	Fifth Semester (3rd year of 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 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)

M.Sc.3rd Year (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	classify the properties of dynamical system
CO4	examine the asymptotic behavior 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.	
	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	Second order linear differential equations with variable coefficients.
2	series solution of Second order linear differential equations.
3	existence and uniqueness of initial value problems.
4	higher order and system of linear differential equation.
5	dynamical system and phase space analysis.
6	the flow of an autonomous equation.
7	solution of asymptotic behavior.
8	boundary value problems for second order equations.
9	solution of higher order BVP.
10	solution of higher order BVP through eigen-functions and Green functions.

4.	**Books Recommended:**
1.	M. W. Hirsch, S. Smale and R. L. Deveney, Differential Equations, Dynamical Systems and Introduction to Chaos, Academic Press,San Diego, 2013.
2.	S. G. Deo, V. Raghavendra, R. Kar and V. Lakshmikantham, Textbook of Ordinary Differential Equations, McGraw-Hill Education, New York,2017.
3.	G. F. Simmons and S. G. Krantz, Differential Equations: Theory, Technique and Practice, 3rd Edition, Chapman and Hall/CRC,Boca Raton, 2022.
4.	S. G. Krantz, Differential Equations: A Modern Approach with Wavelets, CRC Press, Boca Raton,2023.
5.	R. Magnus, Essential Ordinary Differential Equations, Springer,Berlin, 2023.

5.	**Additional Books**
1.	S. L. Ross, Introduction to Ordinary Differential Equations, Wiley,New York, 1991.
2.	M. Braun, Differential Equations and Their Applications, 4th Edition, Springer, Berlin,1993.

M.Sc.3rd Year (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.	
	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	plane statics.
2	equilibrium of system of particles.
3	Necessary conditions for equilibrium (moments).
4	applications in plane statics.
5	plane kinematics.
6	equations of motion of a particle.
7	principle of linear momentum for a system.
8	applications in plane dynamics.
9	applications in plane dynamics.
10	motion of rigid body.

4.	**Books Recommended:**
1.	N. C. Rana and P. C. Joag, Classical Mechanics*,* Tata McGraw-Hill,New Delhi, 25th Edition, 2017
2.	L. D. Landau and E. M. Lifshitz*,* Mechanics: Volume 1 (Course of Theoretical Physics*)*, 3rd Edition, Butterworth-Heinemann,Oxford, 2013.
3.	H. Goldstein, C. P. Poole, and J. L. Safko, Classical Mechanics, Addison Wesley,Boston, 3rd Edition, 2011
4.	R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw-Hill,New Delhi, 2010
5.	D. Morin, Introduction to Classical Mechanics: With Problems and Solutions, Cambridge University Press,Cambridge, 2010

M.Sc.3rd Year (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	demonstrate 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	choose 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.	
	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	basic concepts of probability.
2	random variables.
3	probability distributions: discrete and continuous.
4	Central limit theorem.
5	sampling.
6	interval estimation and confidence interval.
7	Maximum Likelihood Estimation..
8	correlation.
9	regression.
10	testing of hypothesis.

4.	**Books Recommended:**
1.	W. Mendenhall, R. J. Beaver and B. M. Beaver, Introduction to Probability & Statistics, 15th Edition, Cengage Learning,Boston, 2020.
2.	D. C. Montgomery, Applied Statistics and Probability for Engineers, 6th Edition, Wiley India Pvt Ltd.,New Delhi, 2016
3.	R. E. Walpole, R. H. Myers, S. L. Myers, and K. E. Ye, Probability & Statistics for Engineers & Scientists, 10th Edition, Pearson, Boston,2012.
4.	K. Black, Business Statistics: For Contemporary Decision Making, 10th Edition, Wiley,India 2019.
5.	C. M. Grinstead and J. L. Snell, Introduction to Probability, American Mathematical Society, 2nd Revised Edition, 2012.

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	utilize 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 will be based on
1	Introduction to Algorithms and Analysis Techniques
2	Amortized Analysis and Proof Techniques
3	Sorting Algorithms.
4	Divide and Conquer Techniques.
5	Dynamic Algorithms.
6	Searching Algorithms.
7	Backtracking Techniques
8	Graph-Based Algorithms.
9	Branch and Bound Technique.
10	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, 2nd Edition, Pearson Education,Boston, 2022.
3.	M. A. Weiss, Data Structures and Algorithm Analysis in C++ *by, 4th Edition, Pearson,Boston, 2013.*
4	A. Levitin, Introduction to the Design and Analysis of Algorithms by, 3rd Edition, Pearson,Boston, 2012.
5.	R. Sedgewick, K. Wayne, Algorithms, 4th Edition, Addison-Wesley,Boston, 2011.

5.	**Additional Books**
1.	S. Sahni, "Data Structures, Algorithms and Applications in C++," 2nd ed., Universities Press/Orient Longman,Hyderabad,India, 2005.
2.	S. Baase and A. Van Gelder, "Computer Algorithms: Introduction to Design & Analysis,",3rd edition, Addison Wesley,Boston,2002.

M.Sc.3rd Year (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 technique 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 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	HAM
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, Boca Raton,2011.
2.	A. D. Polyanin and V. F. Zaitsev, Handbook of Ordinary Differential Equations: Exact Solutions, Methods, and Problems, 3rdEdition, Chapman and Hall/CRC,Boca Raton,2017.
3.	S. Liao, Homotopy Analysis Method in Nonlinear Differential Equations, Springer-Verlag Berlin Heidelberg, 2012.
4.	W. Paulsen, Asymptotic Analysis and Perturbation Theory, CRC Press, Florida, 2013.
5.	M.H Holmes, Introduction to Perturbation Methods, Springer, New York, 2013.

5.	**Additional Books**
1.	J. B. Doshi, Analytical Methods in Engineering, 4th Edition, Narosa Publishing House,New Delhi, 1999.
2.	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.

M.Sc.3rd Year (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	analyze 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	Apply stochastic differential equations 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, Berlin,2010.
2.	P. Protter, Stochastic Integration and Differential Equations, Springer, 2nd Edition, Berlin,2012.
3.	I. Karatzas and S. E. Shreve, Methods of Mathematical Finance, 2nd Edition, Springer, Berlin,2016.
4.	Jean-François Le Gall, Brownian Motion, Martingales, and Stochastic Calculus, Graduate Texts in Mathematics, Springer,Switzwerland 2nd Edition, 2016.
5.	S. Watanabe and N. Ikeda, Stochastic Differential Equations and Diffusion Processes, North-Holland,Amsterdam 2014.

M.Sc. 3rd Year (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	categorize 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.	
	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,New Delhi, 3rd edition, 2024.
2.	B. Barnes and G. R. Fulford, Mathematical Modelling with Case Studies, Using Maple and MATLAB, 3rd Edition, CRC press,Boca Raton, 2015.
3.	D. T. Luc, Multiobjective Linear Programming an Introduction, Springer International Publishing Switzerland, 2016.
4.	Baoding Liu, Uncertainty Theory, Springer Berlin, Heidelberg, 2015.
5.	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, 2010.

M.Sc.3rd Year (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	analyze 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, Schwarz lemma.	
	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 residue theorem, Number of poles and zeroes of an analytic function, Cauchy's integral formula, Laurent's series, Open mapping theorem, Rouche's theorem, Evaluation of integrals of the type $\int_0 f(\sin\theta, \cos\theta)d\theta$, $\int_{-\infty} f(x)dx$, Improper real integrals of the form $\int_{-\infty} \cos(ax) f(x)dx$ and $\int_{-\infty} \sin(ax) f(x)dx$, Improper integrals with singular points on the real axis.	
	CONFORMAL MAPPINGS	**(09 Hours)**
	Introduction, Conformality Theorem, Mobiüs transformation, translation, rotation, inversion, cross-ratio, critical value of a transformation.	
	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	limit, continuity.
2	differentiability, Cauchy-Riemann equation.
3	analytic functions and harmonic functions.
4	contour integrals.
5	power series, Taylor's series.
6	Maximum/Minimum modulus principle, Schwarz lemma.
7	Singularities and Residues.
8	proper and improper integrations.
9	Conformal mapping.
10	Mobi$\ddot{u}$s transformation.

4.	**Books Recommended:**
1.	J. W. Brown and R. V. Churchill, Complex Variables and Applications, 9th Edition, McGraw-Hill Higher Education, New York,2021.
2.	H. S. Kasana, Complex Variables: Theory and Applications, 2nd Edition, PHI Learning Private Limited, Delhi, 2013.
3.	S. Ponnusamy, Foundations of Complex Analysis, ,2nd edition,Narosa, New Delhi,India, 2014.
4.	J. Bak and D. J. Newman, Complex Analysis, 3rd Edition, Springer, New York,2010.
5.	D. G. Zill and P. Shanahan, Complex Analysis: A First Course with Applications, 3rd Edition, Jones & Bartlett Learning,Burlington, 2014.

5.	**Additional Books:**
1.	A. R. Shastri, An Introduction to Complex Analysis, Macmillan India, New Delhi,1999.
2.	J. B. Conway, Functions of one Complex variable, Springer New York, International Student Edition, Narosa,New Delhi, India, 1995.

M.Sc.3rd Year (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 tensor relationship
CO3	solve problems in continuum theory.
CO4	illustrate the Material derivative concept in obtaining the basic equations of Continuum Mechanics.
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 summation conventions, 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 values Principal directions of symmetric second order tensors.	
	ANALYSIS OF STRESS	**(09 Hours)**
	The continuum concept, Homogeneity, Isotropy, Mass density, Body forces, surfaces forces, Cauchy stress principle; The stress vector, State of stress at a point, The stress tensor - stress vector relationship, Principal stresses, Stress invariants, Stress ellipsoid.	
	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, Elastic symmetry, Isotropic media, Elastic constants, Elastostatic problems, Elastodynamic problems	
	CLASSICAL FLUIDS	**(05 Hours)**

	Viscous Stress Tensor, Stokesian, and Newtonian Fluids, Relation between stresses and 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 will be based on**
1	basics of tensors.
2	operations of tensors.
3	introduction to stress.
4	the Cauchy's stress principle and the stress vector-stress tensor relationship.
5	deformation and strain.
6	material derivatives.
7	material derivative line, surface and volume integrals.
8	fundamentals of continuum mechanics.
9	Elasticity.
10	Stokesian and Newtonian fluids.

4.	**Books Recommended:**
1.	G. T. Mase and G. E. Mase, *Continuum Mechanics for Engineers*, 4th Edition, CRC Press,Boca Raton, 2020.
2.	J. W. Rudnicki, Fundamentals of Continuum Mechanics, John Wiley & Sons Ltd.,Chichester,UK,2015.
3.	J. N. Reddy, An Introduction to Continuum Mechanics with Applications, Cambridge University Press, 2nd edition, Cambridge,2013.
4.	X. Oliver and C. A. de-Saracibar, *Continuum Mechanics for Engineers: Theory & Problems*, 2nd Edition, CRC Press, Boca Raton, 2017.
5.	Y. J. Zhang, Computational Continuum Mechanics, Cambridge University Press,Cambridge, 2018.

5.	**Additional Books :**
1.	G. E. Mase, Theory and Problems of Continuum Mechanics, Schaum's Outline Series, McGraw Hill Book company,New York, 1970.

M.Sc.3rd Year (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	elaborate 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 expert systems, neural networks, fuzzy logic, robotics, natural language processing, and computer 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, Production systems, 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-structured representation of knowledge.	
	PRODUCTION SYSTEM	**(07 Hours)**
	Defining the problems as a state space search, Production systems, Production characteristics, 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 search algorithms, Sample applications, Measure of performance and analysis of search algorithms, Problem reduction, Constraint satisfaction, Means-ends analysis, Issues in 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 – Shafer theory, Symbolic logic under uncertainty : Non-monotonic reasoning, logics for non-monotonic reasoning, Statistical reasoning : Probability and Bayes theorem, Certainty factors, Probabilistic graphical models, Bayesian networks, Markov networks, 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 planning system, 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, Discourse and 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, 3rd Edition, Tata McGraw-Hill,New Delhi, 2017.
2.	S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 4rd Edition,Prentice Hall,Upper Saddle River 2022.
3	W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India,New Delhi,India, 2015.
4.	I. Bratko, Prolog Programming for Artificial Intelligence, 4rd Edition,Addison-Wesley,Boston, 2011
5.	Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media, Sebastopol,2019.

5.	**Additional Books:**
1.	N. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann,San Francisco, 1998.

M.Sc.3rd Year (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.	L. Debnath and F. Shah, Wavelet Transforms and Their Applications, Springer, New York, 2015.
3	Brian Davies, Integral Transforms and Their Applications, 3rd Edition, Springer, New York,2013.
4	K. B. Datta, Mathematical Methods of Science and Engineering: Aided with MATLAB, Cengage Learning,Stamford, 2013.
5.	Ali Akgül and Abdon Atangana, Integral Transforms and Engineering: Theory, Methods, and Applications, CRC Press,Boca Raton, 2023

5.	**Additional 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.

M.Sc. 3rd Year (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.	
	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	T. J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Wiley Publication, Hoboken,2011.
3	C. Mohan, An Introduction to Fuzzy Set Theory and Fuzzy Logic, Viva Books Private Limited, New Delhi,India,2nd edition 2020.
4.	G. J. Klir and B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, 3rd Edition, Springer, Switzerland, 2022.
5.	Rahul Kar et al.**,** Fuzzy Logic Applications in Computer Science and Mathematics, Scrivener Publishing, Beverly,2023.

5.	**Additional Books:**
1.	G. J. Klir, U. St. Clair and B. Yuan, Fuzzy Set Theory Foundations and Applications, PHI Inc. USA, 1997.
2.	D. Dubois and H. Prade, Fuzzy Sets and Systems: Theory and Applications, Academic Press, Cambridge, MA, 1980
3.	Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer, Berlin,Germany,2005.

M.Sc. 3rd 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	assess 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, 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	**(03 Hours)**
	Smart Contract Templates, Oracle, Smart Oracle, Deploying Smart Contract on Block chain.	
	PERMISSIONED BLOCKCHAIN	**(04 Hours)**
	Models and Use-cases, Design Issues, Consensus, Paxos, RAFT Consensus, By zantine 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**
1	Implementation of decentralization and 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.	**<u>Books Recommended:</u>**
1.	Imran Bashir, Mastering Blockchain, 3rd Edition, Packt publishing, Mumbai, 2020.
2.	Andreas Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, 2ndEdition, O'Reilly, Sebastopol,2015.
3.	Melanie Swan, Blockchain Blueprint for a New Economy, 1stEdition, O'Reilly Media,Sebastopol, 2015.
4.	Don and Alex Tapscott, Blockchain Revolution, 1stEdition, Penguin Books Ltd,London,UK, 2018.
5.	Alan T. Norman, Blockchain Technology Explained, 1stEdition, CreateSpace Independent Publishing Platform,North Charleston,2017.