	Fifth Semester (3rd year of B.Tech. MaC)				
1	Ordinary Differential Equations and computations	MA305	3-0-2	4	85
2	Foundation of Data Science	MA307	3-1-0	4	70
3	Machine Learning	MA334	3-0-2	4	85
4	Elective-III (Open Elective)	MA3AA	3-1-0 3-0-2	4	70/85
5	Elective-IV (Specialization#1)	MA3BB	3-X-X	4	70/85
			Total	**20**	**380-410**
	Sixth Semester (3rd year of B.Tech. MaC)				
1	Optimization Techniques and Computing	MA306	3-0-2	4	85
2	Partial Differential Equations and Computing	MA308	3-0-2	4	85
3	Fundamentals of Artificial Intelligence	CS300	3-1-0	4	70
4	Elective-V (Open Elective)	MA3CC	3-1-0 3-2-0	4	70/85
5	Elective-VI (Specialization#2)	MA3DD	3-X-X	4	70/85
6	MOOC Course*		3-0-0/ 3-1-0	3/4	70/85
			Total	**20**	**450-495**
7	Mini Project-II/ Vocational Training / Professional Experience (Optional) (mandatory for exit)	MAV06 / MAP06	0-0-10	5	200 (20 x 10)

	Elective-III & IV		
5	Advanced Mathematical Methods-I	MA351	3-1-0
6	Stochastic Differential equations and computation	MA358	3-0-2
7	Financial Mathematics and computation	MA359	3-0-2
8	Fourier Analysis	MA361	3-1-0
9	Foundations of Cryptography	MA362/CS352	3-0-2/ 3-0-1
10	Mathematical Modelling and computation	MA363	3-1-0
11	Operating Systems	MA364	3-0-2
12	Soft Computing	MA368/365	3-0-2
	Elective-V & VI		
13	Integral and Wavelet Transforms	MA365	3-1-0
14	Theory of Computation	MA366	3-1-0
15	Information Theory and Coding	MA367	3-1-0
16	Data Visualization	MA369	3-0-2
17	Advanced Evolutionary Algorithms	MA370	3-0-2
18	Block Chain Technology	CS360	3-1-0
19	High Performance Computing	MA371/CS357	3-1-0/ 3-0-2
20	Professional Ethics, Economics, and Business Management	MG210	3-1-0
21	Fuzzy Logic and Computation	MA-372	3-1-0

B. Tech. MaC - III, Sem–V ORDINARY DIFFERENTIAL EQUATIONS AND COMPUTATIONS MA305	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	analyze the existence, uniqueness of solutions of linear ODEs on a given interval.
CO2	develops skills in to different types of methods for finding the solution of ODEs.
CO3	elaborate the properties of dynamical systems
CO4	assess the asymptotic behaviour of dynamical systems
CO5	determine the solution of higher order BVP through eigen-functions and Green's functions

2.	**Syllabus**	
	REVIEW OF SOLUTION METHODS FOR DIFFERENTIAL EQUATIONS	**(06 Hours)**
	Second order linear differential equations with variable coefficients and their solution properties, Series solutions (Bessel functions and Legendre polynomials).	
	EXISTENCE AND UNIQUENESS OF INITIAL VALUE PROBLEMS	**(08 Hours)**
	Fixed Point theorem, Picard's and Peano's Theorems, Gronwall's inequality, Continuation of solutions and maximal interval of existence, Dependence on the initial conditions, Extensibility of solutions, Non-Local existence theorem.	
	HIGHER ORDER AND SYSTEMS OF LINEAR DIFFERENTIAL EQUATIONS	**(09 Hours)**
	Fundamental solutions, Wronskian, Variation of parameters, Matrix exponential solution, Behaviour of solutions.	
	DYNAMICAL SYSTEMS AND PHASE SPACE ANALYSIS	**(09 Hours)**
	Dynamical system, The flow of an autonomous equation, Orbits and invariant sets, The Poincare map, Critical points, Proper and improper nodes, Spiral points and saddle points.	
	ASYMPTOTIC BEHAVIOUR	**(06 Hours)**
	Stability of fixed points, Stability via Liapunov's method.	
	BOUNDARY VALUE PROBLEMS FOR SECOND ORDER DIFFERENTIAL EQUATIONS	**(08 Hours)**
	Sturm comparison theorems, Oscillation theory, Regular and periodic Sturm-Liouville problems, Green's function, Solutions of BVP.	

	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1	understanding environment and basic notation, ODE solvers.
2	Plotting of Solutions of first order and second order differential equations.
3	Setting up initial value problems (IVPs)
4	Visualizing solutions and comparing methods
5	Implementation of Numerical Methods for ODEs
6	Analyzing accuracy and stability of solution by numerical methods
7	Developing iterative solutions for ODEs
8	Visualizing convergence and divergence
9	Exploring the effects of initial conditions
10	Lyapunov exponents and stability analysis
11	Introduction to BVP solvers with Practical examples: heat equation, Sturm-Liouville problems
12	Numerical approximation of Green's functions

4.	**Books Recommended:**
1.	M. W. Hirsch, S. Smale and R. L. Deveney, Differential Equations, Dynamical Systems and Introduction to Chaos, Academic Press, 2012.
2.	S. G. Deo, V. Raghavendra, R. Kar and V. Lakshmikantham, Textbook of Ordinary Differential Equations, McGraw-Hill Education, 2015.
3.	G. F. Simmons and S. G. Krantz, Differential Equations: Theory, Technique and Practice, McGraw Hill Education, 2017.
4.	Steven G. Krantz , Differential Equations: Theory, Technique and Practice, Chapman and Hall/CRC; 2nd edition, 2014.
5.	M. Brown, Differential Equations and Their Applications, Springer, 2013.

4.	**Additional Books Recommended:**
1.	S. G. Deo, V. Raghavendra, R. Kar and V. Lakshmikantham, Textbook of Ordinary Differential Equations, McGraw Hill India, edition 3rd, 2017.
2.	M. W. Hirsch, S. Smale and R. L. Deveney, Differential Equations, Dynamical Systems and Introduction to Chaos, Academic Press, United States, 3rd edition, 2013.
3.	S. G. Krantz, Differential Equations: Theory, Technique and Practice, CRC Press, New York, 3rd Edition, 2022.
4.	Noboru Nakanishi and Kenji Seto, Differential Equations and Their Applications, World Scientific, Singapore, Edition 1st, 2022.
5.	M Braun, Differential Equations and Their Applications, Springer New York, NY, Edition 1st, 2013.
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B.Tech. MaC - III, Sem–V, Foundation of Data Science MA307	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes:** **At the end of the course, the students will be able to:**
CO1	acquire a solid foundation in the key concepts of data science, including data processing, analysis, visualization, and interpretation.
CO2	develop the ability to apply mathematical and statistical methods
CO3	gain proficiency in programming languages commonly used in data science
CO4	understand the fundamentals of machine learning algorithms and their practical applications in data science
CO5	critically evaluate the ethical implications of data science

2.	**Syllabus**	
	INTRODUCTION	**(10 hours)**
	Data Science: Benefits and uses, retrieving data, Data preparation and applications, Distributions and probability, Statistical Inference: Populations and samples, Statistical modelling, probability distributions, fitting a model, Hypothesis Testing: t-test, Z-test, chi-square test, F-test, ANOVA schemes, Matrices to represent relations between data, and necessary linear algebraic operations on matrices, Approximately representing matrices by decompositions (SVD and PCA)	
	DESCRIBING DATA	**(09 hours)**
	Types of Data, Types of Variables, Describing Data with Tables and Graphs, Describing Data with Averages, Describing Variability, Normal Distributions and Standard (z) Scores	
	DESCRIBING RELATIONSHIPS	**(09 hours)**
	Correlation, Scatter plots, correlation coefficient for quantitative data, computational formula for correlation coefficient, Regression, regression line, least squares regression line, Standard error of estimate, interpretation of r2, multiple regression equations, regression towards the mean	
	PYTHON LIBRARIES FOR DATA WRANGLING	**(09 hours)**
	Basics of Numpy arrays, aggregations, computations on arrays –comparisons, masks, Boolean logic, fancy indexing, structured arrays, Data manipulation with Pandas, data indexing and selection, operating on data, missing data, Hierarchical indexing, combining datasets, aggregation and grouping, pivot tables	
	DATA VISUALIZATION	**(08 hours)**
	Importing Matplotlib, Line plots, Scatter plots, visualizing errors, density and contour plots, Histograms, legends, colours, subplots, text and annotation, customization, three-dimensional plotting, Geographic Data with Base map, Visualization with Seaborn.	
	Tutorial's will be based on the coverage of the above topics separately.	**(15 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1.	Techniques to handle missing data, outliers, and inconsistencies.
2.	Performing data visualization and basic statistics to extract insights from a dataset.
3.	Implementing a linear regression model to predict outcomes based on input features.

4.	Applying classification algorithms to solve binary or multi-class problems.
5.	Implementing k-means clustering to group similar data points.
6.	Reducing the dimensionality of data while preserving variance using Principal Component Analysis (PCA).
7.	Analyzing and forecasting time series data using basic statistical methods.

4.	**Books Recommended**
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.
4	Peter Bruce, Andrew Bruce, "Practical Statistics for Data Scientists", O'Reilly Media, Inc., 2017.
5	Jake VanderPlas, "Python Data Science Handbook", O'Reilly Media, Inc., 2016.

B.Tech. MaC - III, Sem– V MACHINE LEARNING MA334	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	implement the knowledge of classification, regression, clustering and statistics in Machine learning models
CO2	apply the concept of different regression techniques in Machine learning
CO3	apply different classification, regression, machine learning algorithms and modelling.
CO4	analyze the data patterns and modelling for applying the learning algorithms.
CO5	interpret the performance of an algorithm and comparison of different learning techniques.

2.	**Syllabus**	
	Introduction	**(09 hours)**
	Theory of Statistical Learning Theory: Basics of learning theory, function estimation, understanding data, assessing model accuracy, principles of Maximum likelihood, Bayes and minimax, parametric versus nonparametric methods, Bayesian versus Classical approaches in machine learning. Classification/Regression: nearest neighbour, decision trees, perceptron, support vector machines, VC-dimension, linear least squares regression, Naïve Bayes'.	
	Supervised Learning	**(09 hours)**
	Linear regression (simple and multiple), support vector regression, confidence interval and hypothesis testing of regression coefficients, model accuracy, qualitative predictors, extension of linear models, decision trees. Ensemble methods: Boosting/Bagging and linear and nonlinear regression like polynomial regression, ordinal regression, regression splines, Tree based methods, Random forests.	
	Classification Algorithms	**(07 hours)**
	logistic regression, support vector regression, Bayesian approach for classification, linear discriminant analysis, quadratic discriminant analysis, K-nearest neighbour (KNN) algorithm.	
	Resampling and Regularization	**(08 hours)**
	Over and under sampling approaches, cross validation, linear model selection, subset selection, shrinkage methods, Ridge and Lasso methods, dimension reduction techniques like PCA, ICA and LDA, Principal Component Regression (PCR) and partial least square.	
	Unsupervised learning algorithms	**(07 hours)**
	Clustering methods; k-means clustering and hierarchical , Gaussian mixture model , Principal Component Analysis and expectation maximization algorithm, density estimation	
	Deep Learning	**(05 hours)**
	Perceptron Model; Multilayer perceptron; Gradient Descent and Backpropagation algorithm; brief introduction to deep learning models.	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1.	Hands-on with Numpy/R
2.	Hands-on with Scikit-Learn/R

3.	Linear regression
4.	Logistic regression for classification
5.	Discriminant Analysis
6.	Data Resampling methods
7.	Model Selection methods
8.	Dimension reduction Approaches
9.	Nonlinear models-I
10.	Nonlinear models-II
11.	Unsupervised Learning-I
12.	Unsupervised Learning-II
13.	Neural Networks
14.	Convolutional Neural Networks

4.	**Books Recommended**
1	Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, O'Reilly Media, United States of America, 1st Edition, 2017.
2	Kevin P. Murphy and Francis Bach, Machine Learning: A Probabilistic Perspective (Adaptive Computation and Machine Learning series), MIT Press, United States of America, 4th Edition, 2012.
3	B. Lantz, Machine Learning with R, Packt Publishing Limited, UK, 1st Edition, 2013.
4	P. Mueller and L Massaron, Machine Learning (in Python and R), John Wiley & Sons, New Jersey, 1st Edition, 2016.
5	Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer Texts in Statistics, Springer, New York, 1st Edition, 2017.

5.	**Additional Reference Books**
1	Rodrigo Fernandes de Mello, Moacir Antonelli Ponti, Machine Learning: A Practical Approach on the Statistical Learning Theory, Springer Nature, 2018.
2	Richard Golden, Statistical Machine Learning: A Unified Framework, Chapman & Hall/CRC Texts in Statistical Science, First Edition, 2020.
3	Christopher Bishop, Pattern Recognition and Machine Learning, Springer, Information Science and Statistics Series, Springer, UK, 1st Edition, 2009.

B.Tech. MaC - III, Sem– V Elective ADVANCED MATHEMATICAL METHODS I MA351	Scheme	L	T	P	Credit
		3	1	0	04

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	demonstrate a common framework that distinguishes various multivariate analytic techniques
CO2	develop the solution of ODEs using asymptotic methods
CO3	apply perturbation theory to solve various problems related to engineering and sciences
CO4	solve non-linear ODEs related to engineering and sciences using homotopy analysis method
CO5	design and implement a technique based on varied factors for ODEs

2.	Syllabus	
	INTRODUCTION	**(06 Hours)**
	Review on Power Series Method, Taylor Series Method.	
	ASYMPTOTIC METHODS	**(10 Hours)**
	Introduction, Asymptotic Solutions at Irregular Singular Points at Infinity, Method of Finding Solutions at Irregular Points, Asymptotic Method for Constructing Solutions along with the validity for large values, Asymptotic Solutions of Perturbed Problems, Solutions to ODEs Containing a Large Parameter, Applications.	
	PERTURBATION TECHNIQUES	**(11 Hours)**
	Basic Idea behind the Perturbation Method, Regular Perturbation Theory, Singular Perturbation Theory, Boundary-Layer Method, Applications.	
	METHOD OF MULTIPLE SCALES	**(08 Hours)**
	Introduction, Method of Multiple Scales, Applications.	
	HOMOTOPY ANALYSIS METHOD	**(10 Hours)**
	Introduction, Background, A brief history of the HAM, Characteristic of homotopy analysis method, Some advances of the HAM, Generalized zeroth-order deformation equation, Basic ideas of the homotopy analysis method, Convergence of homotopy-series solution.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1	Power series method.
2	Taylor series method.
3	Finding solution irregular singular point at infinity and irregular points.
4	Finding solutions of perturbed problems ODEs containing a large parameter
5	Perturbation technique
6	Regular perturbation theory.
7	Singular perturbation theory, boundary-layer method.
8	Method of multiple scales and it's applications.
9	Homotopy analysis method
10	Convergence of homotopy-series solution

4.	**Books Recommended:**
1.	S. I. Hayek, Advanced Mathematical Methods in Science and Engineering, 2nd Edition, Chapman and Hall/CRC, 2011.
2.	A. D. Polyanin and V. F. Zaitsev, Handbook of Ordinary Differential Equations: Exact Solutions, Methods, and Problems, 3rdEdition, Chapman and Hall/CRC,2017.
3.	S. Liao, Homotopy Analysis Method in Nonlinear Differential Equations, Springer-Verlag Berlin Heidelberg, 2012.
4	S. Moorthy and I. Manikandan, Advanced Mathematical Methods, 1st Edition,Yes Dee, India, 2016.
5	C. M. Bender, S. A. Orszag, Advanced Mathematical Methods for Scientists and Engineers I. 1st Edition, Springer New York, NY, 2013.

5.	**Additional Reference Books**
1	C. M. Bender and S. A. Orszag, Advanced Mathematical Methods for Scientists and Engineers: Asymptotic Methods and Perturbation Theory, Springer Science &Business Media, New York, 1999.
2	J. B. Doshi, Analytical Methods in Engineering, Narosa Publishing House, 1998.

B.Tech. MaC - III, Sem– V Elective **Stochastic Differential Equations and Computation** MA358	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	explain the basics of stochastic differential equations
CO2	elaborate Ito integrals, and its application to stochastic differential equations
CO3	analyze existence and uniqueness of stochastic differential equations
CO4	solve stochastic differential equations
CO5	explain its application to different boundary value problems

2.	**Syllabus**	
	INTRODUCTION	**(06Hours)**
	Stochastic analogues of classical differential equations.	
	MATHEMATICAL PRELIMINARIES	**(06 Hours)**
	Probability space, Random variable, Stochastic process, Brownian motion.	
	ITO INTEGRAL	**(06 Hours)**
	Definition, Properties, Extensions.	
	ITO FORMULA AND MARTINGALE REPRESENTATION THEOREM	**(09 Hours)**
	One-dimensional Ito formula, Multi-dimensional Ito formula, Martingle representation theorem.	
	STOCHASTIC DIFFERENTIAL EQUATIONS	**(09 Hours)**
	Examples and some solution methods, Existence and Uniqueness result, Weak and strong solutions.	
	APPLICATIONS	**(09 Hours)**
	Boundary value problems, Filtering, Optimal stopping, Stochastic control, The Black-Scholes formula and its application to mathematical finance.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1	Stochastic analogues of classical differential equations.
2	Random variable, Stochastic process, Brownian motion
3	One-dimensional Ito formula
4	Multi-dimensional Ito formula
5	Examples and some solution methods,
6	Existence and Uniqueness result
7	Weak and strong solutions.
8	Boundary value problems
9	Filtering, Optimal stopping
10	Stochastic control, The Black-Scholes formula and its application to mathematical finance.

4.	**Books Recommended:**
1.	B. K. Oksendal, Stochastic Differential Equations: An Introduction with Applications, 6th Edition, Springer, New York, 2010.
2.	P. Protter, Stochastic Integration and Differential Equations, Springer, Berlin, Heidelberg, 2nd Edition, 2012.
3.	I. Karatzas and S. E. Shreve, Methods of Mathematical Finance, Springer, New York, 1st Edition, 2016.
4.	S. Watanabe and N. Ikeda, Stochastic Differential Equations and Diffusion Processes, Elsevier, North-Holland, 2nd Edition, 2014.
5	S Särkkä and A Solin , applied stochastic differential equation, 1st Edition, Cambridge University Press, 2019

5.	**Additional Reference Books**
1	I. Karatzas and S. E. Shreve, Brownian Motion and Stochastic Calculus, Springer, 1998.

B.Tech. MaC - III, Sem– V Elective Financial Mathematics and Computation MA359	Scheme	L	T	P	Credit
		3	1	0	04

1.	Course Outcomes (COs): At the end of the course, the students will be able to
CO1	implement the basic concepts in Probability theory
CO2	demonstrate the concepts relating to functions and annuities
CO3	explain the Arbitrage theorem and Black-Scholes formula
CO4	employ methods related to these concepts in a variety of financial applications
CO5	apply logical thinking to problem related to call and put options and valuing of investment.

2.	Syllabus	
	INTRODUCTION	**(07 Hours)**
	Probability Theory, Stochastic Processes, Poisson Process, Brownian Motion, Martingales Present Value Analysis.	
	INTERESTS RATES AND PRESENT VALUE ANALYSIS	**(07 Hours)**
	Interest rates, Present value analysis, Rate of return, Continuously varying Interest rates.	
	THE ARBITRAGE THEOREM	**(07 Hours)**
	Market Model Specification problems, Arbitrage Theorem, Multi-period binomial Model, Proof of the Arbitrage Theorem.	
	THE BLACK-SCHOLES FORMULA	**(08 Hours)**
	The Black-Scholes formula, Properties of the Black–Scholes Option Cost, The Delta Hedging Arbitrage Strategy.	
	ADDITIONAL RESULTS ON OPTION	**(06 Hours)**
	Call Options on Dividend-Paying Securities, Pricing American Put Options, Estimating the Volatility Parameter.	
	VALUING BY EXPECTED UTILITY	**(10 Hours)**
	Valuing investments by expected utility, Portfolio selection problem, Capital Assets Pricing model, Rates of return, Single period and geometric Brownian motion, Meanvariance analysis of risk - neutral priced call options, Autoregressive models and mean regression, Other pricing options and applications.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1	Stochastic Processes, Poisson Process
2	Brownian Motion, Martingales Present Value Analysis.
3	Present value analysis, Rate of return, continuously varying Interest rates
4	Market Model Specification problems, Arbitrage Theorem, Multi-period binomial Model
5	Properties of the Black–Scholes Option Cost, The Delta Hedging Arbitrage Strategy
6	Dividend-Paying Securities, Pricing American Put Options,
7	Estimating the Volatility Parameter
8	Portfolio selection problem, Capital Assets Pricing model
9	Rates of return, Single period and geometric Brownian motion
10	Analysis of risk - neutral priced call options, Autoregressive models and mean regression

4.	**Books Recommended:**
1.	S. M. Ross, An Introduction to Mathematical Finance, Cambridge University Press, UK, 3rd Edition, 2011.
2.	M. Capi´nski and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Edition, Springer, 2011.
3	K J Hastings, Introduction to Financial Mathematics: Concepts and Computational Methods, CRC Press, 2015.
4	J R Buchanan, An Undergraduate Introduction to Financial Mathematics, 4th Edition, World Scientific Publishing Company, 2022.
5	G. Campolieti, R. N. Makarov, Financial Mathematics, Chapman and Hall/CRC; 1st edition, 2021.

5.	**Additional Reference Books**
1	A. J. Prakash, R. M. Bear, K. Dandapani, G. L. Ghai, T. E. Pactwa and A. M. Parhizgari, The Return Generating Models in Global Finance, Pergamon Press, UK, 1st Edition, 1999.
2	M. S. Joshi, The Concepts and Practice of Mathematical Finance, 2nd Edition, Cambridge University Press, UK, 2nd Edition, 2008.
3	P. Wilmott, Derivatives: The Theory and Practice of Financial Engineering (Frontiers in Finance Series), John Wiley & Sons, 1998.

B.Tech. MaC - III, Sem–VI, Elective FOURIER ANALYSIS MA361	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes:** **At the end of the course, the students will be able to:**
CO1	apply the principles of Fourier series and Fourier transforms to represent periodic and non-periodic functions, respectively.
CO2	Utilize Fourier analysis to solve ordinary and partial differential equations
CO3	Demonstrate the convergence properties of Fourier series
CO4	Apply Fourier analysis techniques to practical problems in engineering, signal processing, and data analysis
CO5	explore the applications in areas such as image processing, pattern recognition, and computational mathematics

2.	**Syllabus**	
	Introduction	**(10 hours)**
	Definition and examples of periodic functions, Definition, formulas, and derivation for piecewise continuous periodic functions of Fourier Series, Convergence of Fourier Series: Dirichlet conditions, pointwise convergence, and uniform convergence, Parseval's theorem, Energy conservation in Fourier series, Application of Fourier series to signal processing and heat equation.	
	Fourier Transform	**(09 hours)**
	Fourier transform on the real line: Definition and basic properties such as Linearity, scaling, shifting, and modulation, Inverse Fourier Transform: Derivation and interpretation, Fourier Transform of Common Functions: Dirac delta function, Gaussian function, and sinc-function, applications in filtering, signal analysis, and solving differential equations.	
	Discrete and Fast Fourier Transform	**(09 hours)**
	Introduction to Discrete Fourier Transform (DFT), properties, and matrix representation, Fast Fourier Transform (FFT**):** Definition**,** Algorithmic implementation and computational efficiency, DFT in Practice: Applications in digital signal processing and image compression, periodicity in DFT: Circular convolution and spectral leakage.	
	Fourier Analysis in Higher Dimensions	**(09 hours)**
	Multivariable Fourier Series: Extension to two or more variables, Fourier Transform in Higher Dimensions: Basic theory and applications in image and signal processing Solution of partial differential equations (PDEs) using Fourier transforms.	
	Applications of Fourier Analysis	**(08 hours)**
	Heisenberg Uncertainty Principle in Fourier analysis, Signal Processing: Noise reduction, filtering, and reconstruction using Fourier methods, Image Processing: Fourier techniques in image enhancement and compression., Quantum mechanics (Schrödinger equation), optics, and acoustics, fluid dynamics, electromagnetism, and image reconstruction	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1.	Writing a program in Python to compute and visualize the Fourier series of standard periodic functions (e.g., square wave, sawtooth wave).
2.	Analyzing the Gibbs phenomenon and convergence properties.

3.	Implementing the discrete Fourier transform (DFT) and Fast Fourier Transform (FFT) on a given signal (e.g., sound or image data).
4.	Filtering noise from the signal using low-pass and high-pass filters based on its frequency components.
5.	Solving a one-dimensional heat equation using separation of variables and Fourier series and compare the analytical solution to a numerical solution using Python.
6.	Implementing 2D Fourier transforms on grayscale images.
7.	Using Fourier transforms to analyze and decompose time-series data into frequency components.

4.	**Books Recommended**
1	Loukas Grafakos, *Classical Fourier Analysis* (3rd Edition), Springer, 2014.
2	Loukas Grafakos, *Modern Fourier Analysis* (3rd Edition), Springer, 2014.
3	T. W. Körner, *A Companion to Analysis: A Second First and First Second Course in Analysis*, Cambridge University Press, 2017.
4	Elias M. Stein, *Harmonic Analysis: Real-Variable Methods, Orthogonality, and Oscillatory Integrals* (Princeton Mathematical Series), Princeton University Press, 2016.
5	Tim Olson, Applied Fourier Analysis, Birkhäuser, 2017

	Additional Books
1	H. Dym and H. P. McKean, Fourier Series and Integrals, Academic Press, 1972.
2	G. B. Folland, Fourier Series, Fourier Transform, and Their Applications, American Mathematical Society, 1992.
3	Mark A. Pinsky**,** Introduction to Fourier Analysis and Wavelets, American Mathematical Society, 2009.
4	Elias M. Stein and Rami Shakarchi, Fourier Analysis: An Introduction*, Princeton University Press, 2003.*

B.Tech. MaC - III, Sem – V, ELECTIVE FOUNDATIONS OF CRYPTOGRAPHY MA362	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes:** **At the end of the course, the students will be able to:**
CO1	explain the basics of Cryptography and Network Security
CO2	find a method to secure a message over insecure channel by various means.
CO3	demonstrate how to maintain the Confidentiality, Integrity and Availability of a data.
CO4	evaluate the security strengths with respect to various parameters
CO5	design a secure cryptosystem as per the requirement of an organization.

2.	**Syllabus**	
	Introduction	**(09 hours)**
	Brief introduction to number theory, Introduction to cryptography, symmetric and asymmetric cryptosystems; Classical cryptography: substitution ciphers (shift, affine, Vigenere ciphers), Hill cipher, permutation cipher, stream ciphers; cryptanalysis of classical ciphers, DES, AES, Shannon's theory, perfect secrecy, one-time pad.	
	Euclidean Algorithm and finite fields	**(07 hours)**
	Euclidean algorithm and the extended Euclidean algorithm, fast exponentiation, the Chinese remainder theorem, primitive roots. Finite fields: Construction and examples. Discrete logarithm problem in general and on finite fields. Polynomials on finite fields and Their factorization/ irreducibility and their application to coding theory.	
	Introduction to public key cryptosystems	**(07 hours)**
	Introduction to public key cryptography, concept of block and stream ciphers, Encryption standard: DES and differential and linear cryptanalysis, Advanced encryption standards, Cryptosystems based on Discrete logarithm problem such as Massey Omura cryptosystems. Algorithms For finding discrete logarithms, their analysis. Diffie-Hellman key exchange, the ElGamal cryptosystem, the RSA cryptosystem.	
	Primality test and algorithms for discrete logarithms	**(07 hours)**
	Primality testing, Miller-Rabin test; Factoring algorithms: Pollard's $p-1$ algorithm, smooth numbers and sieves, the quadratic sieve; Algorithms for computing discrete logarithms: Shank's algorithm, the Pohlig-Hellman algorithm.	
	Cryptographic hash functions	**(07 hours)**
	Cryptographic hash functions, digital signatures standard, RSA digital signatures, ElGamal digital signatures, the digital signature algorithm (DSA), onetime undeniable and fail-stop signatures, computationally collision-free hash functions, extending hash functions, examples of hash functions.	
	Elliptic curves cryptography	**(08 hours)**
	Introduction to elliptic curves, elliptic curves over finite fields, the elliptic curve discrete logarithm problem (ECDLP), elliptic curve cryptography: elliptic Diffie-Hellman key exchange, elliptic El-Gamal cryptosystem, the elliptic curve DSA; Introduction to secret sharing.	
	Practical's will be based on the coverage of the above topics separately.	**(15 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Practicals will be based on**
1.	symmetric and asymmetric cryptosystems
2.	Classical cryptography
3.	Euclidean algorithm and examples
4.	Finite fields construction and examples
5.	public key cryptography
6.	primality testing
7.	Algorithms for computing discrete logarithms
8.	Cryptographic hash functions-I
9.	Cryptographic hash functions-II
10.	elliptic curve Cryptography

4.	**Books Recommended**
1	Hoffstein, J., Pipher, J. and Silverman, J. H., "An Introduction to Mathematical Cryptography", 2nd Edition, Springer, 2014.
2	Stinson, D. R. and Paterson, M. B., "Cryptography: Theory of Practice", 4th Edition, CRC Press, 2019.
3	Katz, J., and Lindell, Y., "Introduction to Modern Cryptography", 2nd Edition, CRC Press, 2014.
4	A R Meijer, Algebra for Cryptologists, 1st edition, Springer, 2016
5	B Johnson, Break the Code: Cryptography for Beginners, Dover Publications, 1st Edition, 2013.

5.	**Additional Reference Books**
1	Buchmann, J. A., "Introduction to Cryptography", 2nd Edition, Springer, 2004.
2	Koblitz, N., "A Course in Number Theory and Cryptography", 2nd Edition, Springer, 1994.

B.Tech. III (Mathematics and Computing), Semester – VII FOUNDATIONS OF CRYPTOGRAPHY CS352	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	Understand formal security definitions, security assumptions, security proofs and number theoretic principles of modern cryptosystems.
CO2	Demonstrate familiarity with modern day cryptosystems and prove its security strengths with respect to the state of the art cryptanalytic attacks.
CO3	Analyse the security strengths of newer cryptosystems.
CO4	Evaluate the security strengths with respect to various parameters
CO5	Design a secure cryptosystem as per the requirement of an organization.

2.	**Syllabus**	
	INTRODUCTION	**(04 Hours)**
	Classical Cryptography and Modern Cryptography, Principles of Modern Cryptography, formal Definitions, Precise Assumptions, Proofs of Security, Provable Security and Real World Security	
	PERFECTLY SECRET ENCRYPTION	**(04 Hours)**
	Formal Definitions, Shannon's Theory, one-Time Pad, Limitations of Perfect Secrecy.	
	PRIVATE-KEY ENCRYPTION	**(06 Hours)**
	Defining Computationally Secure Encryption, Semantic Security, Constructing Secure Encryption Schemes-Pseudorandom Generators and Stream Ciphers, Proofs by Reduction, Cryptanalytic Attacks-Chosen-Plaintext Attacks and CPA-Security, Constructing CPA-Secure Encryption Schemes, Pseudorandom Functions and Block Ciphers, Cpa-Secure Encryption from Pseudorandom Functions, Chosen-Ciphertext Attacks- Defining CCA-Security.	
	BOUNDED LINEAR MAPS ON NORMED LINEAR SPACES	**(10 Hours)**
	Definition and examples, linear maps on finite-dimensional spaces, operator norm, Banach Spaces, Hahn-Banach theorem, and its applications, Open mapping and Closed Graph theorems, Banach-Steinhaus theorem (or the Uniform Boundedness Principle).	
	HASH FUNCTIONS AND APPLICATIONS	**(04 Hours)**
	Hash Functions-one-Wayness and Collision Resistance, Merkle–Damgard Construction, Attacks on Hash Functions-Birthday Attacks, Random-oracle Model, Merkle Trees.	
	MESSAGE AUTHENTICATION CODES	**(04 Hours)**
	Message Authentication Codes – formal Definitions, Design, and Proof of Security, HMAC, CBCMAC, Authenticated Encryption, information-Theoretic Macs, Limitations on information Theoretic Macs	

	ALGORITHMS FOR FACTORING AND COMPUTING DISCRETE LOGARITHMS	**(06 Hours)**
	Algorithms for Factoring-Pollard's P − 1 Algorithm, Pollard's Rho Algorithm, Quadratic Sieve Algorithm, Algorithms for Computing Discrete Logarithms- Pohlig–Hellman Algorithm, BabyStep/Giant-Step Algorithm, Discrete Logarithms From Collisions, index Calculus Algorithm.	
	PUBLIC-KEY ENCRYPTION	**(06 Hours)**
	RSA Encryption, Security Against Chosen-Plaintext Attacks, Security Against Chosen Ciphertext Attacks, RSA Implementation Issues and Pitfalls, Computational DiffieHellman /Decisional Diffie-Hellman Based Encryption, Elliptic Curve Cryptography-Elliptic Curve Over Finite Fields and Binary Fields, Point Addition Operation, Elliptic Curve Discrete Logarithm Problem, Cryptosystems Based on Elliptic Curve.	
	ADVANCED TOPICS	**(08 Hours)**
	Zero-Knowledge Proofs, Secret Sharing Schemes, Lattices and Cryptography	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

4.	**Books Recommended**
1	Katz & Lindell, "Introduction to Modern Cryptography: Principles and Protocols", Third Edition, Publisher: Chapman & Hall/CRC, 2021.
2	Douglas R. Stinson, "Cryptography: Theory and Practice", Third Edition, Publisher: Chapman and Hall/CRC, 2005.
3	Goldreich, "Foundations of Cryptography", Cambridge University Press, 2005 (Volume 1 and 2).
4	William Stallings, "Cryptography and network security: principles and practice", 8th Edition, Upper Saddle River: Pearson, 2017.
5	Forouzan and Mukhopadhyay, "Cryptography and Network Security", 3/E, McGraw Hill, 2015.

ADDITIONAL REFERENCE BOOKS	
1	Schneier, Bruce, "Applied cryptography: protocols, algorithms, and source code in C", 2nd Edition, john wiley & sons, 2007.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

M.Sc. 3rd Year (Mathematics) Semester – V ELECTIVE MATHEMATICAL MODELLING AND COMPUTATION MA363	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	explain the concept of mathematical modelling
CO2	formulate the real world problem into crisp, fuzzy and uncertain Mathematical models
CO3	analyze the mathematical model
CO4	apply mathematical model in analysis of the real world problems
CO5	develop a computational code for simulating the mathematical model of a system

2.	**Syllabus**	
	INTRODUCTION	**(08 Hours)**
	Introduction to modelling, Process of mathematical modelling, Advantage and disadvantage of mathematical model, Modelling based on system of algebraic equations and their solutions. Simple ODE based Model.	
	PREDICTIVE MODELLING	**(07 Hours)**
	Interpolation and extrapolation based Modelling, Simple regression based Mathematical Model, Multi Regression based Mathematical Model. Different Prediction models of Engineering.	
	FUZZY MODELLING	**(08 Hours)**
	Introduction to fuzzy theory, Fuzzy Membership function, Alpha cut, Fuzzy system of Algebraic equation based Model, Fuzzy ordinary differential equation based model, Circuit and Network based Fuzzy model, Physical sciences based model.	
	OPTIMIZATION MODELLING	**(09 Hours)**
	Single objective Linear Programming and Non-Linear Programming Models, Industrial problems and mathematical optimization model.	
	FUZZY OPTIMIZATION MODELLING	**(09 Hours)**
	Fuzzy Single objective Linear Programming based model, Fuzzy Non-Linear Programming Models based, Fuzzy Multi objective Linear Programming based model, Fuzzy Multi objective non-Linear Programming based model.	

	UNCERTAIN MODEL	**(04 Hours)**
	Introduction to Uncertain numbers, Uncertain number based modelling , Difference between Uncertain model, fuzzy model and crisp Model.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1	basics of mathematical modelling.
2	modelling based on algebraic and differential equations.
3	interpolation and extrapolation based modelling.
4	regression based modelling.
5	different prediction models of Engineering.
6	fuzzy system of algebraic equation and fuzzy ordinary differential equation based models.
7	circuit and network based fuzzy model, physical sciences based model.
8	linear and non-linear programming models.
9	industrial problems and concerned mathematical optimization model.
10	fuzzy single objective linear and non-linear programing based models.
11	fuzzy multi objective linear and non-linear programing based models.
12	uncertain models.

4.	**Books Recommended:**
1.	J. N. Kapoor, Mathematical Modelling, New Age International (P) Limited, 3rd edition, 2024.
2.	B. Barnes and G. R. Fulford, Mathematical Modelling with Case Studies, Using Maple and MATLAB, 3rd Edition, CRC press, 2015.
3.	D. T. Luc, Multiobjective Linear Programming an Introduction, Springer International Publishing Switzerland, 1st Edition, 2016.
4.	Baoding Liu, Uncertainty Theory, Springer Berlin, Heidelberg, 4th Edition, 2015.
5	S. Banerjee, Mathematical Modeling: Models, Analysis and Applications, 1st Edition, Chapman and Hall/CRC, 2014.

5.	**Additional Reference Books**
1	J. Lu, G. Zhang, D. Ruan and F. Wu, Multiobjective Group Decision Making Methods, Software and Applications with Fuzzy Set Techniques, Imperial College Press London, UK, 2007.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem– V OPERATING SYSTEMS MA364	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	Understand the significance of operating system in computing devices, exemplify the communication between application programs and hardware devices through system calls.
CO2	Compare and illustrate various process scheduling algorithms.
CO3	Apply appropriate memory and file management schemes.
CO4	Illustrate various disk scheduling algorithms.
CO5	Design access control and protection based modules for an operating system.

2.	Syllabus	
	OPERATING SYSTEM OVERVIEW	**(03 Hours)**
	Operating System (OS) Objectives, Evolution, Types, Major Achievements, Modern Operating Systems, Virtual Machines, OS Design Considerations for Multiprocessor and Multicore.	
	PROCESSES AND THREADS	**(05 Hours)**
	Process Concept, Process States, Process Description, Process Control Block, PCB as a Data Structure in Contemporary Operating Systems, Process Hierarchy, Processes vs Threads, Types of Threads, Multicore and Multithreading, Case Study: Linux & Windows Process and Thread Management and its Related System Calls.	
	CONCURRENCY: MUTUAL EXCLUSION AND SYNCHRONIZATION	**(06 Hours)**
	Principles of Concurrency, Mutual Exclusion, Semaphores, Monitors, Message Passing, Readers/Writers Problem.	
	CONCURRENCY: DEADLOCK AND STARVATION	**(05 Hours)**
	Principles of Deadlock, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Dining Philosopher's Problem, Case Study: Linux & Windows Concurrency Mechanism.	
	SCHEDULING	**(08 Hours)**
	Uniprocessor Scheduling: Long Term Scheduling, Medium Term Scheduling, Short Term Scheduling, Scheduling Algorithms: Short Term Scheduling Criteria, Use of Priorities, Alternative Scheduling Policies, Performance Comparison, Fair-Share Scheduling. Multiprocessor Scheduling: Granularity, Design Issue, Process Scheduling, Thread Scheduling, Real-Time Scheduling: Characteristics of RTOS, Real-Time Scheduling, Deadline Scheduling, Rate Monotonic Scheduling, Priority Inversion. Case Study: Linux & Windows Scheduling.	
	MEMORY MANAGEMENT	**(05 Hours)**
	Memory Hierarchy, Static and Dynamic Memory Allocation, Overview of Swapping, Multiple Partitions, Contiguous and Non-Contiguous Memory Allocation, Concepts of Simple Paging, Simple Segmentation.	
	VIRTUAL MEMORY	**(05 Hours)**

	Virtual Memory Concepts, Paging and Segmentation using Virtual Memory, Protection and Sharing, Fetch Policy, Placement Policy, Replacement Policy, Resident Set Management, Cleaning Policy, Load Control, Case Study: Linux & Windows Memory Management.	
	I/O MANAGEMENT AND DISK SCHEDULING	**(04 Hours)**
	I/O Device, Organisation of the I/O Function, Operating System Design Issue, I/O Buffering, Disk Scheduling, RAID, Disk Cache, Case Study: Linux & Windows I/O.	
	FILE MANAGEMENT	**(04 Hours)**
	Overview of : Files & File Systems, File Structure, File Management Systems, File Organisation and Access, B-tree, File Directories, File Sharing, Record Blocking, Secondary Storage Management, File System Security, Case Study: Linux & Windows File System.	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1.	basic and Advance commands of Linux.
2.	Shell Script and programs based on it.
3.	different Memory management scheme.
4.	different Process scheduling algorithm.
5.	different Disk scheduling algorithm.
6.	Process synchronization and deadlock.
7.	file management system.
8.	input output device management.

4.	**Books Recommended**
1	A.Silberschatz, P. B. Galvin and G. Gagne, "Operating System Concepts", John Wiley & Sons, Hoboken, 10th Edition, 2018.
2	W. Stallings, "Operating Systems: Internals and Design Principles", Pearson Pub., 9th Edition, 2018.
3	W Richard Stevens, Stephen A Rago, "Advanced Programming in the UNIX Environment",Addison Wesley Professional, Boston, 3rd Edition, 2013.
4	A S Tanenbaum, A S Woodhull, Operating Systems : Design and Implementation, 3rd Edition, Pearson, 2015.
5	R. E. Bryant, David R. O'Hallaron, Computer Systems: A Programmer's Perspective, 3rd Edition, Pearson Education India, 2016.

5.	**Additional Reference Books**
1	Kernighan & Pike, "UNIX programming Environment", PHI-EEE, 2nd Edition, 2001.
2	A Tanenbaum, A Woodhull, "Operating Systems - Design and Implementation", PHI EEE, 3rd Edition, 2006.
3	Crawley, "Operating Systems - A Design Oriented Approach", McGraw Hill, 1st Edition, 1998.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem–VI, ELECTIVE-V SOFT COMPUTING MA368	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	develop application on different soft computing techniques like Fuzzy, GA and Neural network
CO2	implement Neuro-Fuzzy and Neuro-Fuzz-GA expert system for problem solving.
CO3	apply the underlying principle of soft computing with its usage in various application
CO4	utilize different soft computing tools to solve real life problems.
CO5	apply the concept of rough sets and learn to handle big data and design and innovate solution for real life problem using bio-inspired techniques

2.	**Syllabus**	
	Introduction	**(10 hours)**
	Overview of Soft Computing, Difference between Soft and Hard computing, Brief descriptions of different components of soft computing including Artificial intelligence systems Neural networks, fuzzy logic, genetic algorithms. Artificial neural networks Vs Biological neural networks, ANN architecture, Basic building block of an artificial neuron, Activation functions, Introduction to Early ANN architectures (basics only)-McCulloch & Pitts model, Associative Memory, Adaptive Resonance Theory, Applications.	
	Fuzzy Set Theory	**(09 hours)**
	Fuzzy sets: Membership functions, Basic operations, Fuzzy relations, Fuzzy Systems, Fuzzy Logic, Fuzzification, Fuzzy Inference, Decision Making, Fuzzy Rule based System, Defuzzification, Applications.	
	Neural Network	**(09 hours)**
	Fundamental Concepts, Neural Network Architecture; Machine Learning Using Neural Networks; Weights, Activation Functions, Learning Models, Learning Rate, Bias, McCulloch Pitts Neuron, Single Layer Neural Network, Multi Layers Neural Networks, Supervised Learning Neural Networks: Perceptron Networks, Radial Basis Function Networks: Back Propagation Neural Network: Architecture, Learning, Applications, & Research Directions; The Boltzman Machine. Unsupervised Learning Networks: Competitive Learning networks; Kohonen Self-Organizing Networks; Hebbian learning; The Hopfield Network; Counter propagation Networks.	
	Genetic Algorithm	**(09 hours)**
	Genetic algorithms basic concepts, encoding, fitness function, reproduction-Roulette wheel, Boltzmann, tournament, rank, and steady state selections, Convergence of GA, Cross over mutation, roulette wheel selection, tournament selection, Population, binary encoding and decoding for any optimization problem.	
	Rough Sets & Nature Inspired Techniques	**(08 hours)**

	Rough Sets: Lower and upper approximations, Discernibility matrix, Accuracy of Approximations, Hybridization of soft computing tools like Neuro-fuzzy, Rough fuzzy, Rough-Fuzzy -GA, Ant Colony based optimization, Particle Swarm Optimization	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1.	Performing Union, Intersection and Complement operations
2.	Implementation of De-Morgan's Law
3.	Plotting various membership functions
4.	Using fuzzy toolbox to model tips value
5.	Implementation of Fuzzy Inference System
6.	Simple fuzzy set operations
7.	Using Hopfield network with no self connection
8.	Generation of ANDNOT function using McCulloch-Pitts neural net
9.	Finding weight matrix and bias of HebbNet to classify two dimensional input patterns
10.	Implementation of Perceptron Learning Algorithm
11.	Implementation of Simple Genetic Application
12.	Generation of XOR function using back propagation algorithm

4.	**Books Recommended**
1	Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Willey, United States, 3rd Edition, 2010.
2	S. Roy and U. Chakraborty, "Soft Computing: Neuro-Fuzzy and Genetic Algorithms", Pearson, India, 1st Edition, 2013.
3	S. Bhattacharya Haldar, "Rough sets, Fuzzy sets and Soft Computing", Narosa Publishing House, New Delhi, 2015.
4	S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, Wiley India (P) Ltd., 2007.
5	L Polkowski, S Tsumoto, T Young Lin, Rough Set Methods and Applications: New Developments in Knowledge Discovery in Information Systems, Physica-Verlag GmbH & Co; 20th edition, 2010.

5.	**Additional Reference Books**
1	G.J. Kl i r and B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Pearson, New Jersey, 1st Edition, 1995.
2	S. Rajasekaran, G. A. VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications", PHI Learning Pvt. Ltd., 2003.
3	B. Yagnanarayana, "Artificial Neural Networks", PHI, Delhi, 2004.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. III (Mathematics and Computing), Semester – V SOFT COMPUTING CS365	Scheme	L	T	P	Credit
		3	0	2	04

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	Acquire knowledge about the human intelligence, artificial Intelligence and the knowledge about the soft computing approaches.
CO2	Apply different soft computing techniques like fuzzy logic, genetic algorithm, neural network and bio-inspired techniques, Evolutionary approaches for problem solving.
CO3	Analyse the learning methods for optimizing the solution.
CO4	Evaluate performance of different soft computing techniques.
CO5	Design and innovate solution for real life example using bio-inspired techniques which mimic human brain abilities.

2.	**Syllabus**	
	INTRODUCTION	**(06 Hours)**
	Concepts of Artificial Intelligence, Need of Machine Learning, Learning Methods, Soft Computing Approach, Fuzzy Computing, Neural Computing, Genetic Algorithms, Associative Memory, Adaptive Resonance Theory, Applications.	
	NEURAL NETWORK	**(13 Hours)**
	Model of Artificial Neuron, Neural Network Architectures, Weights, Activation Functions, Learning Models, Learning Rate, Bias, McCulloch Pitts Neuron, Single Layer Neural Network, Multi Layers Neural Networks, Training Algorithms, Back Propagation Method, Supervised Learning, Unsupervised Learning, Radial Basis Functions, Auto-associative Memory, Bidirectional Hetero-associative Memory, Hopfiled Network, Kohonen Self-organizing Network, Learning Vector Quantization, Simulated Annealing Network, Boltzmann Machine, Applications.	
	FUZZY SET THEORY	**(08 Hours)**
	Fuzzy Sets, Membership, Fuzzy Operations, Properties, Fuzzy Relation, Fuzzy Systems, Fuzzy Logic, Fuzzification, Fuzzy Inference, Decision Making, Fuzzy Rule based System, Defuzzification, Applications.	
	GENETIC ALGORITHMS	**(08 Hours)**
	Fundamentals of Genetic Algorithms, Chromosomes, Encoding, Selection Operator, Mutation Probability, Mutation Operator, Crossover Probability, Crossover Operator, Fitness Function, Different Variants of Genetic Algorithms, Applications.	
	NATURE INSPIRED TECHNIQUES AND HYBRID SYSTEM	**(10 Hours)**
	Ant Colony, Particle Swarm Optimization, Integrating Neural Networks, Fuzzy Logic, and Genetic Algorithms, GA based Back Propagation Networks, Fuzzy Back Propagation Networks, Applications.	

	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

3.	**Practicals**
1	Simulate a simple linear neural network model. Calculate the output of neural net using both binary and bipolar sigmoidal function.
2	Generate AND/NOT/XOR function using McCulloch-Pitts neural net.
3	Write a program to implement Hebb’s rule.
4	Write a program to implement of delta rule. II
5	Write a program for Back Propagation Algorithm
6	Write a program for ACO Algorithm and demonstrate with an example.
7	Write a program for Hopfield Network and explain how energy analysis can be done.
8	Simulate an environment for Multi robot target searching using fuzzy logic and neural networks
9	Write a program to demonstrate the fuzzy operators with examples.

4.	**Books Recommended**
1	Timothy J. rd Ross, “Fuzzy Logic with Engineering Applications”, 3rd Ed., Willey, 2010.
2	B. Yagnanarayana, "Artificial Neural Networks", 1st Ed., PHI, 2009.
3	Simon O. Haykin, "Neural Networks and Learning Machines", 3/E, Prentice Hall, 2009.
4	S. Rajasekaran, G. A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications", PHI, 2007.
5	David E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", 1st Ed., Addison-Wesley Professional, 2006.

ADDITIONAL REFERENCE BOOKS	
1	S. N. Sivanandam, S. N. Deepa, “Principles of Soft Computing”, Wiley India Edition, 2010.
2	Hoffmann F., Koeppen M., Klawonn F., Roy R, “Soft Computing: Methodologies and Applications”, Springer, 2005.
3	Rafik Aziz Aliev, Rashad Rafig Aliyev, “Soft Computing and Its Applications”, World Scientific, 2001.
4	F. Martin, Mc Neill, and Ellen Thro, “Fuzzy Logic: A Practical approach”, AP Professional, 2000.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC – III, Sem– VI OPTIMIZATION TECHNIQUES AND COMPUTING MA306	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	formulate the real world problems into optimization problems and estimate the solution of the problems using the concept of LPP
CO2	analyze the sensitivity of different components of an LPP towards its solution
CO3	to recognize and solve the transportation problem involving a large number of shipping routes.
CO4	apply various methods to select and execute various optimal strategies to win the game.
CO5	explain the basic concept of non-linear optimization

2.	Syllabus	
	Linear Programming Problem	**(09 hours)**
	Introduction, formulation and geometrical ideas of linear programming problems, Convex sets, Graphical Method of solution of L.P.P., Standard form of L.P.P., Simplex Algorithm, Simplex Tableau, Two Phase Method, Big-M Method, Types of Linear Programming solutions.	
	Duality Concept	**(05 hours)**
	Duality, Revised simplex method (with and without artificial variable), Bounded variable technique, Duality theory, Dual simplex method, Modified dual simplex method.	
	Sensitivity Analysis	**(06 hours)**
	Change in the objective function, Change in the requirement vector, Addition of a variable, Addition of a constraint, Parametric analysis of cost and requirement vector.	
	Integer Programming Problems	**(05 hours)**
	Pure and Mixed Integer, Gomory's cutting plane algorithm, Gomory's mixed integer problem algorithm, A branch and bound algorithm.	
	Transportation and Assignment Problems	**(09 hours)**
	Mathematical Model for Transportation Problem, North-West Corner Method, Least Cost Method, Vogel's Approximation Method, Test for optimality, Degeneracy in Transportation Problem, Variations in Transportation Problem. Mathematical Model for Assignment Problem, Solution Method for Assignment Problem, Variations in Assignment Problem, Traveling Salesman Problem.	
	Sequencing Problems and Game Theory	**(06 hours)**
	Processing of Jobs through machines: Problems with n jobs two machines, n jobs three machines and n jobs m machines. Theory of Games: Saddle points, Twoperson zero sum games with and without saddle-points, Maximin and Minimax Principle, Pure and mixed strategies, linear programming formulation of matrix games.	
	Nonlinear Optimization	**(05 hours)**

	Introduction to nonlinear optimization, unconstrained and constrained optimization, Lagrange function, method of Lagrange multipliers, Karush-Kuhn-Tucker theory, convex optimization, sufficiency of KKT under convexity of quadratic programming.	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Practicals will be based on**
1.	solution of LPP by graphical method
2.	finding basic feasible solutions of an LPP
3.	solving an LPP by Simplex Algorithm
4.	solving an LPP by Big-M method
5.	solving an LPP by Two-phase method
6.	Dual Simplex Algorithm
7.	Least Cost method of Transportation problem
8.	Hungarian method of Assignment problem
9.	Steepest Descent method
10.	Conjugate Gradient Method

4.	**Books Recommended**
1	K. Swarup, P. K. Gupta and M. Mohan, Operations Research, 19th Edition, S. Chand & Sons, New Delhi, 2017.
2	H. A. Taha, Operations Research: An Introduction, 9th Edition, Pearson, New Delhi, 2014.
3	J. K. Sharma, Operations Research: Theory and Applications, 6th Edition, Trinity Press, New Delhi, 2017.
4	Ravindran, A., Phillips, D.T. and Solberg, J.J., “Operations Research: Principles and Practice”, John Wiley and Sons, NY, Second Edition (Reprint), 2012.
5	Pant, J.C., “Introduction to Optimization”, 7th Edition, Jain Brothers, 2015.

5.	**Additional Reference Books**
1	Hillier, F. S. and Lieberman, G. J., "Introduction to Operations Research," 11th Ed., McGraw-Hill India, 2021
2	S. Chandra, Jayadeva and A. Mehra, “Numerical Optimization with Applications”, New Delhi : Narosa, 2009.
3	S. S. Rao, “Engineering Optimization: Theory and Practice”, 3rd Ed., New Age International Pvt. Ltd. Publishers, 2013.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem–VI COMPUTATIONAL PARTIAL DIFFERENTIAL EQUATION MA308	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	formulate the physical problem into partial differential equations.
CO2	solve first order linear and nonlinear equations
CO3	analyze the existence and uniqueness of solutions
CO4	classify second order equations into three types of PDEs: parabolic, hyperbolic and elliptic
CO5	discuss the formulation and solution of Laplace, wave and heat equation

2.	Syllabus	
	INTRODUCTION TO PDE	**(06 Hours)**
	Order and degree of PDE, Types of PDE, Solution of simple PDE, Formation of PDE, Initial and Boundary conditions, Types of solution.	
	FIRST ORDER PDE	**(12 Hours)**
	The method of characteristics, The existence and uniqueness theorem, Cauchy problem, Lagrange's method, Compatible system of first order PDEs ,Charpit's method, Jacobi method, Geometrical interpretation and applications of first order PDE.	
	SECOND AND HIGHER ORDER PDE	**(10 Hours)**
	Homogeneous and non-homogeneous PDE of order two and higher with constant coefficient. PDEs reducible to equations with constant coefficients. PDEs of order two with variable coefficients. Classification of PDE, Reduction to canonical or Normal form, Riemann Method, Monges's method.	
	HEAT EQUATION	**(03 Hours)**
	Formulation and physical interpretation, Derivation of fundamental solution, Uniqueness of solution, Method of separation of variables.	
	LAPLACE EQUATION	**(03 Hours)**
	Formulation and physical interpretation, Derivation of fundamental solution, Uniqueness of solution, Dirichlet's principle, Method of separation of variables.	
	WAVE EQUATION	**(03 Hours)**
	Formulation and physical interpretation, D'Alembert's solution, Uniqueness of solution, Method of separation of variables.	

	Finite Difference Method to solve PDEs	**(08 Hours)**
	Introduction, Finite difference (FD) approximations for uniformly spaced grids and general grids, Consistency, Convergence, Stability, Solution of parabolic pde (heat equation), Solution of elliptic pde (wave equation), Solution of hyperbolic pde (Lapalce equation)	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30Hrs.= 75Hrs.)	

3.	**Practicals will be based on**
1	understanding environment and basic notation, PDE solvers.
2	setting up and solving a PDE with specified ICs visualization of solutions
3	setting up and solving a PDE with specified BCs visualization of solutions
4	characteristics method for solving first-order PDEs
5	plotting the characteristics curve of the first order Partial Differential Equation
6	solution of Cauchy Problem for first order Partial Differential Equation.
7	plotting the Integral surfaces of the first order Partial Differential Equation.
8	solution of second order Partial Differential Equation.
9	solution of second order pde
10	Implementing the heat equation using FDM
11	stability and convergence analysis of solution and visualization of temperature distribution over time
12	Wave Equation: Simulating wave propagation and reflectionAnalysis of wave speed and stability

4.	**Books Recommended**
1	M. P. Coleman, “An Introduction to Partial Differential Equations with MATLAB”, CRC Press, UK, 2nd Edition, 2013.
2	P. Prasad and R. Ravindran, “Partial Differential Equations”, New Age International Publishers, New Delhi, 3rd Edition, 2022.
3	L. C. Evans, “Partial Differential Equations”, American Mathematical Society, USA, 3rd Edition, 2022.
4	Aftab Alam, Mohammad Imdad, An Elementary Course on Partial Differential Equations, Cambridge University Press, India, 1st Edition, 2022.
5	Churchill, Ruel V., Fourier series and boundary value problems, McGraw-Hill, New York, 1978.

5.	**Additional Reference Books**
1	T. Amarnath, “An Elementary Course in Partial Differential Equations”, Narosa publications, India, 2nd Edition, 2003.
2	I. N. Sneddon, “Elements of Partial Differential Equations”, Dover Publication, New York, 2006.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem–VI Fundamentals of Artificial Intelligence CS300	Scheme	L	T	P	Credit
		3	1	0	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	Explain foundational AI concepts, including intelligent agents, problem-solving, and knowledge representation
CO2	Implement and analyse uninformed and informed search algorithms for solving AI problems.
CO3	Apply supervised and unsupervised machine learning techniques to real-world datasets
CO4	Develop models for uncertainty using probabilistic approaches, such as Bayesian networks and Hidden Markov Models.
CO5	Construct and train simple neural networks to solve tasks in complex environments.

2.	Syllabus	
	Introduction to Artificial Intelligence	**(10 hours)**
	History and evolution of AI, Definitions and applications of AI, Strong AI vs. Weak AI, Structure of agents, types of agents, Agent environment interaction, PEAS (Performance measure, Environment, Actuators, Sensors) model, Problem formulation, Uninformed search strategies: Breadth-first, Depth-first, Depth-limited, Iterative deepening, Informed search strategies: Best-first, A*, Heuristics	
	Knowledge Representation and Reasoning	**(09 hours)**
	Propositional logic, syntax, and semantics, Logical inference, truth tables, Resolution and proof techniques, Syntax and semantics of first-order logic (FOL), Knowledge-based agents, Production rules and inference engines, Applications of expert systems in decision making, Basic concepts in planning, STRIPS, Classical planning problems, Introduction to scheduling problems	
	Machine Learning Basics	**(09 hours)**
	Learning from data, Performance measures, Supervised Learning: Linear regression, logistic regression, Decision trees and random forests, Support Vector Machines (SVM), Unsupervised Learning: Clustering algorithms: k-means, hierarchical clustering, Dimensionality reduction techniques: PCA, LDA, Neural Networks and Deep Learning: Introduction to neural networks, Perceptron and multi-layer perceptron, Backpropagation and training of neural networks	
	Reasoning Under Uncertainty	**(09 hours)**
	Basic probability theory, Joint and conditional probabilities, Bayes' theorem and Bayesian inference, Introduction to Bayesian networks, Inference in Bayesian networks, Applications of Bayesian networks in diagnosis and decision-making, Introduction to Markov Decision Processes (MDP), Bellman equations, Value iteration and policy iteration, Introduction to Hidden Markov Models (HMMs) and applications, Forward-backward algorithm, Viterbi algorithm	
	Advanced Topics in AI and Applications	**(08 hours)**

	Introduction to reinforcement learning, Q-learning, SARSA, and deep Q-networks (DQN), Introduction to NLP, Text processing, word embeddings, Basic models: Bag-of-words, TF-IDF, RNNs for text generation, Basics of computer vision: Image recognition, object detection, Convolutional Neural Networks (CNN), Ethical considerations in AI: Fairness, transparency, accountability, AI and bias, societal impact, Legal implications of AI	
	Tutorial's will be based on the coverage of the above topics separately	**(30 hours)**
		(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)

3.	**Tutorials will be based on**
1.	Write Python code to implement Breadth-First Search (BFS), Depth-First Search (DFS), and A* search to solve problems like pathfinding in a maze.
2.	Create a decision-making system using production rules for a specific domain
3.	Use Python and libraries like sci-kit-learn to implement supervised learning algorithms like Decision Trees, SVM, and Logistic Regression on datasets
4.	Implement a Bayesian network to diagnose a medical condition or forecast weather, including probabilistic inference and visualization
5.	Implement an HMM for applications like speech recognition or sequence prediction using Python, and run the Viterbi algorithm to decode hidden states
6.	Using TensorFlow or PyTorch, implement a feedforward neural network to classify handwritten digits from the MNIST dataset or perform binary classification on another datase

4.	**Books Recommended**
1	Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig, 2022.
2	Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, MIT Press, 2016.
3	Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (4th Edition), Pearson, 2020.
4	Nils J. Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.
5	K.R. Chowdhary, Fundamentals of Artificial Intelligence, Springer, India, Private Ltd, 2020

5.	**Additional Books**
1	Pattern Recognition and Machine Learning by Christopher M. Bishop, 2009.
2	Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem–VI Elective Integral and Wavelet Transforms MA354	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	apply Fourier integral theorem and condition of its validity
CO2	determine the Fourier, Fourier Sine and Cosine transform of a function
CO3	utilize integral transform techniques to solve 2nd order ODE and PDE arising in Mathematical Physics
CO4	evaluate the solution of difference equation using Z-transform
CO5	demonstrate basic idea of Wavelets and Wavelet transform

2.	**<u>Syllabus</u>**	
	INTRODUCTION TO FOURIER TRANSFORM	**(11 Hours)**
	Fourier Integral Theorem, Definition and basic properties of Fourier transform. Inversion theorem, Convolution theorem, Parseval’s relation, Fourier Cosine and Sine transform, Fast Fourier Transform, Applications to Ordinary and Partial Differential Equations.	
	HANKEL TRANSFORM	**(08 Hours)**
	Hankel transform, Inversion formula of Hankel transform, Parseval relation, Finite Hankel transform, Application to Partial differential equations.	
	MELLIN’S TRANSFORM	**(08 Hours)**
	Properties of Mellin’s transform. Inversion theorem, Convolution theorem, Application of Mellin’ s transform.	
	Z-TRANSFORM	**(08 Hours)**
	Introduction, Linear Systems, Impulse response, Definition of Z-transform and examples, basic operational properties, Inverse Z-transform and examples, Applications of Z-transform to solve finite difference equations, Summation of infinite series.	
	WAVELETS AND WAVELET TRANSFORM	**(10 Hours)**
	Introduction to Wavelet, brief history, Continuous Wavelet Transform, Discrete Wavelet Transform, Basic Properties of Wavelet Transform, Applications of Wavelet Transforms. Triple integrals, evaluation techniques, Application of triple integrals for evaluation of volume.	
	Tutorials will be based on the coverage of the above topics separately.	**(15 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1	Fourier Integral Theorem, Definition and basic properties of Fourier transform. Inversion theorem, Convolution theorem, Parseval's relation
2	Fourier Cosine and Sine transform, Fast Fourier Transform,
3	Applications to Ordinary and Partial Differential Equations
4	Hankel transform, Inversion formula of Hankel transform, Parseval relation
5	Finite Hankel transform, Application to Partial differential equations
6	Inversion theorem, Convolution theorem, Application of Mellin' s transform.
7	Linear Systems, Impulse response, Definition of Z-transform and examples, basic operational properties, Inverse Z-transform
8	Continuous Wavelet Transform, Discrete Wavelet Transform,
9	Basic Properties of Wavelet Transform, Applications of Wavelet Transforms.
10	Triple integrals, evaluation techniques, Application of triple integrals

4.	**Books Recommended:**
1.	L. Debnath and D. Bhatta, Integral Transforms and Their Applications, 3rd Edition, Chapman & Hall, New York, 2014.
2.	L. Debnath and F. Shah, Wavelet Transforms and Their Applications, Springer, New York, 2nd Edition, 2015.
3	S Ramakrishnan, Wavelet Theory and Modern Applications, IntechOpe, 1st Edition, 2024
4.	C M. Akujuobi, Wavelets and Wavelet Transform Systems and Their Applications, Springer Cham, 1st Edition, 2022.
5	F. A. Shah, A. Y. Tantary, Wavelet Transforms, Taylor & Francis Ltd; 1st edition, 2022.

5.	**Additional Reference Books**
1	I. N. Sneddon, The Use of Integral Transform, McGraw-Hill, New York, 1972.
2	L. C. Andrews and B. K. Shivamoggi, Integral Transforms for Engineers, SPIE Press, Bellingham, 1999.
3	R. V. Churchill, Operational Mathematics, McGraw-Hill, New York, 1972.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem– V Theory of Computation MA366	Scheme	L	T	P	Credit
		3	1	0	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	acquire a foundational understanding of sets, relations, functions, and mathematical proof techniques relevant to theoretical computer science.
CO2	implement deterministic and non-deterministic finite automata, regular languages, and regular expressions
CO3	apply context-free grammars (CFG), pushdown automata, and their relation to non-regular languages
CO4	comprehend the Turing machine model and explore undecidability, recursion, and computability
CO5	explore the mathematical theory of computable functions

2.	Syllabus	
	Review of Mathematical Theory	**(09 hours)**
	Sets, Functions, Logical statements, Proofs, relations, languages, Mathematical induction, strong principle, Recursive definitions	
	Regular Languages and Finite Automata	**(09 hours)**
	Regular expressions, regular languages, applications, Automata with output-Moore machine, Mealy machine, Finite automata, memory requirement in a recognizer, definition, union, intersection and complement of regular languages, Non-determinism Finite Automata, Conversion from NFA to FA, $\wedge$- Non-determinism Finite Automata Conversion of NFA- $\wedge$ to NFA and equivalence of three Kleene’s Theorem, Minimization of Finite automata Regular and Non-regular Languages – pumping lemma	
	Context free grammar (CFG)	**(07 hours)**
	Definition, Unions Concatenations and Kleen’s of Context free language Regular grammar, Derivations and Languages, Relationship between derivation and derivation trees, Ambiguity Unambiguous CFG and Algebraic Expressions Bacos Naur Form (BNF), Normal Form – CNF, Closure properties of the class of context- free languages. CYK algorithm for CFL membership, testing emptiness of CFLs.	
	Pushdown Automata, CFL And NCFL	**(08 hours)**
	Definition, deterministic PDA, instantaneous description as a snapshot of PDA computation, notion of acceptance for PDAs, Equivalence of CFG and PDA, Pumping lemma for CFL, Intersections and Complements of CFL, Non-CFL	
	Turing Machine (TM)	**(07 hours)**
	Historical context, informal proofs of undecidability, TM Definition, Model of Computation and Church Turing Thesis, computing functions with TM, Combining TM, Variations of TM, Non-deterministic TM, Universal TM, Recursively and Enumerable Languages, Context sensitive languages and	

	Chomsky hierarchy, Robustness of the model: both natural generalizations and restrictions (Generalizations: multi-track, multi-tape, nondeterministic, etc. Restrictions: semi-infinite tape, counter machines). Church-Turing hypothesis.	
	Computable Functions	**(05 hours)**
	Partial, total, constant functions, Primitive Recursive Functions, Bounded Mineralization, Regular function, Recursive Functions.	
	Tutorials will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Tutorials will be based on**
1.	Set operation problems and recursive formulas for given problems, and their implementation in programming languages
2.	Design of FA and NFA for simple languages manually. Discuss steps to implement them in a programming environment
3.	NFA to DFA conversion for given examples and verification of results with language samples
4.	Concept of regular expressions and their application in pattern matching
5.	DFA minimization algorithm and its significance in reducing state complexity
6.	Parsing techniques and the CYK algorithm for CFGs
7.	PDA for given languages like palindromes or balanced parentheses
8.	Implementation of a Turing machine and its applications
9.	Simulation of the executing a Turing machine for various input tapes and its theoretical implications
10.	Primitive recursive functions and explore their properties

4.	**Books Recommended**
1.	John C. Martin, Introduction to Languages and The Theory of Computation (4th Edition), McGraw-Hill Publishers, 2011
2	Michael Sipser, *Introduction to the Theory of Computation* (3rd Edition), Cengage Learning, 2012.
3	Dexter C. Kozen, *Automata and Computability*, Springer, 2012.
4	Peter Linz, *An Introduction to Formal Languages and Automata* (5th Edition), Jones & Bartlett Learning, 2011.
5	John Hopcroft, Rajeev Motowani, and Jeffrey Ullman, Automata Theory, Languages, and Computation (3rd Edition), Pearson, 2008.

5.	**Additional Books**
1	M Sipser, Theory of Computation, Brooks-Cole, 2008
2	M Sipser, Introduction to the Theory of Computation (2nd Edition), Thomson, 2005.
3	Marvin L. Minsky, Computation: Finite and Infinite, Prentice-Hall (1967)

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem– V INFORMATION THEORY AND CRYPTOGRAPHY MA367	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	find the applications of information theory
CO2	explain about the channel and its capacity, information measure, entropy and coding methods
CO3	develop robust coding schemes and error detection & correcting codes
CO4	apply the concepts of distortion rate, channel capacity and types of channels.
CO5	design the communication system using efficient coding techniques.

2.	Syllabus	
	INTRODUCTION	**(09 hours)**
	Information Source, Symbols, and Entropy, Mutual information, information Measures for Continuous Random Variable, Joint and Conditional Entropy, Relative Entropy, Applications Based on information Theoretic Approach.	
	SOURCE CODING	**(09 hours)**
	Source Coding Theorem, Kraft inequality, Shannon-Fano Codes, Huffman Codes, Run Length Code, Arithmetic Codes, Lempel-Ziv-Welch Algorithm, Universal Source Codes, Prefix Codes, Variable Length Codes, Uniquely Decodable Codes, instantaneous Codes, Shannon's Theorem, Shannon Fano Encoding Algorithm, Shannon's Noiseless Coding Theorem, Shannon's Noisy Coding Theorem	
	COMMUNICATION CHANNEL	**(07 hours)**
	Channel and its Capacity, Continuous and Gaussian Channels, Discrete Memory-Less Channels, Symmetric Channel, Binary Erasure Channel, Estimation of Channel Capacity, Noiseless Channel, Channel Efficiency, Shannon's Theorem on Channel Capacity, Mimo Channels, Channel Capacity with Feedback	
	VIDEO AND SPEECH CODING	**(08 hours)**
	Video Coding Basics, Quantization, Symbol Encoding, Intraframe Coding, Predictive Coding, Transform Coding, Subband Coding, Vector Quantization, Interframe Coding, Motion Compensated Coding, Image Compression, Jpeg, LZ78 Compression, Dictionary Based Compression, Statistical Modelling, Speech Coding, Psycho-Acousting Modelling, Time Frequency Mapping Quantization, Variable Length Coding, Multichannel Correlation and Irrelevancy, Long Term Correlation, Pre-Echo Control, Bit Allocation.	
	ERROR CONTROL CODING	**(07 hours)**
	Overview of Field, Group, Galois Field, Types of Codes, Hamming Weight, Minimum Distance Based Codes, Error Detection and Error Correction Theorems, Maximum Likelihood Decoder, Map Decoder, Linear Block Codes and Their Properties, Equivalent Codes, Generator Matrix and Parity Check Matrix, Systematic Codes, Cyclic Codes, Convolution Codes and Viterbi Decoding Algorithm, Iterative Decoding, Turbo Codes and Low Density-Parity-Check Codes, Asymptotic Equipartition Property, Bch Codes,	

	Generator Polynomials, Decoding of Bch Codes, Reed Solomon Codes, Trellis Codes, Space Time Coding.	
	RATE DISTORTION THEORY	**(05 hours)**
	Rate Distortion Function, Random Source Codes, Joint Source-Channel Coding and the Separation Theorem.	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1.	Calculating entropy, joint entropy, and mutual information for a given set of symbols and probabilities.
2.	Implementing Shannon-Fano and Huffman coding algorithms
3.	Implementing LZW compression algorithm to measure the compression ratio and analyze performance.
4.	Estimating the channel capacity using Shannon's theorem
5.	Using discrete cosine transform (DCT) for image compression.
6.	Implementing Run-Length Encoding (RLE) and Arithmetic Coding to compress text or image data using both methods.
7.	Implementing Hamming code for error detection and correction to simulate data transmission with random bit errors.
8.	Implementing convolutional coding and decode using the Viterbi algorithm.
9.	Implementing Reed-Solomon error correction codes to encode and decode a message using Reed-Solomon coding.
10.	Implementing a basic rate-distortion function and evaluate performance in data compression

4.	**Books Recommended**
1	R. Bose, "Information Theory, Coding and Cryptography", McGraw-Hill, 3rd Ed., 2016
2	T. M. Cover and J. A. Thomas," Elements of information Theory", John Wiley & Sons, New York, 2012.
3	Yury Polyanskiy and Yihong Wu, *Information Theory*, Cambridge University Press, 2024.
4	Jimmy Soni and Rob Goodman, *A Mind at Play: How Claude Shannon Invented the Information Age*, Simon & Schuster, 2017.
5	Benjamín Labatut, *When We Cease to Understand the World*, 2020.

5.	**Additional Books**
1	R. M. Roth, "Introduction to Coding Theory", Cambridge University Press, 2006.
2	Reza, "An introduction to information Theory", Dover, 1994.
3	A. B. Robert, "Information Theory", Dover Special Priced Titles, 2007.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B. Tech. MAC 3rd Year Semester – V **ELECTIVE** **Data Visualization** **MA369**	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**0**	**2**	**04**

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	explain the design principles of data visualization, categories of data visualization, and data visualization tools.
CO2	apply visualization approaches for animation, representing geospatial, network and other high dimensional data.
CO3	analyze the data visualization categories applicability according to the given data.
CO4	evaluate data visualization both in qualitative and quantitative manner by using various mapping.
CO5	represent real-time data using various visualizations tools and techniques.

2.	**Syllabus**	
	INTRODUCTION	**(06 HOURS)**
	Data Visualization, Design, Data and Tasks, Data Types, Dataset Types, Basic Charts and Plots, Use of Statistical Indicators, Multivariate Data Visualization, Principles of Perception, Color, Design, and Evaluation, Graphical Integrity, Data-Ink Ratio, Aspect Ratios & Scales.	
	VISUALISATION FORMATS AND STRATEGIES	**(06 HOURS)**
	Formats-Static Graphs, Interactive Graphs, Infographics, Websites, Animated Videos, GIFs. Strategies-Qualitative and Text-Based Data, Color-Coding, Timelines, Calendars, and Diagrams, Filtering, Parallel Coordinates, Aggregation.	
	DATA VISUALIZATION CATEGORY	**(10 HOURS)**
	Text Data Visualization, Document Visualization, Images and Video, Interactivity and Animation, Temporal Data Visualization, Part-to-Whole Relationships Visualization, Geospatial Data Visualization, Hierarchical Data Visualization, Network Data Visualization, High-Dimensional Data Visualization, Maps.	
	DATA VISUALISATION SYSTEM	**(10 HOURS)**
	Visual Story Telling, Messaging, Effective Presentations, Design for Information, Visualization and Arts, Visualization Systems, Database Visualization, Redesign Principles and Design Dimensionality, Rapidly Prototype Visualizations, Quantitatively and Qualitatively Evaluation of Visualizations.	
	DATA-DRIVEN DOCUMENTS (D3)	**(06 HOURS)**
	Introduction, Relative vs. Absolute Judgments, Luminance Perception, D3 Key Features and Concepts, Visualization Process, Design Iterations, Sketching, Data Types, Statistical Graphs,	

	Interaction Design, Brushing and Linking, Animation, Trees and Networks, Radial Layouts, Linear Layouts, Maps, Tree maps, Choropleth Maps, Cartograms, Symbol Maps, Flow Maps, Real-Time Maps.	
	OTHER DATA VISUALISATION TOOLS	**(07 HOURS)**
	Visualization libraries in R/Python: Matplotlib (Histograms, Bar charts, Line plots, Pie charts, Box plots, Scatter plots), Seaborn (Box, Violin plots, Regression plots, Heatmaps), Bokeh, ggplot2,Creating Dashboards with Plotly and Dash.	
	Practicals will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1	Excel: Use Excel charts for presentation of quantitative data.
2	Tableau: Import and prepare data, Perform data cleaning and harmonization.
3	Tableau: Create data visualizations.
4	Tableau: Use advanced data visualization to discover trends in data sets.
5	Matplotlib: Basic plotting with matplotlib library.
6	D3: Creating lines and circles with select and append.
7	D3: Loading data, displaying it as a bar chart and creating a scatterplot.
8	D3: Draw histograms, violin plots, pie charts and ring charts.
9	Create regression plots and heatmap using seaborn library.
10	Create few standalone interactive plots.
11	Data visualization with ggplot2.
12	Building a dashboard with Plotly and Dash.

4.	**Books Recommended:**
1.	Scott Murray "Interactive Data Visualization for the Web" O'Reilly Media, 2nd Edition, 2017.
2.	Alberto Cairo, “The Truthful Art: Data, Charts, and Maps for Communication” Berkeley, California: New Riders, 1st Edition, 2016, ISBN: 9780321934079.
3.	Andy Kirk, Data Visualisation: A Handbook for Data Driven Design, SAGE Publications Ltd, UK, 2nd Edition, 2019.
4.	Sharada Sringeswara, Purvi Tiwari, U. Dinesh Kumar, Data Visualization: Storytelling Using Data, Wiley, India, 2022.
5	K Jolly, Hands-on Data Visualization with Bokeh, Packt Publishing 1st Edition, 20218

5.	**Additional Reference Books**
1	Ben Fry "Visualizing Data: Exploring and Explaining Data with the Processing Environment" O'Reilly Media, 1/E, 2008, ISBN: 9780596514556.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem–VI, Elective ADVANCED EVOLUTIONARY ALGORITHMS MA370	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	Explain the foundational concepts of evolutionary algorithms, including genetic algorithms, genetic programming, and evolutionary strategies
CO2	Implement and apply advanced techniques such as multi-objective optimization, constraint handling, and self-adaptive evolutionary strategies to solve complex problems
CO3	Critically assess the performance of different evolutionary algorithms, including their convergence behaviour, robustness, and efficiency in various optimization contexts
CO4	Find exposure to recent advances and trends in evolutionary computation
CO5	Apply evolutionary algorithms to real-world problems in fields such as machine learning, engineering design

2.	**Syllabus**	
	Introduction to Evolutionary Algorithms	**(10 hours)**
	Overview of Evolutionary Algorithms (EAs), Genetic Algorithms (GAs) as the foundational model, Inspiration from natural evolution: Selection, Crossover, Mutation, Fitness landscapes and adaptation, Representation of solutions (Binary, Real-valued, Permutations), Population dynamics and selection mechanisms, Schema theorem and the role of crossover and mutation, Genetic drift and convergence	
	Genetic Programming and Variants of EAs	**(09 hours)**
	Genetic Programming (GP): Evolving programs and function, Evolution Strategies (ES): Real-valued optimizations, Differential Evolution (DE): Population-based optimization, Memetic Algorithms: Hybridizing local search with EAs, Tree-based Genetic Programming, Mutation and crossover in GP, and code bloat, Evolutionary Strategies and real-valued mutation strategies, Differential Evolution's exploration and exploitation mechanisms	
	Multi-Objective Evolutionary Algorithms	**(09 hours)**
	Solving multi-objective problems using EAs, Pareto-optimality and non-dominated sorting, Techniques: NSGA-II (Non-dominated Sorting Genetic Algorithm), SPEA2 (Strength Pareto Evolutionary Algorithm), Fitness assignment in multi-objective problems, Diversity preservation: Crowding distance and fitness sharing, Convergence and spread in multi-objective optimization, Practical case studies in engineering design, machine learning	
	Advanced Operators and Techniques	**(09 hours)**

	Advanced crossover and mutation operators (e.g., Simulated Binary Crossover, Polynomial Mutation), Constraint handling techniques in EAs (Penalty functions, Deb's Rules), Adaptive parameter control and self-adaptive EAs, Co-evolutionary algorithms and competitive/cooperative co-evolution, Influence of crossover/mutation on exploration and exploitation, Strategies for solving constrained optimization problems, Self-adaptation of evolutionary parameters, Applications in automated design and game theory	
	Evolutionary Algorithms in Real-World Applications	**(08 hours)**
	Evolutionary Algorithms in machine learning: Hyperparameter optimization, neural network training, Applications in bioinformatics, robotics, finance, and industrial design, Hybrid and parallel EAs for large-scale optimization problems, Swarm intelligence (PSO, Ant Colony Optimization) as related paradigms, Co-evolution of learning agents and optimization of machine learning models, Application-specific case studies: Real-world optimization tasks, Parallelization strategies for evolutionary algorithms, Recent trends in evolutionary computing	
	Practical's will be based on the coverage of the above topics separately.	**(30 ours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)	

3.	**Practicals will be based on**
1.	Implementing a simple genetic algorithm for solving a function optimization problem
2.	Using genetic programming to solve symbolic regression problems
3.	Applying NSGA-II to a multi-objective optimization problem.
4.	Implementing a Differential Evolution (DE) algorithm for solving continuous optimization problems.
5.	Exploring Evolution Strategies (ES) for real-valued optimization tasks.
6.	Experimenting with self-adaptive evolutionary algorithms to handle constraints in optimization problems
7.	Using evolutionary algorithms for training neural networks or optimizing machine learning hyperparameters.

4.	**Books Recommended**
1	Ujjwal Maulik, *Multiobjective Genetic Algorithms for Clustering: Applications in Data Mining and Bioinformatics*, Springer, 2011.
2	Kalyanmoy Deb*,* Multi-Objective Optimization Using Evolutionary Algorithms*, Wiley, 2010.*
3	Kenneth A. De Jong*,* Evolutionary Computation: A Unified Approach*, MIT Press, 2017.*
4	A.E. Eiben and J.E. Smith, *Introduction to Evolutionary Computing* (2nd Edition), Springer, 2015.
5	Kenneth A. De Jong, *Evolutionary Computation: A Unified Approach*, MIT Press, 2016.

5.	**Additional Books**
1	Thomas Bäck, Evolutionary Algorithms in Theory and Practice: Evolution Strategies, Evolutionary Programming, Genetic Algorithms, Oxford University Press, 1996.
2	David E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, *Addison-Wesley, 1989.*
3	Melanie Mitchell, An Introduction to Genetic Algorithms, *MIT Press, 1996.*

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

M.Sc. 3rd Year (Mathematics) Semester –VI Elective BLOCK CHAIN TECHNOLOGY CS360	Scheme	L	T	P	Credit
		3	0	2	4

1.	**Course Outcomes (COs):** **At the end of the course, the students will be able to**
CO1	demonstrate the need, functions and challenges of blockchain technology.
CO2	deploy smart contracts for given use cases.
CO3	analyze blockchain based system structure and security offered therein.
CO4	asses functions, benefits and limitations of various blockchain platforms.
CO5	design and develop solution using blockchain technology in various application domains.

2.	**Syllabus**	
	INTRODUCTION	**(04 Hours)**
	Introduction to Blockchain Technology, Concept of Blocks, Transactions, Distributed Consensus, the Chain and the Longest Chain, Cryptocurrency, Blockchain 2.0, Permissioned Model of Blockchain, Permission less Blockchain.	
	DECENTRALIZATION USING BLOCKCHAIN	**(07 Hours)**
	Methods of Decentralization, Disintermediation, Contest-Driven Decentralization, Routes to Decentralization, the Decentralization Framework Example, Blockchain and Full Ecosystem Decentralization, Storage, Communication, Computing Power and Decentralization, Smart Contracts, Decentralized Autonomous Organizations, Decentralized Applications (DApps), Requirements and Operations of DApps, DApps Examples, Platforms for Decentralizations.	
	CRYPTO PRIMITIVES FOR BLOCKCHAIN	**(05 Hours)**
	Symmetric and Public Key Cryptography, Cryptographic Hard Problems, Key Generation, Secure Hash Algorithms, Hash Pointers, Digital Signatures, Merkle Trees, Patricia trees, Distributed Hash Tables.	
	BITCOINS AND CRYPTOCURRENCY	**(07 Hours)**
	Introduction, Digital Keys and Addresses, Private and Public Keys in Bitcoins,Base58Check Encoding, Vanity Addresses, Multi Signature Addresses, Transaction Lifecycle, Data Structure for Transaction, Types of Transactions, Transaction Verification, The Structure of Block in Blockchain, Mining, Proof of Work, Bitcoin Network and Payments, Bitcoin Clients and APIs, Wallets, Alternative Coins, Proof of Stake, Proof of Storage, Various Stake Types, Difficulty Adjustment and Retargeting Algorithms, Bitcoin Limitations.	
	SMART CONTRACTS	**(02Hours)**
	Smart Contract Templates, Oracle, Smart Oracle, Deploying Smart Contract on Blockchain.	
	PERMISSIONED BLOCKCHAIN	**(04 Hours)**

	Models and Use-cases, Design Issues, Consensus, Paxos, RAFT Consensus, Byzantine General Problem, Practical Byzantine Fault Tolerance.	
	DEVELOPMENT TOOLS AND FRAMEWORKS	**(05Hours)**
	Solidity Compilers, IDEs, Ganache, Meta mask, Truffle, Contract Development and Deployment, Solidity Language, Types, Value Types, Literals, Enums, Function Types, Reference Types, Global Variables, Control Structures, Layout of Solidity Source Code File.	
	HYPERLEDGER	**(05Hours)**
	The Reference Architecture, Requirements and Design Goals of Hyperledger Fabric, The Modular Approach, Privacy and Confidentiality, Scalability, Deterministic Transactions, Identity, Auditability, Interoperability, Portability, Membership Services in Fabric, Blockchain Services, Consensus Services, Distributed Ledger, Sawtooth Lake, Corda.	
	BLCOKCHAIN USE-CASES AND CHALLENGES	**(05Hours)**
	Finances, Government, Supply Chain, Security, Internet of Things, Scalability and Challenges, Network Plane, Consensus Plane, Storage Plane, View Plane, Block Size Increase, Block Interval Reduction, Invertible Bloom Lookup Tables, Private Chains, Sidechains, Privacy Issues, Indistinguishability Obfuscation, Homomorphic Encryption, Zero Knowledge Proofs, State Channels, Secure Multiparty Computation, Confidential Transactions.	
	Practicals will be based on the coverage of the above topics separately.	(**30 Hours)**
		(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)

3.	**Practicals will be based on**
1	Implementation of decentralizationand its applications.
2	Implementation of crypto primitives for blockchain.
3	Implementation of bitcoins
4	Implementation of cryptocurrency.
5	Implementation of smart contract and its application.
6	Implementation of permissioned blockchains.
7	Implementation of development tools
8	Implementation of frameworks
9	Implementation of hyperledger and its application.
10	Implementation of block chain use-cases and challenges.

4.	**Books Recommended:**
1.	Imran Bashir, Mastering Blockchain, Packt publishing, Mumbai, 3rd Edition, 2020.
2.	Andreas Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, O'Reilly, 2ndEdition, 2017.
3.	Melanie Swan, Blockchain Blueprint for a New Economy, O'Reilly Media, 1stEdition , 2015.
4.	Don and Alex Tapscott, Blockchain Revolution, Penguin Books Ltd, UK, 1stEdition , 2018.
5.	Alan T. Norman, Blockchain Technology Explained, CreateSpace Independent Publishing Platform, 1stEdition, 2017.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B. Tech. MaC - III, Sem– V Elective HIGH PERFORMANCE COMPUTING MA371	Scheme	L	T	P	Credit
		3	0	2	04

1.	Course Outcomes: At the end of the course, the students will be able to:
CO1	learn concepts, issues and limitations related to parallel computing architecture and software development.
CO2	apply different parallel models of computation, parallel architectures, interconnections and various memory organization in modern high performance architectures.
CO3	analyze the algorithms to map them onto parallel architectures for parallelism.
CO4	evaluate the performance of different architectures and parallel algorithms with different aspects of real time problems.
CO5	design parallel programs for shared-memory architectures and distributed-memory architectures using modern tools like OpenMP and MPI, respectively for given problems.

2.	Syllabus	
	PARALLEL PROCESSING CONCEPTS	**(08 hours)**
	Levels of Parallelism (Instruction, Transaction, Task, Thread, Memory, Function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc.), Architectures: N-wide Superscalar Architectures, Multi-core, Multi-threaded.	
	FUNDAMENTAL DESIGN ISSUES IN PARALLEL COMPUTING	**(06 hours)**
	Synchronization, Scheduling, Job Allocation, Job Partitioning, Dependency Analysis, Mapping Parallel Algorithms onto Parallel Architectures, Performance Analysis of Parallel Algorithms.	
	FUNDAMENTAL LIMITATIONS FACING PARALLEL COMPUTING	**(06 hours)**
	Bandwidth Limitations, Latency Limitations, Latency Hiding/Tolerating Techniques and their Limitations, Power-Aware Computing and Communication, Power-Aware Processing Techniques, Power-Aware Memory Design, Power-Aware Interconnect Design, Software Power Management	
	PARALLEL PROGRAMMING	**(11 hours)**
	Programming Languages and Programming-Language Extensions for HPC, Inter-Process Communication, Synchronization, Mutual Exclusion, Basics of Parallel Architecture, Parallel Programming Parallel Programming with OpenMP and (Posix) Threads, Message Passing with MPI.	
	PARALLEL PROGRAMMING WITH CUDA	**(10 hours)**
	Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in High Performance Computing Architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Micro architecture and Intel Nehalem Micro architecture), Memory Hierarchy and Transaction Specific Memory Design, Thread Organization.	
	ADVANCE TOPICS	**(04 hours)**
	Petascale Computing, Optics in Parallel Computing, Quantum Computers.	
	Practical's will be based on the coverage of the above topics separately.	**(30 hours)**

	(Total Contact Periods/ Hrs.: 45 Hrs. + 30 Hrs.= 75 Hrs.)

3.	**Practicals will be based on**
1.	parallel processing concepts
2.	design issues in parallel computing
3.	design issues in parallel computing
4.	limitations in parallel computing
5.	limitations in parallel computing
8.	parallel programming
9.	parallel programming with cuda

4.	**Books Recommended**
1	John L. Hennessy and David A. Patterson, "Computer Architecture -- A Quantitative Approach", 4th Edition, Morgan Kaufmann Publishers, 2017, ISBN 13: 978-0-12-370490-0.
2	Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of Gpu Computing), Morgan Kaufmann Publishers, India, 2012.
3	T Sterling, M Brodowicz, M Anderson, High-Performance Computing: Modern Systems and Practices, Morgan Kaufmann Publishers, 2017
4	R Robey, Y Zamora, Parallel and High Performance Computing, Manning Publisher; 1st edition, 2021.
5	S Kurgalin , S Borzunov, A Practical Approach to High-Performance Computing, Springer Cham, 1st Ed, 2021

5.	**Additional Reference Books**
1	Barbara Chapman, Gabriele Jost and Ruud van der Pas, "Using Open MP: portable shared memory parallel programming", The MIT Press, 2008, ISBN-13: 978-0-262-53302-7.
2	Marc Snir, Jack Dongarra, Janusz S. Kowalik, Steven Huss-Lederman, Steve W. Otto, David W. Walker, "MPI: The Complete Reference, Volume2", The MIT Press, 1998, ISBN: 9780262571234.
3	Pacheco S. Peter, "Parallel Programming with MPI", Morgan Kaufman Publishers, 1992, Paperback ISBN: 9781558603394 and https://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. III (Mathematics and Computing), Semester – VII **HIGH PERFORMANCE COMPUTING** **CS357**	**Scheme**	**L**	**T**	**P**	**Credit**
		3	**0**	**2**	**04**

1.	**Course Outcomes (COs):** **At the end of the course, students will be able to**
CO1	Learn concepts, issues and limitations related to parallel computing architecture and software development.
CO2	Apply different parallel models of computation, parallel architectures, interconnections and various memory organization in modern high performance architectures.
CO3	Analyze the algorithms to map them onto parallel architectures for parallelism.
CO4	Evaluate the performance of different architectures and parallel algorithms with different aspects of real time problems.
CO5	Design parallel programs for shared-memory architectures and distributed-memory architectures using modern tools like OpenMP and MPI, respectively for given problems.

2.	**Syllabus**	
	I PARALLEL PROCESSING CONCEPTS	**(08 Hours)**
	Levels of Parallelism (Instruction, Transaction, Task, Thread, Memory, Function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc.), Architectures: Nwide Superscalar Architectures, Multi-core, Multi-threaded.	
	FUNDAMENTAL DESIGN ISSUES IN PARALLEL COMPUTING	**(06 Hours)**
	Synchronization, Scheduling, Job Allocation, Job Partitioning, Dependency Analysis, Mapping Parallel Algorithms onto Parallel Architectures, Performance Analysis of Parallel Algorithms.	
	FUNDAMENTAL LIMITATIONS FACING PARALLEL COMPUTING	**(06 Hours)**
	Bandwidth Limitations, Latency Limitations, Latency Hiding/Tolerating Techniques and their Limitations, Power-Aware Computing and Communication, Power-Aware Processing Techniques, Power-Aware Memory Design, Power-Aware Interconnect Design, Software Power Management.	
	PARALLEL PROGRAMMING	**(11 Hours)**
	Programming Languages and Programming-Language Extensions for HPC, Inter-Process Communication, Synchronization, Mutual Exclusion, Basics of Parallel Architecture, Parallel Programming Parallel Programming with OpenMP and (Posix) Threads, Message Passing with MPI.	
	PARALLEL PROGRAMMING WITH CUDA	**(10 Hours)**
	Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in High Performance Computing Architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Micro architecture and Intel Nehalem Micro architecture), Memory Hierarchy and Transaction Specific Memory Design, Thread Organization.	

	ADVANCE TOPICS	**(04 Hours)**
	Petascale Computing, Optics in Parallel Computing, Quantum Computers.	
	Practicals will be based on the coverage of the above topics.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

4.	**Books Recommended**
1	John L. Hennessy and David A. Patterson, "Computer Architecture -- A Quantitative Approach", 5th Edition, Morgan Kaufmann Publishers, 2017, ISBN 13: 978-0-12-383872-8.
2	Barbara Chapman, Gabriele Jost and Ruud van der Pas, "Using OpenMP: portable shared memory parallel programming", The MIT Press, 2008, ISBN-13: 978-0-262-53302-7.
3	Marc Snir, Jack Dongarra, Janusz S. Kowalik, Steven Huss-Lederman, Steve W. Otto, David W. Walker, "MPI: The Complete Reference, Volume2", The MIT Press, 1998, ISBN: 9780262571234.
4	Marc Snir, Jack Dongarra, Janusz S. Kowalik, Steven Huss-Lederman, Steve W. Otto, David W. Walker, "MPI: The Complete Reference, Volume2", The MIT Press, 1998, ISBN: 9780262571234.
5	https://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
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Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. MaC - III, Sem– V Elective PROFESSIONAL ETHICS, ECONOMICS AND BUSINESS MANAGEMENT MG210	Scheme	L	T	P	Credit
		3	1	0	04

1.	**Course Outcomes:** **At the end of the course, the students will be able to:**
CO1	develop knowledge regarding Professional ethics
CO2	develop knowledge of Economics in engineering
CO3	develop managerial skills to become future engineering managers
CO4	develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO5	build knowledge about modern management concepts
CO6	develop experiential learning through Assignments, Management games, Case study discussion, Group discussion, Group presentations etc.

2.	**Syllabus**	
	PROFESSIONAL ETHICS	**(06 hours)**
	Introduction, Meaning of Ethics, Approaches to Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics.	
	ECONOMICS	**(09 hours)**
	Introduction to Economics, Applications & Scopes Of Economics, Micro & Macro Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis.	
	MANAGEMENT	**(15 hours)**
	Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Theories of Leadership.	
	FUNCTIONAL MANAGEMENT	**(12 hours)**
	Marketing Management: Core Concepts of Marketing, Marketing Mix (4p), Segmentation –Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training; Financial Management: Goal of Financial Management, Key Activities In	

	Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance.	
	MODERN MANAGEMENT ASPECTS	**(03 hours)**
	Introduction to ERP, e – CRM, SCM, RE – Engineering, WTO, IPR etc	
	Tutorial: Case Study Discussion, Group Discussion, management games and Assignments / Mini projects & presentation on related Topics.	**(15hours)**
	(Total Contact Periods/ Hrs.: 45 Hrs. + 15 Hrs.= 60 Hrs.)	

3.	**Tutorials will be based on**
1.	Case Study Discussion
2.	Group Discussion
3.	Management games
4.	Assignments / Mini projects & presentation on related Topics

4.	**Books Recommended**
1	Balachandran V. and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, PHI, 2nd Edition, 2011.
2	Prasad L.M., Principles & Practice of Management, Sultan Chand & Sons, 8th Edition, 2015.
3	Banga T. R. & Sharma S.C., Industrial Organisation & Engineering Economics, Khanna Publishers, 25th Edition, 2015.
4	Everett E. Adam, Ronald J. Ebert, Production and Operations Management, Prentice Hall of India, 5th edition, 2012.
5	Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014.
6	Tripathi P.C., Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013.
7	Chandra P., Financial Management Theory and Practice, Tata McGraw Hill, 11th Edition, 2022.

ADDITIONAL REFERENCE BOOKS	
1	Crane A. & Matten D., Business Ethics: Managing Corporate Citizenship and Sustainability in the Age of Globalisation, Oxford University, 4th edition, 2016.
2	Fritzsche D. J., Business Ethics: a Global and Managerial Perspectives, McGraw Hill Irwin, Singapore, 2005.
3	Mandal S. K., Ethics in Business and Corporate Governance, Tata McGraw Hill, 2011.

Sardar Vallabhbhai National Institute of Technology (SVNIT) Surat
Department of Mathematics
Bachelor of Technology in Mathematics and Computing (MaC)

B.Tech. IV (Mathematics and Computing), Semester – VII Fuzzy Logic and Computation MA-372	Scheme	L	T	P	Credit
		3	1	0	04

1.	Course Outcomes (COs): At the end of the course, students will be able to
CO1	demonstrate the concepts of crisp sets and fuzzy sets
CO2	apply various operations on fuzzy sets
CO3	demonstrate the fuzzy arithmetic
CO4	solve the fuzzy equations
CO5	solve the Engineering problems using the theory of fuzzy sets and fuzzy mathematics

2.	Syllabus	
	INTRODUCTION	**(9 Hours)**
	Uncertainty, Imprecision and Vagueness, Brief history of Fuzzy logic, Foundation of Fuzzy Theory, Definition of Fuzzy sets, Fuzzy sets verse crisp sets, Alpha-cuts, Theorems on Cuts, Normality Extension Principle. Types of operations, Completion, Union and intersection, De'Morgan Laws, Cartesian products. Algebraic products. Bounded sum and difference, t-norm, t-conorms.	
	FUZZY ARITHMETIC	**(6 Hours)**
	Fuzzy numbers. Addition, Subtraction, Multiplication and Division, Triangular and trapezoid fuzzy numbers.	
	FUZZY RELATIONS AND FUZZY EQUATIONS	**(10 Hours)**
	Crisp verses fuzzy relations, Binary fuzzy relations, Fuzzy equivalence relations, Fuzzy ordering relations. Fuzzy relation equations, Sup-i composition, Inf-w composition, Solution methods.	
	FUZZY LOGIC	**(8 Hours)**
	Fuzzy Propositions: Unconditional and unqualified propositions, Unconditional and qualified propositions, Conditional and unqualified propositions, Conditional and qualified propositions. Fuzzy Quantifiers: Various fuzzy propositions with quantifiers, Linguistic hedges. Fuzzy Inference: Inference from conditional fuzzy propositions, Inference from conditional and qualified/ quantified fuzzy propositions.	
	FUZZY CONTROLARS AND ENGINEERING APPLICATIONS	**(12 Hours)**
	Fuzzy rule-based system, Aggregation of fuzzy rules, Graphical techniques of inference, Fuzzy controlar, Applications in Civil engineering, Mechanical engineering and Computer engineering.	
	Tutorials will be based on the coverage of the above topics separately.	**(30 Hours)**
	(Total Contact Time: 45 Hours + 30 Hours = 75 Hours)	

4.	**Books Recommended**
1	Zimmerman H. J., Fuzzy Set Theory and its Applications, 3rd Edition, Kluwer Academic Publishers, Boston, MA, 2015.
2	Lee K. H., First Course on Fuzzy Theory and Applications, Springer, 2005.
3	Klir G. J. and Yuan B., Fuzzy Sets & Fuzzy Logic: Theory & Applications, PHI Inc. USA, 1997.
4	Dubois D. and Prade H., Fuzzy Sets and Systems: Theory and Applications, Academic Press, Cambridge, MA, 1980
5	Ross T. J., Fuzzy Logic with Engineering Applications, 3rd Edition, Wiley Publication, 2011.
6	Mohan C., An Introduction to Fuzzy Set Theory and Fuzzy Logic, Viva Books Private Limited, 2nd Edition 2020.