Sardar Vallabhbhai National Institute of Technology (SVNIT)
Surat Department of Mathematics

Five Years Integrated B.Sc. and M.Sc. Programme in Mathematics

	Fifth Semester (3rd year of Integrated BSc and MSc)				
1	Ordinary Differential Equations	MA301	3-1-0	4	70
2	Mechanics	MA303	3-1-0	4	70
3	Probability and Statistics-I	MA331	3-1-0	4	70
4	Analysis of Algorithms	MA332	3-1-0	4	70
5	Elective (Open Elective)	MA3AA	3-X-X	¾	55/70/85
			Total	**19-20**	**335-365**
6	Mini Project-I Preliminary Part-I Vocational Training / Professional Experience (Optional) (mandatory for exit)	MAV05 / MAP05	0-0-10	5	200 (20 x 10)
	Sixth Semester (3rd year of Integrated BSc and MSc)				
1	Complex Analysis	MA302	3-1-0	4	70
2	Continuum Mechanics	MA304	3-1-0	4	70
3	Metric Space	MA333	3-1-0	4	70
4	Fundamentals of Artificial Intelligence	CS300	3-0-2	4	85
5	Elective (Open Elective)	MA3BB	3-X-X	¾	55/70/85
			Total	**19-20**	**335-380**
6	Mini Project-I Preliminary Part-II Vocational Training / Professional Experience (Optional) (mandatory for exit)	MAV06 / MAP06	0-0-10	5	200 (20 x 10)

Sr. No.	**Elective**	**Code**	**Scheme L-T-P**
1	Advance Mathematical Methods-I	MA351	3-1-0
2	Stochastic Differential Equations	MA352	3-1-0
3	Mathematical Modelling	MA353	3-1-0
4	Integral and Wavelet Transform	MA354	3-1-0
6	Fuzzy Set theory	MA356	3-1-0
7	Block Chain Technology	CS360	3-0-2

Int. B.Sc.& M.Sc. III (Mathematics) Semester – V ORDINARY DIFFERENTIAL EQUATIONS MA301	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	analyze the existence, uniqueness of first and higher order linear ODEs on a given interval.
CO2	develops skills for different types of methods for finding the solution of ODEs.
CO3	elaborate the properties of dynamical system
CO4	assess the asymptotic behaviour of dynamical system
CO5	determine the solution of higher order BVP through eigen-functions and Green functions

2.	Syllabus	
	REVIEW OF SOLUTION METHODS FOR DIFFERENTIAL EQUATIONS	**(06 Hours)**
	Second order linear differential equations with variable coefficients and its solution properties, Series solution (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 SYSTEM OF LINEAR DIFFERENTIAL EQUATION	**(07 Hours)**
	Fundamental solutions, Wronskian, Variation of constants, Matrix exponential solution, Behaviour of solutions.	
	DYNAMICAL SYSTEM AND PHASE SPACE ANALYSIS	**(08 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	**(07 Hours)**
	Stability of fixed points, Stability via Liapunov's method.	
	BOUNDARY VALUE PROBLEMS FOR SECOND ORDER EQUATIONS	**(09 Hours)**

	Sturm comparison theorems, Oscillation theory, Regular and periodic Sturm-Liouville problems, Green's function.	
	Contribution of Indian Scientist/Mathematician	
	Ancient Indian mathematicians such as Aryabhata (476–550 AD), Brahmagupta (598–668 AD), Bhaskara II (1114–1185 AD), and Madhava (1340–1425 AD): The mathematical foundations (astronomical mathematical models, algebraic methods, early ideas of differential calculus, and infinite series) that later became essential for the theory of ordinary differential equations). Subrahmanyan Chandrasekhar (1910–1995 AD): Systems of ODEs to stellar structure, stability, and fluid mechanics, making him the leading Indian figure associated with ODEs in the modern era.	
	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**
1	Tutorial will be based on Second order linear differential equations with variable coefficients.
2	Tutorial will be based on series solution of Second order linear differential equations.
3	Tutorial will be based on existence and uniqueness of initial value problems.
4	Tutorial will be based on higher order and system of linear differential equation.
5	Tutorial will be based on dynamical system and phase space analysis.
6	Tutorial will be based on the flow of an autonomous equation.
7	Tutorial will be based on solution of asymptotic behaviour.
8	Tutorial will be based on boundary value problems for second order equations.
9	Tutorial will be based on solution of higher order BVP.
10	Tutorial will be based on solution of higher order BVP through eigen-functions and Green functions.

4.	**Books Recommended:**
1.	M. Brown, Differential Equations and Their Applications, Springer, 1992.
2.	S. L. Ross, Introduction to Ordinary Differential Equations, Wiley, 1991.
3.	M. W. Hirsch, S. Smale and R. L. Deveney, Differential Equations, Dynamical Systems and Introduction to Chaos, Academic Press, 2013.
4.	S. G. Deo, V. Raghavendra, R. Kar and V. Lakshmikantham, Textbook of Ordinary Differential Equations, McGraw-Hill Education, 2017.
5.	G. F. Simmons and S. G. Krantz, Differential Equations: Theory, Technique and Practice, McGraw Hill Education, 2006.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – V MECHANICS MA303	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 concepts of plane statics
CO2	apply fundamental laws of Newtonian mechanics and conservation principles to practical applications.
CO3	explain the motion of a particle in resisting medium and General motion under a central force
CO4	illustrate the motion of a rigid body rotating about a fixed axis and its practical applications
CO5	demonstrate motion of a rotating frame and motion of a particle relative to a rotating frame

2.	Syllabus	
	PLANE STATICS	**(09 Hours)**
	Introduction, Equilibrium of a particle, The triangle of forces, The polygon of forces, Lamy's theorem, equilibrium of system of particles, External and Internal forces, Necessary conditions for equilibrium (forces), Moment of a vector about a line, The theorem of Varignon, Necessary conditions for equilibrium (moments), Equipollent systems of forces, Couples, Moment of a couple, reduction of a general plane force system, Work and potential energy, The principle of virtual work.	
	APPLICATIONS IN PLANE STATICS	**(06 Hours)**
	Mass center, Theorems of Pappus, Gravitation, Friction, Laws of static and kinetic friction, Flexible cables, General formula for all flexible cables hanging freely, The suspension bridge, The common catenary.	
	PLANE KINEMATICS	**(06 Hours)**
	Kinematics of a particle, Tangential and Normal components of velocity and acceleration, Radial and transverse components, The hodograph.	
	PLANE DYNAMICS	**(09 Hours)**
	Equations of motion of a particle, Principle of angular momentum for a particle and system, Principle of energy for a particle and system, Principle of linear momentum for a system, d'Alembert's principle, Hamilton's principle, Some techniques of calculus of variation, Derivation of Lagrange's equation from Hamilton's principle	

	APPLICATIONS IN PLANE DYNAMICS	**(09 Hours)**
	Motion in resisting medium, motion of particles of varying mass, Central orbits, Kepler's law of motion, Moment of inertia: theorem of parallel axes, Theorem of perpendicular axes, Kinetic energy and angular momentum, Konig's theorem, Rigid body rotating about a fixed axis, The compound pendulum, Cylinder rolling down an inclined plane.	
	INTRODUCTION TO DYNAMICS IN SPACE	**(06 Hours)**
	Euler's dynamical equations for the motion a rigid body, Motion of rigid body about fixed axis, Motion of rigid body about rotating axis, Coriolis acceleration.	
	Valuable Contribution of Indian Scientist/ Mathematician	
	FOUNDATIONAL CONTRIBUTIONS TO MECHANICS BY INDIAN SCIENTIST: Satyendra Nath Bose (1894 – 1974) (Indian theoretical physicist and Mathematician): Indistinguishability of particles, Bose – Einstein Statistics, Bose – Einstein distribution, Chandrasekhara Venkata Raman (1888–1970) (Indian Physicist): Raman effect, Mechanics of sound and vibrations, Raman Spectroscopy Vikram Sarabhai (1919–1971) (Father of the Indian Space Programme): Rocket Mechanics, Orbital Mechanics, Institutional Mechanics	
	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**
1	Tutorial will be based on plane statics.
2	Tutorial will be based on equilibrium of system of particles.
3	Tutorial will be based on Necessary conditions for equilibrium (moments).
4	Tutorial will be based on applications in plane statics.
5	Tutorial will be based on plane kinematics.
6	Tutorial will be based on equations of motion of a particle.
7	Tutorial will be based on principle of linear momentum for a system.
8	Tutorial will be based on applications in plane dynamics.
9	Tutorial will be based on applications in plane dynamics.
10	Tutorial will be based on motion of rigid body.

4.	**Books Recommended:**
1.	J. L. Synge and B. A Griffith, Principle of Mechanic, 2nd Edition, Tata McGraw Hill, New Delhi, 2008.
2.	H. Goldstein, C. P. Poole and J. L. Safko, Classical Mechanics, 3rd Edition, Addison Wesley Publishing company, Inc., 2002.
3.	N. C. Rana and P. C. Joag, Classical Mechanics, Tata McGraw-Hill, 2001.
4.	R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw-Hill, 2000.
5.	P. V. Pant, Classical Mechanics, Alpha Science International, 2005.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – V **PROBABILITY AND STATISTICS-I** **MA331**	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 basic ideas of measures of central tendency, dispersion and their applications
CO2	adapt the knowledge of various Probability distributions and their applications
CO3	evaluate correlation, regression and confidence intervals to formulate hypotheses
CO4	apply statistical techniques for sampling of big data
CO5	select the appropriate statistical techniques for estimation of data

2.	**Syllabus**	
	REVIEW ON PROBABILITY AND DESCRIPTIVE MEASURES	**(07 Hours)**
	Historical development, Basic Concepts, Measures of Central Tendency, Measures of Dispersion, Tchebycheff's theorem and Empirical rule, Measures of relative standing, some principles of statistical model. Random variables, Probability, conditional probability and Bayes' theorem. Expected value, Moment generation function and variance of a random variable, covariance.	
	PROBABILITY DISTRIBUTIONS	**(10 Hours)**
	Probability Distributions: binomial and multinomial distribution, geometric distribution, hypergeometric distribution, normal distribution, gamma distribution, exponential distribution, negative binomial distribution, Two dimensional distribution, Joint and Marginal distribution.	
	CENTRAL LIMIT THEOREM	**(04 Hours)**
	Central limit theorem for Bernoulli trails, Normal approximation to binomial, The general central limit theorem.	
	SAMPLING METHODS	**(07 Hours)**
	Random Sampling and Methods of Sampling, Sampling Distribution and Standard Error, Sampling Distribution of the Sample Mean, Central Limit Theorem, Sampling Distribution of the Sample Proportion, Sampling Distribution of the difference between two sample means and Sampling Distribution of the difference between two sample proportions.	
	ESTIMATION METHODS	**(09 Hours)**

	Point Estimation, Interval Estimation, Confidence Interval, Large Sample Confidence Interval for a Population Mean μ, Large Sample Confidence Interval for a Population Proportion, estimating the difference between two Population means, estimating the Difference between two Binomial proportions, Maximum Likelihood Estimation.	
	CORRELATION AND REGRESSION	**(08 Hours)**
	Correlation, Multiple correlation, Linear Regression, Properties of the Least Square Estimators, Inferences concerning the Regression coefficients, Analysis of variance for Linear Regression, Testing the usefulness of the Linear Regression Model. Multiple regression, Testing the significance of the regression coefficients, Testing of linear hypothesis, Bias in the regression estimators due to choice of wrong model.	
	Valuable Contribution of Indian Scientist/ Mathematician	
	C. R. Rao: Cramér: C. R. Rao inequality, Rao–Blackwell theorem and Rao score test. P. C. Mahalanobis: M-distance (D) and pioneering methodology for large-scale sample surveys. R. C. Bose: Methods in design of experiments. S. N. Roy: Roy's largest root test and fundamental methods in multivariate statistical analysis.	
	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**
1	Tutorial will be based on basic concepts of probability.
2	Tutorial will be based on random variables.
3	Tutorial will be based on probability distributions: discrete and continuous.
4	Tutorial will be based on Central limit theorem.
5	Tutorial will be based on sampling.
6	Tutorial will be based on interval estimation and confidence interval.
7	Tutorial will be based on Maximum Likelihood Estimation..
8	Tutorial will be based on correlation.
9	Tutorial will be based on regression.
10	Tutorial will be based on testing of hypothesis.

4.	**Books Recommended:**
1.	W. Mendenhall, R. J. Beaver and B. M. Beaver, Introduction to Probability & Statistics, 15th Edition, Cengage Learning, 2020.
2.	C. M. Grinstead and J. L. Snell, Introduction to Probability, American Mathematical Society, 2nd Revised Edition, 2004.
3.	D. C. Montgomery, Applied Statistics and Probability for Engineers, 6th Edition, Wiley India Pvt Ltd., 2016
4.	R. E Walpole, R. H. Myers, S. L. Myers and K. E. Ye, Probability & Statistics for Engineers & Scientists, 9th Edition, Pearson, 2010.
5.	K. Black, Business Statistics: For Contemporary Decision Making, 10th Edition, Wiley, 2019.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – V ANALYSIS OF ALGORITHMS MA332	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	analyze algorithms using mathematical, empirical, and asymptotic analysis techniques.
CO2	implement the divide and conquer technique to solve problems.
CO3	use dynamic programming to solve optimization problems.
CO4	design and analyze searching algorithms.
CO5	apply various notions in cryptography and primality testing.

INTRODUCTION	**(07 Hours)**
Introduction to Algorithms, Analysis Techniques: Mathematical, Empirical and Asymptotic Analysis, Recurrence Relations and Solving Recurrences, Mathematical Proof Techniques, Amortized Analysis, Probabilistic Analysis.	
DIVIDE AND CONQUER APPROACH	**(08 Hours)**
Sorting & Order Statistics, Divide and Conquer Technique, Various Comparison based Sorts, Analysis of the Worst-Case and the Best-Cases, Randomized Sorting Algorithms, Lower Bound on Sorting, Non-comparison-based Sorts, Medians and Order Statistics, Min-Max Problem, Polynomial Multiplication.	
DYNAMIC PROGRAMMING	**(08 Hours)**
Motivation, Matrix Multiplication Problem, Assembly Line Problem, Coin Changing Problem, Longest Common Subsequence, 0/1 Knapsack problem, All-pairs Shortest Path Problems, Dynamic Programming Control Abstraction, Optimal Binary Search Tree.	
SEARCHING ALGORITHMS	**(09 Hours)**
Backtracking, N-Queens Problem, Sum of Subset Problem, Complexity Analysis, Branch & Bound, Least Cost Branch & Bound (LCBB), LCBB Complexity Analysis, 15-Puzzle Problem, Traveling Sales Person Problem.	
NUMBER THEORETIC ALGORITHMS	**(07 Hours)**
Number Theoretic Notions, GCD, Modular Arithmetic, Chinese Remainder Theorem, Generators, Cyclic Groups, Galois Fields, Applications in Cryptography, Primality Testing.	

NP-COMPLETE PROBLEMS	(06 Hours)
Polynomial Time, Verification, NP-completeness, Search Problems, Reductions, Dealing with NP-Completeness, Approximation Algorithms: Local Search Heuristics.	
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**
1	Tutorial will be based on Introduction to Algorithms and Analysis Techniques
2	Tutorial will be based on Amortized Analysis and Proof Techniques
3	Tutorial will be based on Sorting Algorithms.
4	Tutorial will be based on Divide and Conquer Techniques.
5	Tutorial will be based on Dynamic Algorithms.
6	Tutorial will be based on Searching Algorithms.
7	Tutorial will be based on Backtracking Techniques
8	Tutorial will be based on Graph-Based Algorithms.
9	Tutorial will be based on Branch and Bound Technique.
10	Tutorial will be based on Number Theoretic Algorithms and NP-Complete Problems.

4.	**Books Recommended:**
1.	T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to Algorithms," 4rd ed., MIT Press, 2022.
2.	J. Kleinberg and E. Tardos, "Algorithm Design," 1st ed., Pearson Education, Reprint 2006.
3.	S. Sahni, "Data Structures, Algorithms and Applications in C++," 2nd ed., Universities Press/Orient Longman, 2005.
4.	S. Baase and A. Van Gelder, "Computer Algorithms: Introduction to Design & Analysis," 3rd ed,2002.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – V 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 techniques based on varied factors for ODEs

2.	Syllabus	
	INTRODUCTION	**(06 Hours)**
	Review on Power Series Method, Taylor Series Method.	
	ASYMPTOTIC METHOD	**(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**
1	Tutorial on power series method.
2	Tutorial on Taylor series method.
3	Tutorial on finding solution irregular singular point at infinity and irregular points.
4	Tutorial on finding solutions of perturbed problems ODEs containing a large parameter
5	Tutorial on perturbation technique
6	Tutorial on regular perturbation theory.
7	Tutorial on singular perturbation theory, boundary-layer method.
8	Tutorial on method of multiple scales and it's applications.
9	Tutorial on HAM
10	Tutorials on convergence of homotopy-series solution

4.	**Books Recommended:**
1.	C. M. Bender and S. A. Orszag, Advanced Mathematical Methods for Scientists and Engineers: Asymptotic Methods and Perturbation Theory, Springer Science &Business Media, 1999.
2.	S. I. Hayek, Advanced Mathematical Methods in Science and Engineering, 2nd Edition, Chapman and Hall/CRC, 2011.
3.	J. B. Doshi, Analytical Methods in Engineering, Narosa Publishing House, 1998.
4.	A. D. Polyanin and V. F. Zaitsev, Handbook of Ordinary Differential Equations: Exact Solutions, Methods, and Problems, 3rdEdition, Chapman and Hall/CRC,2017.
5.	S. Liao, Homotopy Analysis Method in Nonlinear Differential Equations, Springer-Verlag Berlin Heidelberg, 2012.

Int. B.Sc.& M.Sc. III (Mathematics) Semester –V Stochastic Differential Equations MA352	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**
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, 2010.
2.	I. Karatzas and S. E. Shreve, Brownian Motion and Stochastic Calculus, Springer, 1998.
3.	P. Protter, Stochastic Integration and Differential Equations, Springer, 2nd Edition, 2012.
4.	I. Karatzas and S. E. Shreve, Methods of Mathematical Finance, Springer, 2010.
5.	S. Watanabe and N. Ikeda, Stochastic Differential Equations and Diffusion Processes, North-Holland, 2014.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – V MATHEMATICAL MODELLING MA353	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 TO MATHEMATICAL MODELLING	**(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.	
	PREDICTION 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 their by 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, Difference between Uncertain model, fuzzy model and crisp Model, Uncertain number based modelling.	
	Valuable Contribution of Indian Scientist/ Mathematician	
	Prasanta Chandra Mahalanobis: Mahalanobis Model, Feldman-Mahalanobis model**.** Aryabhata (476–550 CE): Computing trigonometry, planetary motion based 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**
1	Tutorial on basics of mathematical modelling.
2	Tutorial on modelling based on algebraic and differential equations.
3	Tutorial on interpolation and extrapolation based modelling.
4	Tutorial on regression based modelling.
5	Tutorial on different prediction models of Engineering.
6	Tutorial on fuzzy system of algebraic equation and fuzzy ordinary differential equation based models.
7	Tutorial on circuit and network based fuzzy model, physical sciences based model.
8	Tutorial on linear and non-linear programming models.
9	Tutorials on industrial problems and concerned mathematical optimization model.
10	Tutorial on fuzzy single objective linear and non-linear programing based models.
11	Tutorial on fuzzy multi objective linear and non-linear programing based models.
12	Tutorial on 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, 2016.
4.	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, 2007.
5.	Baoding Liu, Uncertainty Theory, Springer Berlin, Heidelberg, 2015.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – VI **COMPLEX ANALYSIS** **MA302**	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 fundamentals of function of complex variables
CO2	evaluate contour integrals
CO3	deduct the poles and singularities with applications
CO4	evaluate proper and improper integrals
CO5	explain the basic concept of conformal mappings in complex plane with applications

2.	**Syllabus**	
	FUNCTIONS OF COMPLEX VARIABLE	**(12 Hours)**
	Limit, Continuity, Differentiability, Analytic function, Cauchy-Riemann equation,Construction of analytic function, Harmonic function	
	CONTOUR INTEGRATION	**(11 Hours)**
	Cauchy's theorem, Cauchy's inequality, Morera's theorem, Liouville's theorem.Power Series, Taylor's series, Maximum/Minimum modulus principle, Schwarzlemma.	
	SINGULARITIES AND RESIDUES	**(13 Hours)**
	Classification of Singularities: Isolated, removable, pole and essential singularities,Properties of zeroes and poles, Residue at pole, Residue at infinity, Cauchy's residuetheorem, Number of poles and zeroes of an analytic function, Cauchy's integralformula, Laurent's series, Open mapping theorem, Rouche's theorem, Evaluation ofintegrals of the type $\int_0^{2\pi} f(\sin\theta, \cos\theta)d\theta$, $\int_{-\infty}^{\infty} f(x)dx$, Improper real integrals ofthe form $\int_{-\infty}^{\infty} \cos(ax)\, f(x)dx$ and $\int_{-\infty}^{\infty} \sin(ax)\, f(x)dx$, Improper integrals with singularpoints on the real axis.	
	CONFORMAL MAPPINGS	**(09 Hours)**
	Introduction, Conformality Theorem, Mobi$\ddot{u}$s transformation, translation, rotation, inversion, cross-ratio, critical value of a transformation.	
	Valuable Contribution of Indian Scientist/ Mathematician	
	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**
1	Tutorials on limit, continuity.
2	Tutorials on differentiability, Cauchy-Riemann equation.
3	Tutorials on analytic functions and harmonic functions.
4	Tutorials on contour integrals.
5	Tutorials on power series, Taylor's series.
6	Tutorials on Maximum/Minimum modulus principle, Schwarz lemma.
7	Tutorials on Singularities and Residues.
8	Tutorials on proper and improper integrations.
9	Tutorial on Conformal mapping.
10	Tutorial on Mobi$\ddot{u}$s transformation.

4.	**<u>Books Recommended:</u>**
1.	J. W. Brown and R. V. Churchill, Complex Variables and Applications, 9thEdition,McGraw-Hill Higher Education, 2021.
2.	J. B. Conway, Functions of one Complex variable, Springer, International StudentEdition, Narosa, 1995.
3.	H. S. Kasana, Complex Variables: Theory and Applications, 2ndEdition, PHILearning Private Limited, Delhi, 2013.
4.	S. Ponnusamy, Foundations of Complex Analysis, Narosa, 2nd edition, 2014.
5.	A. R. Shastri, An Introduction to Complex Analysis, Macmillan India, New Delhi,1999.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – VI **CONTINUUM MECHANICS** **MA304**	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 the usefulness of tensors in Continuum Mechanics.
CO2	analyze the Cauchy's stress principle to develop the stress vector-stress tensorrelationship
CO3	solve problems in continuum theory.
CO4	illustrate the Material derivative concept in obtaining the basic equations of ContinuumMechanics.
CO5	apply the concept of mechanics in modern engineering and technology.

2.	**Syllabus**	
	REVIEW OF TENSORS	**(05 Hours)**
	Cartesian tensors, Tensor rank, Indicial notations; Range and summationconventions, Transformation laws for Cartesian tensors, Kronecker delta,Orthogonality conditions, Addition of Cartesian tensors, Multiplication by a scalar,Tensor multiplication, Matrix representation of Cartesian tensors, Principal valuesPrincipal directions of symmetric second order tensors.	
	ANALYSIS OF STRESS	**(09 Hours)**
	The continuum concept, Homogeneity, Isotropy, Mass density, Body forces, surfacesforces, Cauchy stress principle; The stress vector, State of stress at a point, Thestress tensor - stress vector relationship, Principal stresses, Stress invariants, Stressellipsoid.	
	DEFORMATION AND STRAIN	**(07 Hours)**
	Lagrangian and Eulerian description, Finite strain tensor, Small deformation theory, Rotation tensor, Strain invariant, Principal strains, Cubical dilatation	
	MOTION AND FLOW	**(08 Hours)**
	Material derivatives, Path line and stream lines, Rate of deformation, Vorticity vector, Material derivative of Line, Surface and Volume integrals.	
	FUNDAMENTAL LAWS OF CONTINUUM MECHANICS	**(08 Hours)**
	Equation of continuity, Equations of motion, Principle of angular momentum, Conservation of energy, Clausius-Dirhem inequality, Dissipation Function	
	LINEAR ELASTICITY	**(03 Hours)**

	Generalized Hooke's law, Strain energy function, Isotropy, Anisotropy, Elasticsymmetry, Isotropic media, Elastic constants, Elastostatic problems,Elastodynamic problems	
	CLASSICAL FLUIDS	**(05 Hours)**
	Viscous Stress Tensor, Stokesian, and Newtonian Fluids, Relation between stressesand rate of strain for compressible Newtonian viscous fluids.	
	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**
1	Tutorial on basics of tensors.
2	Tutorial on operations of tensors.
3	Tutorial on introduction to stress.
4	Tutorial on the Cauchy's stress principle and the stress vector-stress tensor relationship.
5	Tutorial on deformation and strain.
6	Tutorial on material derivatives.
7	Tutorial on material derivative line, surface and volume integrals.
8	Tutorial on fundamentals of continuum mechanics.
9	Tutorials on Elasticity.
10	Tutorial on Stokesian and Newtonian fluids.

4.	**Books Recommended:**
1.	G. T. Mase and G. E. Mase, Continuum Mechanics for Engineers, CRC press, 3rd edition, 2009.
2.	G. E. Mase, Theory and Problems of Continuum Mechanics, Schaum's Outline Series,McGraw Hill Book company, 1970.
3.	J. W. Rudnicki, Fundamentals of Continuum Mechanics, John Wiley & Sons Ltd.,2015.
4.	J. N. Reddy, An Introduction to Continuum Mechanics with Applications,Cambridge University Press, 2nd edition,2013.
5.	X. Oliver and C. A. de-Saracibar, Continuum Mechanics for Engineers: Theory &Problems, 2ndEdition, 2017.

Int. B.Sc. & M.Sc. III (Mathematics) Semester –VI METRIC SPACES MA333	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	explain the basic definition of metric spaces and corresponding topological concepts.
CO2	discuss sequences in metric spaces and their convergence and completeness.
CO3	elaborate on compactness and its characterization.
CO4	illustrate the concept of connectedness and can apply different aspects related to metric continuity.
CO5	discuss the continuity and its geometric properties along with fixed point concepts.

2.	Syllabus	
	BASIC DEFINITIONS AND NOTIONS	**(10Hours)**
	Need of "metric", abstract definition and examples of metric spaces, Consequences: Open balls and open sets and their properties and characterizations, Closed Sets and their properties and characterizations. Meaning of "Topology", Subspace topology and product topology with characterizations, Interior, Exterior, Boundary Points, Interior, Exterior and Boundary of a set and their properties and characterizations in terms of open and closed sets, Limit Points and Cluster points, Closure of a set, Dense sets and their properties and characterizations, Bounded sets and their properties and characterizations, Distance between sets, Equivalent metrics.	
	SEQUENCES IN METRIC SPACE	**(06 Hours)**
	Sequences and their convergence in a metric space, Characterizations of closed sets, limit points, cluster points, dense sets in terms of sequences and their convergence, Cauchy sequences in a metric space, Complete metric space: Difference between Cauchy sequences and convergence in abstract metric spaces, Completion of a metric space, Baire category theorem with a few applications at the beginner level.	
	COMPACTNESS	**(06 Hours)**
	Compact Spaces: Motivation, definition and their properties, Characterization of compact spaces in terms of sequentially compact, Closed and totally bounded and open cover definition, Equivalence of these definitions.	

	CONNECTEDNESS	**(05 Hours)**
	Connected sets, Connected Components, totally disconnected sets.	
	CONTINUITY	**(10 Hours)**
	Motivation behind continuity of functions in metric spaces, The three equivalent definitions of continuity: sequence definition, epsilon–delta definition and open sets definition, Other characterizations of continuity in terms of open sets, closed sets, closure and interior of images and pre-images of sets, Uniform continuity and Lipschitz continuity, its properties and characterizations, Continuous functions on compact spaces and the Arzela-Ascolli's theorem, Continuous functions on connected spaces and path connectedness, Open and closed maps and their properties, Homeomorphisms and their importance.	
	BANACH CONTRACTION PRINCIPLE AND ITS APPLICATIONS	**(05 Hours)**
	Contraction mappings, Contractive mappings, Non-expansive mappings, Fixed points, Banach contraction principle, Applications of Banach contraction principle to root finding problems, System of linear equations, Implicit function theorem.	
	Valuable Contribution of Indian Scientist/ Mathematician	
	Kerala School (c. 14th–16th century AD): Established infinite series and approximation methods that influenced modern analysis. K. Chandrasekharan (1920–2017 AD): Made significant contributions to classical and functional analysis. C. S. Seshadri (1932–2020 AD): Contributed fundamentally to topology through algebraic geometry and vector bundles. M. S. Raghunathan (1941–2021 AD): Advanced the study of Lie groups, topological groups, and differential geometry. Applications: Metric spaces and topology in functional analysis	
	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**
1	Metric spaces, examples of metrics, open balls, open sets, and basic properties.
2	Closed sets, subspace topology, product topology, interior, exterior, boundary, and closure of sets.
3	Limit points, cluster points, dense sets, bounded sets, distance between sets, and equivalent metrics.
4	Sequences in metric spaces, convergence of sequences, characterization of closed and dense sets using sequences.
5	Cauchy sequences, complete metric spaces, completion of metric spaces, and the Baire Category Theorem.

6	Compactness: Open cover compactness, sequential compactness, total boundedness, and equivalence of compactness criteria.
7	Connectedness, connected components, totally disconnected spaces, and path connectedness.
8	Continuity in metric spaces: sequential and open-set definitions; uniform continuity and Lipschitz continuity.
9	Continuous functions on compact and connected spaces, Arzelà–Ascoli Theorem, open maps, closed maps, and homeomorphisms.
10	Banach Contraction Principle, contraction mappings, fixed-point theorems, and applications to root-finding, systems of linear equations, and the Implicit Function Theorem.

4.	**Books Recommended:**
1.	P. K. Jain and K. Ahmed, Metric Spaces, 2nd Edition, Narosa Publications, 2004.
2.	S. Kumaresan, Topology of Metric Spaces, 2nd Edition, Narosa Publications, 2011.
3.	S. Shirali and H. L. Vasudeva, Metric Spaces, Springer, 2006.
4.	G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Education, 1963.
5.	D. Gopal, P. Kumam and M. Abbas, Background and Recent Developments in Metric Fixed Point Theory, CRC Press, 2017.

Int. B.Sc.& M.Sc. III (Mathematics) Semester – VI **FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE** **CS300**	**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	enhance the role of agents and how it is related to environment and the way of evaluating it and how agents can act by establishing goals
CO2	apply various knowledge representation technique, searching techniques, constraint satisfaction problem and example problems- game playing techniques.
CO3	analyse the current scope, potential, limitations, and implications of intelligent systems.
CO4	evaluate the AI techniques suitable for recent areas of applications like expertsystems, neural networks, fuzzy logic, robotics, natural language processing, andcomputer vision.
CO5	design a real world problem for implementation and understand the dynamic behavior of a system.

2.	**Syllabus**	
	INTRODUCTION TO AI	**(03 Hours)**
	Intelligent agents, AI techniques, AI-problem formulation, AI applications, Productionsystems, Control strategies.	
	KNOWLEDGE REPRESENTATION	**(07 Hours)**
	Knowledge representation using predicate logic, Introduction to predicate calculus,Resolution, Use of predicate calculus, Knowledge representation using other logic-structuredrepresentation of knowledge.	
	PRODUCTION SYSTEM	**(07 Hours)**
	Defining the problems as a state space search, Production systems, Productioncharacteristics, Production system Characteristics, Forward and backward,State-space search, Problem solving methods - Problem Graphs, Matching,Indexing.	
	PROBLEM-SOLVING THROUGH SEARCH	**(07 Hours)**
	Generate and test, BFS, DFS, Blind, Heuristic, Problem-reduction, A, A*, AO*,Minimax, Constraint propagation, Neural, Stochastic, and Evolutionary searchalgorithms, Sample applications, Measure of performance and analysis of searchalgorithms, Problem reduction, Constraint satisfaction, Means-ends analysis, Issuesin the design of search programs.	
	KNOWLEDGE INFERENCE	**(06 Hours)**
	Knowledge representation – Production based system, Frame based system. Inference – backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – certainty factors, Bayesian	

	theory-Bayesian network-Dempster – Shafertheory, Symbolic logic under uncertainty : Non-monotonic reasoning, logics fornon-monotonic reasoning, Statistical reasoning : Probability and Bayes theorem,Certainty factors, Probabilistic graphical models, Bayesian networks, Markovnetworks, Fuzzy logic.	
	GAME PLAYING AND PLANNING	**(06 Hours)**
	Overview and example domain: Overview, Minimax, Alpha-Beta cut-off, Refinements, Iterative deepening, The blocks world, Components of a planningsystem, Goal stack planning, Nonlinear planning using constraint posting,Hierarchical planning, Reactive systems, Other planning techniques.	
	NATURAL LANGUAGE PROCESSING	**(04 Hours)**
	Introduction, Syntactic processing, Semantic analysis, Semantic analysis, Discourseand pragmatic processing, Spell checking.	
	EXPERT SYSTEMS	**(05 Hours)**
	Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge acquisition – Meta Knowledge, Heuristics, Typical expert systems – MYCIN, DART, XOON, Expert systems shells.	
	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.	**Practical's**
1	Practical assignment to understanding basic concepts of prolog.
2	Practical assignment to implement various search strategies.
3	Practical assignment to implement various algorithm based on game theory.
4	Practical assignment to implement meta heuristic algorithm.
5	Implementation of heuristic based search techniques.
6	Implementation of neural network based application.
7	Implementation of fuzzy logic based application.
8	Implementation of fuzzy inference engine for an application.
9	Implementation of neuro-fuzzy based system.
10	Implementation of MYCIN, DART, XOON

4.	**Books Recommended:**
1.	E. Rich and K. Knight, Artificial Intelligence, 3nd Edition, Tata McGraw-Hill, 2017.
2.	S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 4rd Edition,Prentice Hall, 2022.
3.	N. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann, 1998.
4.	W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PrenticeHall of India, 2015S.
5.	I. Bratko, Prolog Programming for Artificial Intelligence, 4rd Edition,Addison-Wesley, 2011

Int. B.Sc.& M.Sc. III (Mathematics) Semester –VI **Integral and Wavelet Transform** **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.	**Syllabus**	
	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**
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.	I. N. Sneddon, The Use of Integral Transform, McGraw-Hill, New York, 1972.
3.	L. C. Andrews and B. K. Shivamoggi, Integral Transforms for Engineers, SPIE Press, Bellingham, 1999.
4.	L. Debnath and F. Shah, Wavelet Transforms and Their Applications, Springer, New York, 2015.
5.	R. V. Churchill, Operational Mathematics, McGraw-Hill, New York, 1972.

Int. B.Sc.& M.Sc. III (Mathematics) Semester –VI Fuzzy Set Theory MA356	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 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	**(06 Hours)**
	Definition of Fuzzy sets. Fuzzy sets verse crisp sets, Alpha-cuts, Theorems on Alpha -Cuts, Normal Fuzzy Set, cardinality of fuzzy set, hamming distance, Fuzzy subset, Convex fuzzy sets, Type-2 fuzzy set, The Zadeh's extension principle.	
	OPERATIONS ON FUZZY SETS	**(06 Hours)**
	Types of operations, Completion, Union and intersection, De'Morgan Laws, Cartesian products. Algebraic products. Bounded sum and difference, t-norm, t-conorms.	
	FUZZY NUMBERS AND EQAUTIONS	**(08 Hours)**
	Fuzzy numbers, Addition, Subtraction, Multiplication and Division, Triangular and trapezoidal fuzzy numbers, Shape function, fuzzy equations: A+X=B, AX=B.	
	FUZZY RELATIONS	**(12 Hours)**
	Fuzzy relations on fuzzy sets, Binary fuzzy relations, Min-Max composition and its properties, Fuzzy equivalence relations, Fuzzy ordering relations, Fuzzy relation equations, Fuzzy Compatibility relations, Sup-i composition, Inf-w composition, Solution methods.	
	FUZZY LOGIC	**(07Hours)**
	An overview of classical logic. Multivalued logics. Fuzzy propositions. Fuzzy quantifiers. Linguistic variables. Inference from conditional fuzzy propositions, the compositional rule of inference.	
	ENGINEERING APPLICATIONS	**(06 Hours)**

	Fuzzy controller, Applications in Engineering Sciences, Real world problems using Fuzzy.	
	Valuable Contribution of Indian Scientist/ Mathematician	
	Sankar K. Pal, (1975–1982): Foundational principles for machine intelligence in visual computing by introducing fuzzy image entropy, measures of fuzziness, and grey-level uncertainty algorithms for digital image processing. **Madan M. Gupta (1977–1985):** Co-developed the formal mathematical framework for **f**uzzy arithmetic operations via alpha-cuts and the Extension Principle (notably in his seminal 1985 monograph with A. Kaufmann), enabling applications in engineering control and fuzzy-neuro systems. **Intuitionistic Fuzzy Decision Making & Matrix Theory (Indian OR & Applied Math School, 1990s–2000s):** Indian mathematicians made major foundational contributions to generalized fuzzy sets (such as Intuitionistic Fuzzy Sets and Picture Fuzzy Sets) by defining aggregation operators, fuzzy matrix operations, and Multi-Criteria Decision Making (MCDM) tools (like Fuzzy TOPSIS and VIKOR adaptations).	
	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**
1	Alpha-cuts, Convex fuzzy
2	Extension principle
3	Triangular and trapezoid fuzzy numbers, fuzzy equations.
4	Crisp verses fuzzy relations,
5	Binary fuzzy relations, compatibility
6	Fuzzy equivalence relations, Fuzzy ordering relations
7	Fuzzy relation equations, Sup-i composition,
8	Inf-w composition
9	Fuzzy proposition, Fuzzy Quantifiers
10	Multivalued Logic, Inference Systems, Application

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

Int. B.Sc.& M.Sc. III Year (Mathematics) Semester –VI 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	analyse 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	**(04Hours)**
	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, Blockchainand Full Ecosystem Decentralization, Storage, Communication, Computing Powerand 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, KeyGeneration, Secure Hash Algorithms, Hash Pointers, Digital Signatures, MerkleTrees, 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, TransactionLifecycle, Data Structure for Transaction, Types of Transactions, TransactionVeri_cation, The Structure of Block in Blockchain, Mining, Proof of Work, BitcoinNetwork and Payments, Bitcoin Clients and APIs, Wallets, Alternative	

	Coins,Proof of Stake, Proof of Storage, Various Stake Types, Di_culty Adjustment and Retargeting Algorithms, Bitcoin Limitations.	
	SMART CONTRACTS	**(02Hours)**
	Smart Contract Templates, Oracle, Smart Oracle, Deploying Smart Contract onBlockchain.	
	PERMISSIONED BLOCKCHAIN	**(04 Hours)**
	Models and Use-cases, Design Issues, Consensus, Paxos, RAFT Consensus, ByzantineGeneral Problem, Practical Byzantine Fault Tolerance.	
	DEVELOPMENT TOOLS AND FRAMEWORKS	**(05Hours)**
	Solidity Compilers, IDEs, Ganache, Metamask, Truffle, Contract Development andDeployment, Solidity Language, Types, Value Types, Literals, Enums, FunctionTypes, Reference Types, Global Variables, Control Structures, Layout of SolidparticSource Code File.	
	HYPERLEDGER	**(05Hours)**
	The Reference Architecture, Requirements and Design Goals of HyperledgerFabric, 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 andChallenges, Network Plane, Consensus Plane, Storage Plane, View Plane, BlockSize Increase, Block Interval Reduction, Invertible Bloom Lookup Tables, PrivateChains, Sidechains, Privacy Issues, Indistinguishability Obfuscation, HomomorphicEncryption, 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**
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 hyper ledger and its application.
10	Implementation of block chain use-cases and challenges.

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