Dimensionality Reduction and Cluster Analysis: Factor analysis, Kernel PCA, Independent Component Analysis, ISOMAP, LLE, feature Selection, DBSCAN Algorithm, DENCLUE, Spectral clustering.

LAB WORK: Implementation of any 2-3 techniques from each **UNIT** (selected by the instructor) using Python.

Text Books:

1. Kevin P. Murphy, Machine learning – a Probabilistic Perspective, MIT Press, 2012
2. Jeeva Jose, Introduction to Machine Learning using Python.

Reference Books:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007
2. Simon Hay kin, Neural Network – a comprehensive foundation, Pearson Education-1994
3. Tom Mitchell, Machine Learning – McGraw Hill Science, 1997.

Any other textbook recommended by the instructor.

R.Bala

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

NUMERICAL OPTIMIZATION

Course Code: BMA- 588 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	formulate univariate and multivariate optimization models for real-life situations and apply first-order gradient-based methods to solve unconstrained optimization problems,	Create/Apply
CLO 2	Explain the mostly-studied first-order iterative algorithms for optimization problems in deep learning,	Understand
CLO 3	discuss the theory of some second-order gradient-based optimization methods and apply them to solve unconstrained optimization problems,	Understand and apply
CLO 4	cast real-life problems into linear programming problems and apply select methods to solve the LPP.	Create and Apply
CLO 5	select and apply some classical algorithms to solve constrained optimization problems and convex optimization problems.	Apply

SYLLABUS

Unit-I: Background, Dimensional, and multi-dimensional Optimization with types. Gradient-Based Optimization Methods (I): method of steepest descent, conjugate gradient method, the generalized reduced gradient method, and gradient projection method.

Unit-II: Stochastic gradient method (SGD), SGD with momentum, NAG, Adagrad, RMS Prop, Adadelta, Adam, Nadm, Adamx,

Unit-III: Gradient-based Optimization Methods (II): Newton-type methods (Newton's method, Levenberg- Marquardt's method), The quasi-Newton method.

Unit-IV: Linear Programming: Convex analysis, Simplex method, Two-phase simplex method, Duality theory, Dual simplex method.

Autar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

Unit-V: Constrained Optimization Methods: Lagrange's multiplier, The Kuhn-Tucker conditions, Covex optimization, Penalty function techniques, The Method of the multiplier, and linearly constrained problems-Cutting plane method. Primal-dual method.

LAB WORK: Implementation of any 2-3 techniques from each **UNIT** (selected by the instructor) using MATLAB.

Text Books:

1. M.C. Joshi, K.M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, 2004.
2. J.A. Snyman, Practical Mathematical Optimization, Springer Sciences, 2005.
3. Nocedal J, Wright S.J., Numerical Optimization, Springer
4. Stephen Boyd, Lieven Vandenberghe, Convex Optimization, Cambridge University Press.

Any other textbook recommended by the instructor.

COMPUTATIONAL STATISTICS

Course Code: BMA- 590 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Demonstrate familiarity with various statistical regression and classification algorithms as the supervised machine learning models and apply them for data analysis,	Understand/ Apply
CLO 2	Analyze the techniques/approaches of the model assessment and selection and the techniques to prevent/avoid model overfitting and use the better one (s).	Analyze
CLO 3	Select and use some nonparametric statistical learning models and apply boosting techniques to improve models' predictive accuracy and performance,	Understand/ Apply
CLO 4	Analyze and apply some well-known supervised	Analyze/

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Appliied Sciences
HBTU, Newabganj, Kanpur 208002

	learning algorithms: SVM and kernel SVM for regression and classification and KNN classifiers,	Apply
CLO 5	Utilize some specific unsupervised learning techniques: kernel PCA and Gaussian mixture models algorithms and ensemble techniques for supervised learning,	Apply

SYLLABUS

Unit-I: Linear Methods for Regression and Classification: Overview of supervised learning, Linear regression models and least squares, Multiple regression, Subset selection, Ridge regression, least angle regression, and Lasso, Linear Discriminant analysis, Logistic regression.

Unit-II: Model Assessment and Selection: Bias, Variance and model complexity, Bias-variance trade-off, Optimism of the training error rate, Estimate of In-sample prediction error, Effective number of parameters, Bayesian approach and BIC, Cross-validation, Bootstrap methods, conditional or expected test error.

Unit-III: Additive Models, Trees, and Boosting: Generalized additive models, Regression and classification trees and random forests, Boosting methods-exponential loss and AdaBoost, Numerical Optimization via gradient boosting, Examples (Spam data, California housing, New Zealand fish, Demographic data)

Unit-IV: Support Vector Machines (SVM), and K-nearest Neighbor: Basis expansion and regularization, kernel smoothing methods, SVM for classification, Reproducing Kernels, SVM for regression, K-nearest-Neighbor classifiers (Image Scene Classification)

Unit-V: Unsupervised Learning: Cluster analysis: kernel K-means and EM algorithms, Markov clustering, Gaussian mixtures, and selection,

LAB WORK: Implementation of any 2-3 techniques from each UNIT (selected by the instructor) using R.

Texts Books:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning-Data Mining, Inference, and Prediction, Second Edition, Springer Verlag, 2009.
2. **(For lab only)** –G. James, D.Witten, T.Hastie, R.Tibshirani-An introduction to statistical learning with applications in R, Springer, 2013.

Reference Books:

1. C.M. Bishop – Pattern Recognition and Machine Learning, Springer, 2006.

Prof. Ram Autar
23/10/2022
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

2. L. Wasserman. L.-All of Statistics: A Concise Course in Statistical Inference, New York: Springer Sciences+ Business Media

Any other textbook recommended by the instructor.

Note: Text 1 and 2 and reference 2 are available online.

SEMESTER III

FUNCTIONAL ANALYSIS

Course Code: BMA-651 **L-T-P-C:** 3-1-0-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Explain the general theory of topological vector space with examples and other related space structures, state their important properties and related concepts, and have proficiency in proving related theorems	Apply
CLO 2	Define the Baire category, demonstrate proficiency in proving Baire's theorem, Banach-Steinhaus theorem, Open Mapping theorem, and Closed graph theorem, using related concepts, and explain Bilinear mappings and important results	Recall
CLO 3	Illustrate various concepts of convexity, weak topologies, compact convex sets, and extreme points and prove related theorems, define vector-valued integration and holomorphic functions and prove related theorems	Apply
CLO 4	Explain the basic concepts of the normed dual of a normed space and prove closely related theorems, define adjoints and compact operators and prove related theorems	Apply
CLO 5	Illustrate some interesting applications of the concepts and theorems studied in proving other important results and celebrated theorems of functional analysis	Apply

R.Bal

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

SYLLABUS

Unit-I: Topological Vector Spaces: Normed spaces, Topological Vector Spaces, Invariance, types of topological Vector Spaces, Separation properties, Linear mappings, Finite dimensional Spaces, Metrization, Boundedness, and continuity, Bounded linear transformations, Seminorm, and local continuity, Quotient spaces, Seminom and quotient spaces, The spaces with $0<p<1$.

Unit-II: Completeness: Baire Category, Baire's Theorem, Banach- Steinhaus Theorem, The open mapping theorem, The closed graph theorem, Bilinear mappings.

Unit-II: Convexity: The Hahn-Banach theorems, Weak topologies, Compact convex sets, Extreme points, The Krein-Milman theorem, Vector-valued integration, Holomorphic functions.

Unit-IV: Duality in Banach Spaces: The normed dual of a normed space, Adjoints, Compact operators.

Unit-V: Some Applications: A continuity theorem, closed subspaces of spaces, The range of a vector-valued measure. A generalized Stone-Weierstrass theorem, Two interpolation theorems, A fixed point theorem, Haar measure on compact groups, and Uncomplemented subspaces.

Reference Books:

1. I. W. Rudin, Functional Analysis, Tata McGraw-Hill Publishing Company Ltd., New Delhi, Chapters 1, 2, 3, 4, 5.
2. B.V. Limaye, Functional Analysis, New Age International Ltd. (Second Edition).
3. J. 8. Conway, A course in functional Analysis, GTM 96, Springer-Verlag` 1990.
4. K. Yoshida, Functional Analysis, GTM,123, Springer-Verlag,1980

Any other text recommended by the instructor.

Any other textbook recommended by the instructor.

COMPLEX ANALYSIS

Course Code: BMA-653 **L-T-P-C:** 3-1-0-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	Bloom's Level

Rutar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Appliied Sciences
HBTU, Newabganj, Kanpur 208002

CLO 1	Get equipped with the understanding of differentiation, integration, and power series representation of holomorphic functions; state, prove and apply related theorems as well as the calculation of residues.	Recall
CLO 2	Examine the analyticity of complex functions by using C-R equations, analyze the boundary behavior of Poisson integral, and illustrate the mean value property and representation theorems for harmonic and holomorphic functions.	Apply
CLO 3	Discuss the concepts of compactness and convergence in the space of analytic functions; apply Runge's theorem and Mittag-Leffler's theorem to approximate analytic functions by rational functions	Examine
CLO 4	Illustrate the applications of conformal mappings, demonstrate an understanding of other related concepts, state and prove Jensen's formula and concerning theorems; the Riemann mapping theorem, Weierstrass factorization theorem, Munz- Szasz theorem	Apply
CLO 5	Demonstrate an understanding of the analytic continuation of an analytic function along a curve and its properties; state, prove and use the monodromy theorem and Picard theorem,	Create

SYLLABUS

Unit-I: Elementary Properties of Holomorphic Functions: Complex differentiation, Integral over the path, The Local Cauchy's theorem, The power series representation, The open mapping theorem, The global Cauchy's theorem, The calculus of residues.

Unit-II: Harmonic Functions: The Cauchy-Riemann equations, The Poisson integral, The mean value property, the Boundary behavior of Poisson integrals, and the Representation theorems. The Maximum Modulus Principle: The Schwarz lemma, The Phragmen-Lindelof method. An Interpolation theorem, A converse of the maximum modulus theorem.

Unit-III: Compactness, and convergence in the space of analytic functions: Approximation by rational Functions, Runge's theorem, The Mittag-Leffler theorem, Simply connected regions.

Unit-IV: Conformal Mappings: Preservation of angles. Linear fractional transformations, Normal families, The Riemann mapping theorem, The class S, and Continuity at the boundary. Zeros of Holomorphic functions: Infinite products, The Weierstrass factorization theorem, An Interpolation problem,

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences

[illegible] Network, Hopfield Networks, Boltzmann machines, Restricted Boltzmann Machines, Deep Belief Networks and Deep Boltzmann Machines.

Unsupervised Learning: Clustering; K-means clustering; Hierarchical clustering; Expectation Maximization, Graphical Models: Introduction to Directed Graphical Models (Bayesian Networks), Conditional Independence in Directed Graphical Models, Markov Random Fields.

Text Books:

1. C. M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 2003.
2. T. M. Mitchell, Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.
3. S. Haykin, Neural Networks and Learning Machines, Prentice Hall of India, 3rd Edition, 2010.
4. I. Goodfellow, Y. Bengio and A. Courville, Deep Learning, MIT Press, 2016.

Any other textbook recommended by the subject.

DEEP LEARNING

Course Code: BCS-055 L-T-P-C: 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	Bloom's Level
CLO 1	Acquire and implement various exact and approximate probabilistic inference algorithms to solve real-life problems.	Examine
CLO 2	Comprehend select Reinforcement Learning algorithms and the theory behind them and implement them to solve real-world problems.	Recall
CLO 3	Explain the fundamental concepts of regularization and optimization in deep learning and their significance and implement related algorithms.	Apply
CLO 4	Explain the basic principles behind CNNs and RNNs and employ related algorithms to train real data.	Apply
CLO 5	Remember the fundamentals and the applications of autoencoders, and deep belief networks and design & implement relevant algorithms to solve real-world problems.	Recall

Autar
23/07/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Nawabganj, Kanpur 208002

SYLLABUS

Unit-I: **Inference:** Exact inference for graphical models, Variational inference, Monte Carlo inference, MCMC inference, Learning undirected Gaussian graphical models.

Unit-II; **Reinforcement learning and control-MDP,** Bellman equations, value iterations, and policy, iteration. Linear quadratic regulation, LQG, Q-learning Value function approximation Policy search, Reinforce POMDPs.

Unit-III: Review of backpropagation,

Regularization for Deep Learning. Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Regularization, and Under-Constrained Problems, Dataset Augmentation, Noise Robustness, Semi-Supervised Learning, and Multitask Learning. Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging, and Other Ensemble Methods. Dropout. Adversarial Training, Tangent Distance. Tangent Prop and Manifold Tangent Classifier.

Optimization for Training Deep Models: How Learning Differs from Pure Optimization, Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates, Approximate Second-order Methods, Optimization Strategies, and Meta-Algorithms.

Unit-IV: **Convolutional Networks:** The Convolution Operation, Motivation, Pooling, convolution, and Pooling as an infinitely strong prior, Variants of the Basic Convolution Function, Structured Outputs Data Types, Efficient convolution Algorithms, Random or Unsupervised Features, The Neuroscientific Basis for Convolutional Networks, Convolutional Networks and the History of Deep Learning.

Sequence Modeling: Recurrent and Recursive Nets: Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory.

Unit-V: **Practical Methodology:** Performance Metrics, Default Baseline Models, Determining Whether to Gather More Data, Selecting Hyperparameters, Debugging Strategies, Example-Multi-Digit Number Recognition.

Linear Factor Models: Slow Feature Analysis, Sparse Coding,

Autoencoders: Under complete Autoencoders, Regularized Autoencoders, Representational Power, Layer Size and Depth, Stochastic Encoders and Decoders, Denoising Autoencoders, Learning Manifolds with Autoencoders, Contractive Autoencoders, Predictive Sparse Decomposition, Applications of

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

Autoencoders.

Deep Generative Models: Boltzmann Machines, Restricted Boltzmann Machines, Deep Belief Networks.

LAB WORK: Implementation of any 2-3 algorithms from each **UNIT** (selected by the instructor) using Python.

Text Books

1. Ian Goodfellow, YashuaBengio, and Aaron Courville, Deep Learning, The MIT Press, 2016
2. Kevin P. Murphy, Machine Leaning-a probabilistic prospective MIT Press,2012
3. Tom Mitchel, Machine Learning, McGraw Hill.

Any other textbook recommended by the instructor.

PEC-1: COMPUTER VISION

Course Code: BMA-659 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Demonstrate an understanding of the fundamentals of the image formation process and other related concepts as well as models	Create
CLO 2	Appreciate and implement different fundamental image processing algorithms/ techniques for computer vision.	Apply
CLO 3	Demonstrate an understanding of image descriptors and feature descriptors and implement the same to extract factures from image data.	Create
CLO 4	Apply machine learning algorithms to process images in order to derive meaningful information and make appropriate recommendations.	Apply
CLO 5	Develop real-world applications of interest using computer vision techniques using the experience gained from the implementation of popular computer vision applications.	Create

Prof. Ram Autar
Dean
School of Basic And Appliied Sciences
HBTU, Newabganj, Kanpur 208002

SYLLABUS

Unit 1: Introduction to Computer Vision: Basic Concepts of Image Formation, Image Formation, Radiometry, Geometric Transformation, Geometric Camera Models, Image Reconstruction from a Series of Projections.

Unit 2: Image Processing Concepts: Fundamentals of Image Processing, Image Transforms, Image Filtering, Colour Image Processing, Mathematical Morphology, Image Segmentation.

Unit 3: Image Descriptors and Features: Texture Descriptors, Colour Features, Edge Detection, Object Boundary and Shape Representations, Interest or Corners Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency.

Unit 4: Machine Learning Algorithm for Computer Vision: Statistical Machine Learning Algorithms for different Computer Vision applications, supervised and unsupervised learning, Gaussian Classifier, Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Artificial and Deep Networks for Computer Vision applications.

Unit 5: Application of Computer Vision: Medical Image Segmentation, Motion Estimation, Object Tracking, Face and Facial Expression Recognition, Image Fusion, Gesture Recognition.

LAB WORK: Implementation of any 2-3 algorithms from each **UNIT** (selected by the instructor) using Python.

Text Books:

1. Forsyth and Pence, Computer Vision (A Modern Approach), Pearson Education, 2015
2. M.K.Bhuyan, Computer Vision and Image Processing – Fundamentals and Applications, CRC Press, USA
3. Jan Erik Solen, Programming Computer Vision Python, O'Reilly

Any other textbook recommended by the instructor.

Rutar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

SEMESTER IV

DIFFERENTIAL EQUATIONS

Course Code: BMA-652 **L-T-P-C:** 3-1-0-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	**Bloom's Level**
CLO 1	Show proficiency in examining the existence and uniqueness of solutions to IVPs,	Evaluate
CLO 2	Demonstrate expertise in the analysis of and methods to solve non-linear differential equations and in examining the stability of linear and non-linear systems of ODEs,	Apply
CLO 3	Explain how the analytical solutions to ODE-BVPs are obtained by different methods,	Apply
CLO 4	Formulate and solve PDE-BVPs involving the Laplace equation,	Create
CLO 5	Demonstrate understanding of different methods to solve the wave equation-a parabolic PDE.	Create

SYLLABUS

Unit-I: **Existence and uniqueness of solutions:** Lipschitz condition, Gronwall inequality, successive approximation, Picard's theorem, continuation and dependence on initial conditions, Existence of solutions in the large systems, Existence and uniqueness of solutions of systems, Fixed point method, Systems of linear differential equations: nth order equation as a first order System, System of first-order equations, Existence and uniqueness theorem, fundamental matrix, Non-homogeneous linear systems, Linear Equations with constant coefficients

Unit-II: Non-linear Differential Equations: Existence theorem, Extremal solutions, Upper and lower solutions, Monotone iterative method and method of quasi linearization, Stability of Linear and Nonlinear systems: Critical points, System of equations with constant coefficients, Linear equations with constant coefficients, Lyapunov stability.

Unit-III: **Boundary value problem for ordinary differential equations**: Sturm-Liouville problem, Eigenvalue, and Eigen functions, Expansion in Eigen functions, Green's function, Picard's theorem for Boundary value problems. Series solution of Legendre and Bessel equations.

Rutar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Appliied Sciences
HBTU, Newabganj, Kanpur 208002

Unit-IV: The Laplace equation: Boundary value for Laplace's equation, fundamental solution, Integral representation and mean value formula for harmonic functions, Green's function for Laplace's equation, Solution of the Dirichlet problem for a ball, solution by separation of variables.

Unit-V; The wave equation: solution by the method of separation of variables, D'Alembert solution of the wave equation, Solution of the wave equation by Fourier transform method.

LAB WORK: Implementation of any 2-3 algorithms from each **UNIT** (selected by the instructor) using MATLAB/MAPPLE.

Text Books:

1. Earl A. Coddington, Norman Levinson, The Theory of ordinary Differential Equations
2. J. Sinha Roy, S. Padhy, ACourse on Ordinary and Partial Differential Equations,
   Kalyani Publishers.
3. Tyn Mint-U, Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, Fourth Edition, Birkhauser.
4. Lawrence Evans, Partial Differential Equations, Second Edition, Graduate Studies in
   Mathematics, AMS.
5. S. D. Deo, V. Lakshmikantham and V. Raghavendra: Text Book of Ordinary Differential Equations, Second Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, Chapters 4(4.I-4.7),5,6(6.I-6.5),7(7.5),9(9.I-9.5).

Any other textbook recommended by the instructor.

BIG DATA ANALYTICS

Course Code: BMA-654 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	Bloom's Level
CLO 1	Understand Big Data and its analytics in the real world	Examine
CLO 2	Analyze the Big Data framework like Hadoop and	Apply

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences

	NOSQL to efficiently store and process Big Data to generate analytics	
CLO 3	Design of Algorithms to solve Data-Intensive Problems using the Map Reduce Paradigm	Create
CLO 4	Design and Implementation of Big Data Analytics using pig and spark to solve data-intensive problems and generate analytics	Create
CLO 5	Implement Big Data Activities using Hive	Apply

SYLLABUS

Unit-I: Essentials of Big Data and Analytics: Data, Characteristics of data and Types of digital data, Sources of data, Working with unstructured data, Evolution, and Definition of big data, Characteristics and Need of big data, Challenges of big data; Overview of business intelligence, Data Science and Analytics, Meaning and Characteristics of big data analytics, Need of big data analytics, Classification of analytics, Challenges to big data analytics, Importance of big data analytics, Basic terminologies in the big data environment.

Unit-II: Hadoop: Introducing Hadoop, Need of Hadoop, limitations of RDBMS, RDBMS versus Hadoop, Distributed computing challenges, History of Hadoop, Hadoop overview, Use case of Hadoop, Hadoop distributors, HDFS (Hadoop Distributed File System), Processing data with Hadoop, Managing resources and applications with Hadoop YARN (Yet Another Resource Negotiator), Interacting with Hadoop Ecosystem.

Unit–III: Mapreduce Programming: Introduction, Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression, Real-time applications using MapReduce, Data serialization, and Working with common serialization formats, Big data serialization formats.

Unit–IV: HIVE: Introduction to Hive, Hive architecture, Hive data types, Hive file format, Hive Query Language (HQL), User-Defined Function (UDF) in Hive;

Unit–V: PIG: The anatomy of Pig, Pig on Hadoop, Pig Philosophy, Use case for Pig; ETL Processing, Pig Latin overview, Data types in Pig, Running Pig, Execution modes of Pig, HDFS commands, Relational operators, Piggy Bank, Word count example using Pig.

LAB WORK: Implementation of any 2-3 algorithms from each **UNIT** (selected by the instructor) using Python.

Text Book:

1. Seema Acharya, Subhashini Chellappan, "Big Data Analytics", 1st Edition, Wiley, 2015.

31

Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

Reference Books:

1. Boris Lubinsky, Kevin t. Smith, Alexey Yakubovich, "Professional Hadoop Solutions", 1st Edition, Wrox, 2013.
2. Chris Eaton, Dirk Deroos et. al., "Understanding Big data", Indian Edition, McGraw Hill, 2015.
3. Tom White, "HADOOP: The Definitive Guide", 3rd Edition, O Reilly, 2012.
4. Vignesh Prajapati, "Big Data Analytics with R and Hadoop", 1st Edition, Packet Publishing Limited, 2013

PEC-II: NATURAL LANGUAGE PROCESSING

Course Code: BMA-656 **L-T-P-C:** 3-0-2-4

Course Learning Outcomes:

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:	***Bloom's Level***
CLO 1	Comprehend the key concepts of NLP and identify the NLP challenges and issues.	*Recall*
CLO 2	Develop language modeling for various corpora across different languages.	*Create*
CLO 3	Illustrate computational methods to understand the language phenomenon of word sense disambiguation.	*Apply*
CLO 4	Design and develop applications for text or information extraction/summarization/classification.	*Create*
CLO 5	Apply different machine learning techniques for translating a source to the target language(s).	*Apply*

SYLLABUS

Unit-I: Introduction to NLP: History and introduction of NLP, Advantages of NLP, Disadvantages of NLP, Components of NLP, Applications of NLP. How to build an NLP pipeline? Phases of NLP, NLP APIs, NLP Libraries.

32

23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

Unit-II: Language Modeling and Part of Speech Tagging: Unigram Language Model, Bigram, Trigram, N-gram, Advanced smoothing for language modeling, Empirical Comparison of Smoothing Techniques, Applications of Language Modeling, Natural Language Generation, Parts of Speech Tagging, Morphology, Named Entity Recognition.

Unit-III: Words and Word Forms: Bag of words, skip-gram, Continuous Bag-of-Words, Embedding representations for words, Lexical Semantics, Word Sense Disambiguation, Knowledge-Based and Supervised Word Sense Disambiguation.

Unit-IV: Text Analysis, Summarization, and Extraction: Sentiment Mining, Text Classification, Information Extraction, Named Entity Recognition, Relation Extraction, Question Answering in Multilingual Setting, NLP in Information Retrieval, Cross-Lingual IR.

Unit-V: Machine Translation (MT): Need of Machine Translations, Problems of Machine Translations, Machine Translations Approaches, Direct Machine Translations, Rule-Based Machine Translation, Knowledge-Based MT System, Statistical Machine, Translation (SMT), Parameter learning in SMT (IBM models) using EM, Encoder-decoder architecture, Neural Machine Translation.

LAB WORK: Implementation of any 2-3 algorithms from each UNIT (selected by the instructor) using Python.

Text Books:

1. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech
2. Recognition Jurafsky, David, and James H. Martin. PEARSON Foundations of Statistical Natural Language Processing. Manning, Christopher D., and Hinrich Schutze, Cambridge, MA: MIT Press
3. Natural Language Understanding. James Allen. The Benjamin/Cummings Publishing Company Inc.
4. Natural Language Processing with Python-Analyzing Text with the Natural Language Toolkit Steven Bird, Ewan Klein, and Edward Loper.

Any other textbook recommended by the instructor.

Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HSTU, Hamirpur, Kangra 206002
23/10/2022

PROGRAM LEARNING OUTCOMES

After successful completion of the M.Sc. (Mathematics and Data Science) Program at H.B.T.U., Kanpur, students will be able to:

PLO1	Discipline Knowledge	Attain profound expertise in the interdisciplinary field of two key areas of mathematics and data science.
PLO2	Problem Analysis	Aware of the process of understanding real-world problems and users' needs and proposing solutions to meet those needs.
PLO3	Analytical & Logical Thinking	Display strong analytical, logical and critical thinking skills to justify his/her strategies, actions, and decisions.
PLO4	Design/Development of Solutions	Attain hands-on experience in developing data strategy, visualizing data, employing data engineering, performing data analysis, formulating mathematical models, performing model validation, and choosing the best one.
PLO5	Modern Tool Usage	Use appropriate software to solve real-life problems and apply programming/coding concepts of Python, R, and MATLAB to various scientific investigations, data analysis, problem- solving and interpretations
PLO6	Enlightened Citizenship	Aware to become an enlightened citizen with a commitment to deliver one's responsibilities within the scope of bestowed rights and privileges.
PLO7	Environment & Sustainability	Attain a deep understanding of environmental and sustainability concepts, identify relevant problems, manage them and find their potential solutions
PLO8	Ethics	Demonstrate and maintain the highest standards of professional ethics in teaching,

R.Bala

Ram Autar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences

		research, and other career activities
PLO9	Individual & Team Work	Formulate an inspiring vision, set direction, build a team who can help achieve the vision, motivate and inspire team members to engage with the vision, and use management skills to guide people to the right destination in a smooth and efficient way.
PLO10	Scientific Communication	Communicate the result of the problem undertaken inwardly to colleagues and/or outwardly with important stakeholders.
PLO11	Life Long Learning	Inculcate the habit of self-learning throughout life through self-paced and self-directed learning/professional practice.
PLO12	Research Skills	Demonstrate ability to conduct high-quality research with the applications of fundamental ethical principles to research activities.
PLO13	Career Opportunities	Attain a deep understanding of mathematical and data science concepts with their applications, and demonstrate excellence in their field of study to serve in academia as Professors, in industries as data scientists, and as data engineers, in the public and private sectors.

Prof. Ram Autar
23/10/2022
Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002

PROGRAM SPECIFIC OUTCOMES

	On satisfying the requirements of the course and upon its successful completion, students will have knowledge/skills/competency to:
PSO 1	Analyze and solve real-world problems using different mathematical and computational approaches
PSO 2	Formulate, parametrized, solve and analyze mathematical models for real-life problems.
PSO 3	Develop the ability to build and assess data-based models
PSO 4	Be competent in industry-relevant data-based languages including R, Python, and MATLAB
PSO 5	Demonstrate skills in data analytics, machine learning, deep learning computer vision, and natural programming languages
PSO 6	Analyze small and large-scale data sets using mathematical computational approaches
PSO 7	Gain confidence in research and data science skills and management through real-life-based projects

R. Bala

Autar

23/10/2022

Prof. Ram Autar
Dean
School of Basic And Applied Sciences
HBTU, Newabganj, Kanpur 208002