NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF MATHEMATICS

Revised Curriculum and Syllabi for the Degree of 2 Yr. M. Sc. in MATHEMATICS

(To be effective from the batches admitted in the Academic Session 2020-2021 Onwards)
Revision Approved in PGAC meeting on 28/08/2020

Date: 28th August, 2020

COURSE CURRICULUM

SEMESTER-I

Sub. Code	Subject	L	T	P	Credit
MA1101	Complex Analysis	3	1	0	4
MA1102	Probability & Stochastic Processes	3	1	0	4
MA1103	Ordinary and Partial Differential Equations	3	1	0	4
MA1104	Linear Algebra	3	1	0	4
MA1105	Real Analysis	3	1	0	4
MA1151	Programming Languages Lab	0	0	6	4

TOTAL CREDIT - 24

SEMESTER-II

Sub. Code	Subject	L	T	P	Credit
MA2101	Integral Transforms and Integral Equations	3	1	0	4
MA2102	Functional Analysis	3	1	0	4
MA2103	Modern Algebra	3	1	0	4
MA2104	General Mechanics and Variational Calculus	4	1	0	3+2
MA2105	Numerical Analysis	3	1	0	4
MA2151	Numerical Analysis Lab	0	0	3	2

TOTAL CREDIT - 23

SEMESTER-III

Sub. Code	Subject	L	T	P	Credit
MA3101	Operations Research	3	1	0	4
MA3102	Graph Theory	2	1	0	3
MA3103	Fluid Dynamics	3	1	0	4
	Elective-I	3	1	0	4
	Elective-II	3	1	0	4
MA3151	Project and Seminar-I	0	0	3	3

TOTAL CREDIT - 22

SEMESTER-IV

Sub. Code	Subject	L	T	P	Credit
MA4101	Topology	3	1	0	4
MA4102	Generalized Functions and Wavelets	2	1	0	3
	Elective-III	3	1	0	4
	Elective-IV	3	1	0	4
MA4151	Project and Seminar-II	0	0	8	4
MA4153	Grand Viva	0	0	2	2

TOTAL CREDIT - 21

TOTAL COURSE CREDIT - 90

List of Electives

Sl. No.	Subject Code	Subject Name
1	MA9111	Geophysics
2	MA9112	Nonlinear Waves
3	MA9113	Mathematical Modeling
4	MA9114	Advanced Complex Analysis
5	MA9115	Advanced Modern Algebra
6	MA9116	Automata and Algorithms
7	MA9117	Differential Geometry
8	MA9118	Optimization Techniques
9	MA9119	Fuzzy Mathematics
10	MA9120	Nonlinear Analysis
11	MA9121	Advanced Operations Research
12	MA9122	Algebraic Coding Theory
13	MA9123	Dynamical Systems and Chaos Theory
14	MA9124	Computational Fluid Dynamics
15	MA9125	Soft Computing
16	MA9126	Cryptography
17	MA9127	Decision Theory
18	MA9128	Measure Theory
20	MA9129	Multivariate Statistical Analysis
21	MA9130	Commutative Algebra

SUMMARY OF COURSES

Sub Discipline: DEPARTMENTAL CORE

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER(S)
MA1101	COMPLEX ANALYSIS	3-1-0	4	Dr. M. F. Ali
MA1102	PROBABILITY & STOCHASTIC PROCESSES	3-1-0	4	Dr S. Maitra & Prof. S. Sarkar (Mondal)
MA1103	ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS	3-1-0	4	Dr. P. Pal & Dr P. P. Gopmandal
MA1104	LINEAR ALGEBRA	3-1-0	4	Dr P. Pal
MA1105	REAL ANALYSIS	3-1-0	4	Dr L. K. Dey
MA2101	INTEGRAL TRANSFORMS AND INTEGRAL EQUATIONS			Dr. A. Pal & Dr P. P. Gopmandal
MA2102	FUNCTIONAL ANALYSIS	3-1-0	4	Dr L. K. Dey
MA2103	MODERN ALGEBRA	3-1-0	4	Dr. S. Bagchi
MA2104	GENERAL MECHANICS AND VARIATIONAL CALCULUS	4-1-0	3+2	Dr. S. Maitra & Dr P. P. Gopmandal
MA2105	NUMERICAL ANALYSIS	3-1-0	4	Prof. S. Sarkar (Mondal) & Dr. A. Pal
MA3101	OPERATIONS RESEARCH	3-1-0	4	Dr S. Kar
MA3102	GRAPH THEORY	2-1-0	3	Dr A. Pal
MA3103	FLUID DYNAMICS	3-1-0	4	Dr. P. Pal & Dr P. P. Gopmandal
MA4101	TOPOLOGY	3-1-0	4	Dr L. K. Dey & Dr F. Ali
MA4102	GENERALIZED FUNCTIONS AND WAVELETS	3-0-0	3	Dr. S. Maitra

Sub Discipline: DEPARTMENTAL ELECTIVES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
MA 9111	GEOPHYSICS	3-1-0	4	Prof. S. Sarkar (Mondal)
MA9112	NONLINEAR WAVES	3-1-0	4	Dr. S. Maitra
MA9113	MATHEMATICAL MODELING	3-1-0	4	Dr. S. Maitra
MA9114	ADVANCED COMPLEX ANALYSIS	3-1-0	4	Dr. M. F. Ali
MA9115	ADVANCED MODERN ALGEBRA	3-1-0	4	Dr L. K. Dey
MA9116	AUTOMATA AND ALGORITHMS	3-1-0	4	Prof. S. Kar & Dr. G. Panigrahi
MA9117	DIFFERENTIAL GEOMETRY	3-1-0	4	Dr L. K. Dey
MA9118	OPTIMIZATION TECHNIQUES	3-1-0	4	Prof. S. Sarkar (Mondal)
MA9119	FUZZY MATHEMATICS			Prof. S. Kar
MA9120	NONLINEAR ANALYSIS	3-1-0	4	Dr L. K. Dey
MA9121	ADVANCED OPERATIONS RESEARCH	3-1-0	4	Prof. S. Kar
MA9122	ALGEBRAIC CODING THEORY	3-1-0	4	Dr S. Bagchi
MA9123	DYNAMICAL SYSTEMS AND CHAOS THEORY	3-1-0	4	Dr. P. Pal
MA9124	COMPUTATIONAL FLUID DYNAMICS	2-0-2	4	Dr. P. P. Gopmandal
MA9125	SOFT COMPUTING	3-1-0	4	Dr. S. Kar
MA9126	CRYPTOLOGY	3-1-0	4	Dr. S Bagchi
MA9127	DECISION THEORY	3-1-0	4	Dr. G. Panigrahi
MA9128	ADVANCED STATISTICAL ANALYSIS	3-1-0	4	Prof. S. Kar
MA9129	MEASURE THEORY	3-1-0	4	Dr L. K. Dey
MA9130	MULTIVARIATE STATISTICAL ANALYSIS	3-1-0	4	Prof. S. Kar
MA9131	COMMUTATIVE ALGEBRA	3-1-0	4	Dr S. Bagchi

Sub Discipline: LABORATORY & SESSIONAL COURSES

MA1151	PROGRAMMING LANGUAGES LAB	0-0-6	4
MA2151	NUMERICAL ANALYSIS LAB	0-0-3	2

Sub Discipline: PROJECT, SEMINAR etc.

MA3151	PROJECT and SEMINAR - I	0-0-6	3
MA4151	PROJECT and Seminar-II	0-0-8	4
MA4153	GRAND VIVA	0-0-2	2

SYLLABUS

SEMESTER-I

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA1101	Complex Analysis	PCR	3	1	0	4	4
Prerequisite		Basic concepts of Real Analysis.					
Course Outcomes		Upon successful completion of this course students will be able to: • CO1: understand when and where a given function is analytic and be able to find it series development; • CO2: understand basic properties of complex integration and acquire the skill of contour integration to evaluate complicated real integrals via residue calculus; • CO3: describe conformal mappings between various plane regions and its application.					

Course Content	**No. of lectures**
Topology of the complex plane, limits, continuity, stereographic projection, elementary complex functions, linear fractional transformations.	10
Differentiability, Analytic function, Cauchy-Riemann equations, harmonic functions, power series, radius of convergence, differentiation of power series.	10
Curves, complex line integrals, Cauchy's Theorem, winding number, Cauchy's integral formula, Morera's theorem.	10
Cauchy's inequality and its applications, Liouville's theorem, identity theorem, maximum modulus principle, Schwarz lemma.	10
Taylor's Theorem, Laurent's series, singularities, classification of singularities, Casorati-Weierstrass theorem, Cauchy's Residue theorem, Evaluation of real integrals.	10
Argument principle, Rouche's theorem, open mapping theorem, conformal mappings.	6
Total Number of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Complex Variables with Applications	S. Ponnusamy and H. Silverman	Birkhauser, Boston	2006
2	Complex Analysis	T. W. Gamelin	Springer	2001
3	Complex Variables and Applications	J. W. Brown and R. V. Churchill	McGraw Hill	2008

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Complex Analysis	L. V. Ahlfors	McGraw-Hill	1979
2	Functions of one Complex Variable	J. B. Conway	Springer-Verlag	1978
3	Theory of functions of a complex variable (Vol- I & II)	A. I. Murkushevich	Prentice-Hall Inc.	1965

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total hours per week	
MA1102	Probability & Stochastic Processes	PCR	3	1	0	04	04
Prerequisite		Knowledge of probability at 10+2 level					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand the concept and identify the field of application of probability. CO2: apply the knowledge of probability in real life problem solving CO3: know basics of stochastic processes CO4: identify the applications of Markov processes, random walks, Poisson processes.					

Course Content	**No. of lectures**
Probability: Historical development of the subject and basic concepts, important terminologies, definitions.	3
Random variables, distribution and density functions, discrete probability distributions- binomial and multinomial distribution, negative binomial distribution. Geometric distribution, hypergeometric distribution, Poisson distribution, continuous probability distribution – normal distribution, Beta & gamma distribution, exponential distribution, chi-squared and Weibull distribution, joint and marginal distribution, conditional distribution.	12
Mathematical Expectation: Mean of random variable, variance and covariance, means and variances of linear combinations of random variables.	5
Distribution of sum of independent random variables, convergence of a sequence of random variables, convergence in distribution, convergence in probability, convergence in L^p, law of large numbers, Tchebychev inequality.	8

Stochastic Processes: Description & Specification of Stochastic Process, Stationary Processes, Martingales.	4
Markov Chains: Definitions, Chapman-Kolmogorov Equations & classification of states, Applications of Markov chains, Time reversible Markov chains.	6
Poisson Process: Poisson Process, Inter-arrival & waiting time distributions, Non-homogeneous Poisson Process, Conditional Poisson process.	4
Continuous time Markov chains: Continuous time Markov chains, Birth &Death Processes, Kolmogorov differential equations, Randomization.	4
Random walks: random walks in one and two dimensions and the properties	4
Markov Processes with continuous state space: Brownian motion, wiener process, differential equations for a wiener process, Kolmogorov equations	6
Total	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Probability and Statistics for Engineers and Scientists	Walpole, Myers, Myers, and Ye	Pearson	2012
2	Introduction to probability	C. Grinstead and J. Snell	American Mathematical Society	1997
3	Probability and stochastic processes	Roy D Yates and David J. Goodman	John Wiley and Sons	1998

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Stochastic processes	J. Medhi	New Age International Publishers	2008
2	Introduction to probability and statistics	Mendenhall, Beaver, and Beaver	Cengage Learning	2012

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA1103	Ordinary and Partial Differential Equations	PCR	3	1	0	4	4
Prerequisite		Void					
Course Outcomes		Upon successful completion of this course students will be able to understand: CO1: fundamentals of initial and boundary value problems					

	CO2: properties of Bessel functions and Legendre polynomials and their applications CO3: basic existence and uniqueness theorems initial and boundary problems CO4: techniques to solve the problems and applications of Ordinary Differential Equations and Partial Differential Equations

Course Content	**No. of lectures**
Ordinary Differential Equations (ODE)	
Review of solution methods for first order as well as second order equations: Existence and Uniqueness of solution, Initial Value Problems, Existence and Uniqueness theorem, Lipschitz condition. Series solution around ordinary point and a regular singular point, Bessel functions and Legendre polynomials.	14
Higher Order Linear Equations and linear Systems: Fundamental solutions, Wronskian, variation of constants, matrix exponential solution, and behavior of solutions.	2
Boundary Value Problems for Second Order Equations: Green's function, Sturm Liuville problems, Perturbation theory for two-dimensional linear system.	12
Partial Differential Equations (PDE)	
Review of First order PDE: Linear, semi-linear, quasi-linear and non-linear equations, Cauchy Problems for First Order Hyperbolic Equations: Lagrange method, Charpit method, Method of characteristics, Monge cone	5
Second order PDE: Classification, Characteristics, and Canonical forms of equations in two independent variables, Well-posed problems	3
Laplace equation: Mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using Perron's method (without proof)	6
Wave equation: D'Alembert solution, spherical means. Initial-boundary value problems on bounded domains, and well-posedness. Uniqueness via Energy method, method of spherical means and Duhamel's principle	6
Heat equation: Initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results	5
Separation of variables method: for Wave, Lapalce, Heat equations	3
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Differential Equations	Shepley L. Ross	Wiley	1984
2	Differential Equations with Applications and Historical Notes	George Simmons	CRC Press	2017
3	Partial Differential Equations, Graduate Studies in Mathematics	L. C. Evans	AMS	1998
4	Elements of Partial Differential Equations	I. N. Sneddon	Dover Publications	2006

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Nonlinear Ordinary Differential Equations	D. W. Jordan, and P. Smith	Oxford University Press	1999
2	Partial differential equations	F. John	Springer	1982
3	Partial differential equations: An introduction	W. Strauss	Wiley	2008

Department of Mathematics

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA1104	Linear Algebra	PCR	3	1	0	4	4
Prerequisite		Elementary ideas of algebraic structures.					
Course Outcomes		Upon successful completion of this course students will be able to understand: CO1: basic properties of linear transformations CO2: various normal forms of linear operators and its applications CO3: basic properties of inner product spaces and its applications CO4: fundamentals of bilinear forms					

Course Content	**No. of lectures**
Vector Spaces: Review of vector spaces over fields, subspaces, bases and dimension. Systems of linear equations, matrices, rank, and Gaussian elimination method.	4
Linear transformations: Definition, the algebra of linear transformation, Rank of a linear transformation, matrix representations, change of a basis, rank-nullity theorem, linear functional, and dual spaces.	6
Linear Operators: Brief review, Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, Invariant Subspaces, and Cayley-Hamilton Theorem.	6
Canonical Forms: Similarity of linear transformations, Triangular Forms and Diagonal Forms, Direct-sum Decomposition, Invariant Direct Sums, and The Primary Decomposition Theorem. Jordan Blocks and Jordan Forms, and Rational Canonical Form.	12
Introduction to the MATLAB software for solving linear algebra problems (Systems of ODE)	7
Inner Product Spaces: Inner products, Inner product spaces, linear functionals and Adjoints, Unitary Operators, Normal Operators.	6
Operators on Inner Product Spaces: Introduction, Forms on Inner Product Spaces, Positive Forms, Spectral Theory	9
Bilinear forms: Symmetric and skew-symmetric bilinear forms, Groups Preserving Bilinear Forms	6
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Linear Algebra	K. Hoffman and R. Kunze	Prentice Hall of India	2004
2	Linear Algebra	S. H. Fridberg, A. J. Insel and L.E. Spence	Pearson India	2015
3	Linear Algebra and its Applications	G. Strang	Thomson Learning Asia Pvt Ltd	2003

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Finite Dimensional Vector Spaces	P. Halmos	Springer-Verlag	1987
2	Advanced Linear Algebra	S. Roman	Springer	2005

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA1105	Real Analysis	PCR	3	1	0	4	4
Prerequisite		Elementary ideas of real valued functions of single variables.					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand the basics of real analysis and measure theory CO2: master basic concepts from measure theory, including sets of measure zero, measurable functions, the Lebesgue integral and Lebesgue spaces CO3: understand and apply the notions of convergence involving sequences of functions, including the difference between point wise and uniform convergence CO4: understand and apply integration theory in one or several variables to formulate and solve problems in mathematics and technology.					

Course Content	**No. of lectures**
Convergence Theorems: Point wise and Uniform convergence, Dini's Theorem, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Approximation of a continuous function by Polynomials: Weierstrass theorem.	10
Functions of Bounded Variation: Definitions, basic properties and geometrical meaning of functions of bounded variation, continuity, differentiability and Riemann integrality of functions of bounded variation, total variation, Jordan's theorem.	4

Riemann Integral: Riemann integral and its properties, characterization of Riemann integrable functions. Riemann-Lebesgue Lemma, Drawbacks of Riemann Integral, Lebesgue's recipe, Riemann-Stieltjes integral.	12
Lebesgue Measure: Ring and σ-ring generated by a class of sets, Monotone class of sets, Monotone class generated by a ring, Borel Sets. Outer Measure and Measurable Sets, construction of a nonmeasurable set, Lebesgue measure onR^n, Measure space, Measurable Functions	14
Lebesgue Integral: Integrating Bounded Measurable Functions, Criteria for Integrability and Properties of the Lebesgue Integral, Integral of Nonnegative Simple Measurable Functions, Properties of Nonnegative Simple Measurable Functions, Monotone Convergence Theorem and Fatou's Lemma. Properties of Integrable Functions and Dominated Convergence Theorem, Integration on Product Spaces, Fubini's Theorems, Lebesgue integral as limits, Comparison of Lebesgue and Riemann Integrals.	16
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Real Mathematical Analysis	Charles Chapman Pugh	UTM, Springer International Publishing	2015
2	Real Analysis	N.L. Carothers	Cambridge University Press	2018

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Principles of Real Analysis	Aliprantis C. D., Burkinshaw O.	3rd Edition, Harcourt Asia Pte Ltd.	1998
2	Real Analysis-Theory of Measure and integration	J Yeh	World Scientific	2014

Department of Mathematics

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA1151	Programming Languages Lab	PCR	0	0	6	6	4
Prerequisite		Fundamental ideas about computer and programming					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: Understand basics of programming and program development lifecycle; CO2: Understand the control flow of execution and various program structures; CO3: Able to write programs on data storage management using c and c++.					
Course Content							**No. of**

	Lab classes
Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart drawing.	10
Handling the C character set, identifiers and keywords, data type & sizes, variable names, declaration, statements.	8
Use of Operators & Expressions in programming**:** Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf.	10
Implementations of Flow of Control in C and C++: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels.	10
Implementations of Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register variables, scope rules, recursion, function prototypes, C preprocessor, command line arguments.	12
Implementations of the concepts of arrays and pointers: One dimensional arrays, pointers and functions, multidimensional arrays.	10
Writing programs on Structures, Union and Files: Basic of structures, structures and functions, arrays of structures, bit fields, formatted and unformatted files.	10
Implementations of basic Data Structures like Arrays, Stacks Queues, Searching & Sorting Algorithms using C and C++.	6
Implementations of the concepts of trees using C and C++: Traversals in a tree, Binary Search tree, B + tree, B tree.	8
Total Number of Lab Classes	84

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Computer Programming in C,	V. Rajaraman	Prentice Hall of India	1994
2	Data Structures	Seymour Lipschutz	McGraw-Hill	1986

Reference Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Basic Computation and Principles of Computer Programming	E. Balagurusamy	TMH.	2010

SEMESTER-II

<table>
<tr><th colspan="8">Department of Mathematics</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MA2101</td><td>Integral Transforms and Integral Equations</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Prerequisite</td><td colspan="6">--</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">Upon successful completion of this course students will be able to:
CO1: understand various types of Integral Transformations and Integral Equations and related application in applied mathematics and theoretical physics
CO2: learn different methods to solve Integral Equations
CO3: solve various physical problems by integral transforms and integral equation methods
CO4: Learn to apply various transformation to solve ODE and PDE</td></tr>
<tr><th colspan="7">Course Content</th><th>No. of lectures</th></tr>
<tr><th colspan="8">Integral Transforms</th></tr>
<tr><td colspan="7">Fourier Integrals and Fourier Transforms: Fourier Integral Representation, Fourier Integral Theorem, Different forms of Fourier Integrals, Fourier Transform and Inverse of Fourier Transform, Fourier Sine and Cosine transforms and their inverse Transforms, Complex Fourier Transform and its inversion formula, Properties of Fourier Transform, Fourier Transforms for functions of many variables, Perseval’s Relations. Application to ODE & PDE.</td><td>12</td></tr>
<tr><td colspan="7">Laplace Transforms: Definition of Laplace Transform, Existence Theorem, Properties of Laplace Transform, Laplace Transform of Derivatives, Laplace Transform of Integrals, Special techniques for finding Laplace Transform, Inverse of Laplace Transform, Properties of Inverse Laplace Transforms, Partial Fraction method for finding the Inverse of Laplace Transform, Application to ODE.</td><td>12</td></tr>
<tr><td colspan="7">Henkel Transform: Properties of Henkel Transform, Evaluation of Henkel Transform.</td><td>4</td></tr>
<tr><td colspan="7">Mellin Transform: Properties of Mellin Transform, Evaluation of Mellin Transform.</td><td>4</td></tr>
<tr><td colspan="7">Z – Transform: Definition of Z- transform, Properties of Z – Transform, Z – Transform of some standard functions, Theorems on Z – transform, Differentiation, Convolution Theorem, Inverse Z – Transform and different methods for finding Inverse Z – transforms.</td><td>4</td></tr>
<tr><th colspan="8">Integral Equations</th></tr>
<tr><td colspan="7">Introduction to Linear integral equations, Formation of Integral equations and classification Volterra integral equations, Fredholm integral equations, conversion of initial and boundary value problems to an integral equation</td><td>4</td></tr>
<tr><td colspan="7">Various types of kernels: Symmetric kernel, Separable kernel, Iterated kernel, resolvent kernel, Solution of Volterra integral equation using: Resolvent kernel, Successive approximation, Neumann series method. Cauchy kernel, Abel Equation</td><td>4</td></tr>
</table>

Fredholm integral equations, Fredholm equations of the second kind, the method of Fredholm determinants, iterated kernels, integral equations with degenerate kernels, eigen values and eigen functions of a Fredholm alternative, construction of Green s function for BVP, singular integral equations.	12
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Linear Integral Equations, Theory and Technique	R. P. Kanwal	Academic Press	1971
2	Linear Integral Equations	S.G. Mikhlin	Routledge	1961
3	The Uses of Integral Transforms	I.N. Sneddon	McGraw-Hill.	1972

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Linear Integral Equations	W. V. Lovitte	Dover Publications	2005
2	Integral Transforms for Engineers	Andrews, Shivamoggi	PHI	2003
3	Integral Transforms	C. J. Tranter	Methuen & Co	1962

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA2102	Functional Analysis	PCR	3	1	0	4	4
Prerequisite		Real Analysis and elementary metric spaces					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand the fundamental properties of metric spaces and normed linear spaces and also learn the important properties of operators CO2: understand and apply the four fundamental theorems of functional analysis CO3: understand the fundamentals of spectral theory, and appreciate some of its power.					

Course Content	**No. of lectures**
Metric space: Definitions and examples; spaces like $l^p, l^\infty, C[a,b]$. Continuity and equivalent metrics, compactness, Cauchy sequences, completeness and completion of metric space, Baire Category Theorem and its application.	10
Banach Spaces and Fundamental Theorems: Normed Linear Spaces, Banach Spaces, Equivalent Norms, Finite dimensional normed linear spaces, Riesz Lemma, Banach's Fixed Point Theorem and its applications. Bounded Linear Transformations, Normed linear spaces of bounded linear transformations, Uniform Boundedness Theorem, Open Mapping Theorem, Closed Graph Theorem, Linear Functionals, Hahn-Banach Theorem, Dual Space, and Reflexivity of Banach Spaces.	20
Hilbert Spaces: Real Inner Product Spaces and its Complexification, Cauchy-Schwarz Inequality, Parallelogram law, Pythagorean Theorem, Hilbert Spaces, Orthonormal Sets, Complete Orthonormal Sets, Structure of Hilbert Spaces, Orthogonal Complement and Projection Theorem.	16
Operators: Riesz Representation Theorem, Adjoint of an Operator on a Hilbert Space, Reflexivity of Hilbert Spaces, Self-adjoint Operators, Positive Operators, Projection Operators. Spectral Theory-Point Spectrum, Invertible Operator, Resolvent and Spectrum.	10
Total Number of Lectures	**56**

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Introductory Functional Analysis with Applications	Kreyszig, E.	John Wiley and Sons, New York	1889
2	Foundations of Functional Analysis	Ponnusamy, S.	Narosa Publishing House	2017

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	A Course in Functional Analysis,	Conway, J. B.	Springer Verlag, New York,	1990
2	First Course in Functional Analysis	Goffman, C. and Pedrick, G.	Prentice Hall of India, New Delhi,	1987

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA2103	Modern Algebra	PCR	3	1	0	4	4
Prerequisite		Elementary ideas of algebraic structures.					
Course Outcomes		Upon successful completion of this course students will be able to:					

	CO1: Explain the fundamental concepts of modern algebra such as groups and rings and their role in modern mathematics and applied contexts; CO2: Demonstrate accurate and efficient use of modern algebraic techniques; CO3: Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from modern algebra; CO4: Apply problem-solving using modern algebraic techniques applied to various situations in engineering, physics and other mathematical contexts.

Course Content	**No. of lectures**
Preliminary concept: Sets and Equivalence relations and partitions, Division algorithm for integers, primes, unique factorizations, Chinese Remainder Theorem, Euler ϕ-function.	8
Groups: Cyclic groups, Permutation groups, Isomorphism of groups, Cosets and Lagrange's Theorem, Normal subgroups, Quotient groups, Group Homomorphisms, Cayley's Theorem, Group Action, Cauchy's Theorem, Sylow Theorems and their applications.	16
Rings: Ideals and Homomorphism, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Polynomial and Power Series Rings.	12
Divisibility Theory: Euclidean Domain, Principal Ideal Domain, Unique Factorization Domain.	10
Fields: Field extensions, Algebraic extensions, Finite Fields.	10
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Abstract Algebra Theory and Applications	Thomas W. Judson	Orthogonal Publishing	2019
2	Contemporary Abstract Algebra	G. A. Gallian	Narosa Publishers	2013

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Algebra	T. W. Hungerford	Springer	2009
2	Abstract Algebra	D. S. Dummit and R. M. Foote	John Wiley & Sons, Inc.	1999
3	Fundamentals of Abstract Algebra	D. S. Malik, J. N. Mordeson and M. K. Sen	McGraw-Hill	1997

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA2104	General Mechanics and Variational Calculus	PCR	4	1	0	5	5
Prerequisite		--					

Course Outcomes	Upon successful completion of this course students will be able to understand: CO1: Inertial and non inertial reference frames; Parameters defining the motion of mechanical systems and their degrees of freedom; CO2: the fundamental concept of Lagrangian and Hamiltonian concept to study the motion of rigid body, dynamics of system of particles; CO3: the basics of Quantum and Continuum mechanics; CO4: the theory of optimizing a functional & apply the formula that determines stationary paths of a functional to deduce the differential equations for stationary paths in various cases.

Course Content	**No. of lectures**
General Mechanics	
Moving coordinates systems, Gallilean transformation, inertial and noninertial frames of reference. Constrained motions in Cartesian coordinates, Principle of virtual work, D'Alembert's principle. Degrees of freedom, generalized coordinates. Lagrange's formulation in generalized coordinates, generalized forces, cyclic coordinates, Lagrange's formulation in generalized coordinates, generalized forces, cyclic coordinates	12
Canonically conjugate coordinates and momenta, Legendre transformation, Hamiltonian. Principle of least action, Hamilton's principle, Hamilton's equations of motion, Two body central force problem, Symmetry properties and conservation laws, Noether's theorem .	8
Canonical Transformation, Generating function, Poisson bracket, Identities on Poisson brackets, Hamilton-Jacobi theory, Solution of the Hamilton –Jacobi equation .	10
Planck's law, Photo electric effect, Bohr's theory, Compton effect, de Broglie waves; Wave-particle dualism, Uncertainity Principle, Path integrals, Fundamental laws and foundation of quantum mechanics. Schrodinger equation.	9
The Continuum hypothesis, Analysis of strain and stress; Concepts of body forces/surface forces, Stress- strain relations	5
Variational Calculus	
Variation and its Properties: Euler's equation, Brachistochrone problem, shortest distance between two points, Curves of minimum arc of surface of revolution.	4
Geodesics: Geodesics in spherical polar and cylindrical coordinates, Functional dependent on higher order derivatives, Variational problems involving several unknown functions, Functional involving several independent variables-Ostrogradsky equation, Optimization under constraints and Lagrange multipliers.	10
Isoperimetric Problems: Isoperimetric problems involving constraints as functional Variational problems with moving boundaries, Transversality conditions.	4
Lagrange's Equations: Lagrange's equations for dynamical systems, Hamilton's principle, Sturm-Lioville's problem and variational methods, Raleigh's principle, Direct methods of Ritz and Kantorovich methods, Applications.	10
Total Number of Lectures	70

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Classical Mechanics	H. Goldstein,	Narosa Publication	1998
2	Differential equations and the calculus of variations	L. Elsgolts,	MIR Publication, Moscow	1977
3	Introduction to Quantum Mechanics	David Griffiths	Pearson	2015

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Mechanics	L. Landau, E. Lifshitz	Pergamon Press	1969
2	Calculus of Variations with applications	A. S. Gupta	Prentice-Hall of India Pvt. Ltd.	2004
3	Quantum Mechanics	F. Schwable	Springer	2007

Department of Mathematics

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA2105	Numerical Analysis	PCR	3	1	0	4	4
Prerequisite		Elementary ideas of functions, differentiation and integration					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: Understand various interpolation formula and applications CO2: Understand and apply linear polynomial geometric curve fitting CO3: Solve system linear and non- linear equations, Eigen value problems, ODE, PDE					

Course Content	No. of lectures
Finite Difference: Symbolic operators and their relations.	4
Interpolation: Central difference formulae of Gauss, Stirling formula, Bessel formula, Cubic spline interpolation.	6
Approximation of function: Curve fitting by least square method (linear, polynomial, geometric, etc.), Chebyshev polynomial and Minimax property, Use of orthogonal polynomials,Gram-Schmidt orthogonalisation method, Economization of power series.	6
Numerical integration: Newton-Cotes formulae-open type, Newton-Cotes formulae-closed type, Romberg integration, Gaussian quadrature: Gauss-Legendre and Gauss-Chebyshev quadratures, Comparison of Newton-Cotes and Gaussian quadratures.	8

Solution of non-linear equations: Root of a polynomial by Birge-Vieta method, Graeffe's root squaring method, System of non-linear equations: fixed point method and Newton-Raphson methods, Convergence and rate of convergence.	6
Solution of a system of linear equations: Matrix inverse by partial and complete pivoting, LU decomposition method, Solution of tri-diagonal system of equations, Ill-conditioned linear systems, Relaxation method.	6
Eigenvalue problem: Power method to find largest eigenvalue of eigenvector, Jacobi's method to find eigenvalues and eigenvectors of a symmetric matrix.	6
Solution of ordinary differential equation: Runge-Kutta method (second and fourth order methods), Runge-Kutta method to solve a system of equations, Runge-Kutta method to solve second order IVP, Single step and multi-step methods, Predictor-corrector method: Milne's method, Adam-Moulton method, Solution of second order boundary value problem by finite difference method, Stability analysis, Finite element method to solve BVP.	8
Partial differential equation: Finite difference scheme, Parabolic equation: Crank-Nicolson method, Elliptic and hyperbolic equations: iteration method.	6

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Numerical Mathematical Analysis	Jsames B. Scarbarough	Oxford University Press	1930
2	Introductory Methods of Numerical Analysis	S.S. Sastry	Prentice Hall of India	2005

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Numerical Methods for Ordinary Differential Equations	David F. F. Griffiths, Desmond J. Higham	Springer	2010
2	Numerical Methods for Scientists and Engineers	R. W. Hamming	Dover Publications	1987

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA2151	Numerical Analysis Lab.	PCR	0	0	3	3	2
Prerequisite		Ideas about C and C++ Programming and numerical methods					

Course Outcomes	Upon successful completion of this course students will be able to: CO1: Understand basics of C and C++ programming; CO2: Able to prepare the flow charts for different numerical methods; CO3: Able to write programs on different numerical methods using C and C++.

Course Content	**No. of Lab classes**
Solution of system of linear equations by Matrix inversion, Gauss elimination, L-U decomposition methods, Jacobi's method, Gauss-Seidel iterative method.	9
Solution of Algebraic and Transcendental equations by Iteration method, Newton Raphson Method, Graeffe's root squaring method.	6
Determination of Eigen value, Eigen vectors by Power method.	4
Interpolation: - Newton's forward and backward interpolation, Lagrange's interpolation, Central difference interpolation, cubic spline interpolation.	9
Numerical integration by Trapezoidal rule, Simpson's 1/3rd rule, Romberg's integration, Gaussian quadratures.	6
Solution of ODE by Runge-kutta method and Milne's Predictor- corrector method.	4
Solution of PDE by finite difference method.	4
Total Number of Lab Classes	42

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Computer Programming in C,	V. Rajaraman	Prentice Hall of India	1994

2	Numerical Recipes in C++, The art of scientific computing	William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery.	Cambridge University Press	2002 (2nd edition)

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Basic Computation and Principles of Computer Programming	E. Balagurusamy	Tata McGraw-Hill	2010

SEMESTER-III

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 3101	Operations Research	PCR	3	1	0	4	4
Prerequisite		Elementary ideas of linear algebra, Probability and numerical methods					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: Extension of linear programming algorithms, different types programming techniques for linear programming problems. CO2: The concept of deterministic inventory problems and apply the knowledge to solve real-life problems. CO3: The theory of Game and Bimatrix game and solution methodologies. CO4: The basics of network analysis, model developments and solution methodologies.					

Course Content	No. of lectures
Extension of Linear Programming: Revised Simplex, Bounded Variables, Dual Simplex, Sensitivity Analysis.	12
Integer Programming: Branch and bound algorithm, Cutting plane methods for pure and mixed Integer programming problems, Knap-sack problem, travelling salesman problem.	06
Stochastic Programming: Chance constrained programming technique, Stochastic linear programming, Stochastic non-linear programming, Two stage programming technique.	06
Dynamic Programming: Bellman's principle of optimality and recursive relationship of dynamic programming for various optimization problems.	06
Deterministic Inventory Management: Concept of inventory and various inventory parameters, EOQ formula, EOQ with quantity discount, Multi-item Inventory and Multiple	06

Constraints, Inventory with deterministic non-constant demand rate, Concept of Lead time, safety stock and service level.	
Game Theory: Maxmin and Minmax principle, two –person Zero-sum games with saddle point. Game problems without saddle point, Pure strategy, Solution of a 2 × 2 game problem without saddle point, Graphical method of solution for n ×2 and 2 ×n game problem, Reduction rule of a game problem(Dominance rule), Algebraic method of solution of game problem without saddle point, Reduction of a game problem to linear programming problem. Bimatrix games: LCP formulation, Lemke's salgorithm for solving bimatrix.	10
Network Analysis: Introduction to network analysis, Shortest path problem, Construction of minimal spanning tree, Flows in networks, Maximal flow problems. Definition of a project, Job and events, Construction of arrow diagrams, Determination of critical paths and calculation of floats. Resource allocation and least cost planning, Use of network flows for least cost planning. Uncertain duration and PERT, PERT COST system. Crashing, Updating (PERT and CPM).	10

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Operations Research-Theory and applications	J.K. Sharma	Macmillan	2006
2	Operations Research-Principals and practice	Ravindran, Philips, Solbery	John Wiley & Sons	2013
3	Game Theory an Introduction	E.N.Barron	John Wiley & Sons	2010

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Operations Research	F.S. Hiller & G.J. Leiberman	Gc Graw Hill	2000
2	Introduction to Linear and Nonlinear Programming	D. G. Luenberger	Addison Wesley	1973

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA3102	Graph Theory	PCR	3	0	0	3	3
Prerequisite		NIL					

Course Outcomes	Upon successful completion of this course students will be able to: CO1: understand various kind of Graphs and its properties CO2: learn the properties of trees, planar Graphs and non planar graphs CO3: understand application of Graphs in various fields

Course Content	No. of lectures
Graphs: Definition of graph, Basic terminology, Directed graphs and weighted graphs, Types of graphs, Graph isomorphism, Sum and product of graphs, Components, Connected and disconnected graphs, Euler path, Euler circuit and Euler theorem, Hamiltonian path and circuit.	4
Trees: Definition, Properties of trees, Distance, radius, diameter and centre of graphs and trees, Binary tree, Binary tree traversal, Application.	6
Planar graphs: Definition, Planar and non-planar graphs, Kuratowaski's two graphs, Homeomorphic graphs, Geometric and combinatorial duals, Applications of planar graphs.	6
Cut-set and cut-vertices: Definition of cut-set and cut-vertices, Rank and nullity, Fundamental circuits and fundamental cut-sets, Connectivity and separability, Cut-edge and bridge,Network flow problem, Applications.	8
Colouring and Matching: Definition, Chromatic number and Chromatic polynomial, Bipartite graph, Chromatic partitioning, Matching and its application, Covering, Five-colour and Four-colour theorems, Applications.	6
Graph Algorithms: Matrix representation of graphs, Shortest path algorithms: Dijkstra and Floyd's algorithms, Spanning tree and minimum spanning tree, Prim's and Kruskal's algorithms to find spanning tree, Binary tree traversal, DFS and BFS of a graph.	6
Intersection graphs: Interval graph, Circular-arc graphs, Permutation graphs, Trapezoid graphs, Chordal graphs, Applications.	4
Applications of graphs: in Computer Science, Operations Research, Chemistry, Planning, Biological Sciences.	2

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Graph Theory	B. West Douglas	Prentice Hall of India	2001
2	Graph Theory With Applications to Engineering & Computer Science	Narsingh Deo	Prentice Hall of India	1979
3	A Text Book of Graph Theory	R. Balakrishnn, K. Ranganathan	University Text	2000

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Model Graph Theory	Bela Bollobas	Springer	1998
2	Algorithmic Graph Theory & Par fact Graphs Advanced Linear Algebra	M.C. Golumbic	Elsevier	1980

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA3103	Fluid Dynamics	PCR	3	1	0	4	4
Prerequisite		MA 2104: Ordinary and Partial Differential Equations					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand the properties of fluids and the applications of fluid mechanics CO1: derive basic governing equations of both inviscid and viscous fluid flows CO2: analyze simple fluid flows like flow past rigid cylinder, sphere, Couette flow, Poiseuille Flow etc. CO3: understand basics of dimensional Analysis and boundary layer theory.					

Course Content	**No. of lectures**
Review of gradient, divergence and curl. Elementary idea of tensors.	6
Kinematics of Fluids in Motion: Continuum Hypothesis, Lagrangian and Eularian description; Velocity of fluid, Streamlines, path lines, streak lines, Steady and unsteady flows, Velocity potential, Vorticity vector, Equation of continuity, Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid, Euler's equation of motion, Bernoulli's equation.	14
Singularities of flow, Source, Sink, Doublets, Rectilinear vortices. Complex variable method for two-dimensional problems, Complex potentials for various singularities, Circle theorem, Blasius theorem, Theory of images and its applications to various singularities.	12
Three dimensional flow, Irrotational motion, Weiss's theorem and its applications. Viscous flow, Vorticity dynamics, Vorticity equation, Stress and strain analysis, Navier-Stokes equation, Some solutions of Navier-Stokes equations (Couette flow, Poiseuille Flow).	16
Dimensional Analysis, Reynolds number, Boundary layer Equations.	8
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	A Text Book of Fluid Dynamics	F. Chorlton	Von Nostrand Reinhold/CBS	1985
2	Fluid Mechanics	P. K. Kundu, I. M. Kohen, and D. R. Dowling	Academic Press	2011

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	An Introduction to Fluid Dynamics	G. K. Batchelor	Cambridge University Press	1993
2	Fluid Mechanics	L. D. Landau, and E. M. Lifshitz	Pergamon Press	1987
3	Fluid Mechanics, 5th ed	F. M. White	McGraw-Hill	2003

4	Theoretical Hydrodynamics, 4th ed.	L.M. Milne Thomson	McMillan & Co ltd.	1962

SEMESTER-IV

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA4101	Topology	PCR	3	1	0	4	4
Prerequisite		Basic concepts of Real Analysis.					
Course Outcomes		Upon successful completion of this course students will be able to: • CO1: know about the several type of topological spaces, for example subspace topology, product topology and able to construct continuous functions on these topological spaces. • CO2: know the definition and basic properties of connected spaces, path connected spaces, compact spaces, and locally compact spaces; • CO3: characterize several types of topological spaces using separation axioms, Bair category theorem and other important results; • CO4: Apply theoretical concepts in topology to understand real world applications.					

Course Content	**No. of lectures**
Order Relation, Countable and Uncountable Sets, Cardinal Numbers, Axiom of Choice, Well-Ordered Sets, Maximum Principle, Zorn's Lemma, Ordinal Numbers.	5
Topological spaces, Basis and Subbasis for a topology, Order Topology, Product topology on $X \times Y$, Subspace Topology, Limit Points, Closed Sets, Closure and Interior of a set.	11
Continuous Functions, Open maps, Closed maps and Homeomorphisms, Product and Box Topology, Metric Topology, Quotient Topology.	12
Connected and Path Connected Spaces, Connected Sets in Real Line, Components, Local Connectedness, Compact Spaces, Compact Sets in Real Line, Heine-Borel Theorem, Limit Point Compactness, Sequential Compactness, Compactness in Metric Spaces, Local Compactness, One Point Compactification, Tychonoff Theorem.	14

Countability Axioms, The Separation Axioms, Lindelöf spaces, Regular spaces, Normal spaces, Urysohn Lemma, Tietze Extension Theorem, Equicontinuity, Ascoli-Arzela Theorem, Baire Category Theorem. Applications: space filling curve, nowhere differentiable continuous function.	14
Total Number of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Topology	J. R. Munkres	Prentice Hall of India Pvt. Ltd.	2000
2	Topology	J. Dugundgi	Allyn and Bacon	1966
3	Introduction to Topology and Modern Analysis	G.F. Simmons	McGraw-Hill	1963

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to General Topology	K D. Joshi	New Age International	1983
2	General Topology	J. L. Kelley	Van Nostrand Reinhold Co., New York	1995

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA4102	Generalized Functions and Wavelets	PCR	3	0	0	3	3
Prerequisite							
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand basic properties of generalized functions; CO2: know wavelets and its uses; CO3: use them in physical problems.					
Course Content							**No. of lectures**
Differential equations with non-differentiable solutions, Weak formulation of differential equation. Weak solution							4
Test functions, distributions, delta function and its uses, delta sequence, Heaviside function and its uses							6

derivative of a generalized function, Laplace transform of distribution, distribution solution of ordinary and partial differential equations	6
Basics of Fourier transform, Gibb's phenomenon, windowed Fourier transform	4
Wavelet, scaling functions, Haar wavelets	3
Multiresolution analysis, properties of scaling functions, decomposition and reconstruction algorithm,	6
filters and diagrams, Daubechies wavelets and its construction	4
Applications of wavelet analysis, numerical solution of a partial differential equation using wavelets	6
Wavelet transform and its properties	3
Total Number of Lectures	**42**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	An Introduction to Fourier analysis and generalized functions	M.J. Lighthill	Cambridge University Press	1958
2	Wavelet transform and their applications	L. Debnath and F. Shah	Birkhauser	2015
3	A first course in wavelet with Fourier analysis	A. Boggess and F.J. Narcowich	Cambridge University Press	2009

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Generalized functions	D.S. Jones	Cambridge University Press	1982
2	Wavelet Transform	R.S. Pathak	Atlantis Press/World Scientific.	2009

List of Electives

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total number of contact hours per week				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9111	Geophysics	PEL	3	1	0		04
Prerequisite		Analysis of stress and strain, Concept of body force / surface force, Hooke's law					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand the composition & rheology of interior of the earth;					

	CO2: become more familiar with geophysical techniques and to develop a better understanding of fundamental principles; CO3: develop mathematical models of different earthquake faults.

Course Content	No. of lectures
Theory of Elastic Waves: Infinitesimal strain, stress-strain relation, stress equation of motion, Body waves and surface waves - P & S waves, Rayleigh waves, Stonely waves, Love waves and their characteristics.	14
Ray Theory: Reflection and refraction of seismic waves, travel time analysis.	10
Geophysical Prospecting: Internal constitution of the earth, reflection shooting and refraction shooting.	10
Seismic ground motion: Continental drift and theory of plate tectonics, microseism, tsunami, foreshock, and aftershock.	4
Models of Linear Viscoelasticity: Maxwell model, SLS model, Burger model, their constitutive equations, Correspondence principle.	8
Basics of Earthquake Faults: Mathematical models of earthquake faults in Maxwell half-space.	10
Total Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Fundamentals of Geophysics	William Lowrie	Cambridge University Press	2007
2	Quantitative Seismology (2nd edition)	Keiiti Aki and Paul G. Richards	University Science Books	2009
3	Earthquake and Volcano Deformation	Paul Segall	Princeton University Press	2010

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	An Introduction to the theory of Seismology	K. E. Bullen, Bruce A. Bolt	Cambridge University Press	1987
2	Classical and Computational Solid Mechanics	Fung and Tong	World Scientific	

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9112	Nonlinear Waves	PEL	3	1	0	4	4
Prerequisite							
Course Outcomes		Upon successful completion of this course students will be able to: CO1: to be acquainted with the partial differential equations occurring in fluids and plasmas; CO2: to know linear and nonlinear theory (in particular, soliton) related to waves; CO3: be familiar with kinetic theory of plasma.					

Course Content	No. of lectures
Theory of nonlinear waves: Linear waves, Dispersive and nondispersive waves, group and phase velocity, dispersion relation, Fourrier transform method	4
shallow water waves, deep water waves, K-dv equation and its solutions, Schrodinger equation and its solutions	8
soliton and its properties, conservation laws, Lax pair, Integrability and detecting methods, Painleve analysis, Backlund transformation, Symmetries, inverse scattering method	14
Perturbative methods: Regular and singular perturbation; method of multiple scales, Phase space methods.	12
applications to plasma dynamics: Basics of plasma, quasineutrality, Debye length, mobility of charged particles, effect of magnetic field, electrostatic and electromagnetic waves in a plasma,	8
Fluid dynamic theory of plasma, instability of waves	4
Kinetic theory of plasmas**,** Particle distribution function, Boltzmann-Vlasov equation, Vlasov Maxwell equations, Landau damping	8
Total Number of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Nonlinear waves, solitons and chaos	E. Infeld and G. Rowlands	Cambridge University Press	1992
2	Introduction to Plasma Physics	F. F. Chen	Plenum Press	1974

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Elements of soliton theory	G L Lamb	John Wiley&Sons	1980

2	Astrophysical plasmas and fluids	V.Krishnan	Kluwer Academic Publishers	1999

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9113	Mathematical Modeling	PEL	3	1	0	04	04
Prerequisite		Knowledge of differential and integral calculus, probability					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand and apply the rules to build mathematical models; CO2: understand to analyze the models using mathematical techniques; CO3:to provide them with basic applications stochastic analysis.					

Course Content	**No. of lectures**
Basics of Mathematical Modeling: Elementary mathematical models; Role of Mathematics in problem solving; Concept of mathematical modeling; System approach; formulation, analysis of models; Sensitivity analysis, Dimensional analysis	10
Mathematical Modeling through ordinary differential equations: Linear growth and decay model, Nonlinear growth and decay models (Logistic law of population growth).	4
Mathematical Modeling through system of ordinary differential equations of first order: Prey-Predator models, linear stability, Mathematical modeling of epidemics.	10
Mathematical Modeling using delay differential equations: Delay models, linear stability anslysis	5
Mathematical Modeling through Difference equations: Mathematical modeling in population dynamics and genetics, Mathematical modeling in probability theory	9
Mathematical Modeling through partial differential equations: PDE model for birth-death immigration-emigration process, linear stability, PDE model for a stochastic epidemic process with no removal	10
Mathematical modeling through stochastic Differential Equations: Brownian motion and its properties, Ito formula, Ito integrals and its properties, Comparison between Ito and Stratonovich integrals.	8
Total Number of Lectures	56

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Mathematical Biology	J.D. Murray	Springer	2008

2	Stochastic differential equations, An introduction with applications	B. K. Oksendal	Springer	2014

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Mathematical methods in biology	J.D. Logan and W.R. Wolesensky	Wiley.	2009
2	Elements of Mathematical Ecology	Mark Kot	Cambridge University Press	2012

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9114	Advanced Complex Analysis	PEL	3	1	0	4	4
Prerequisite		Basic concepts of Complex Analysis					
Course Outcomes		Upon successful completion of this course students will be able to: • CO1: construct analytic function from a harmonic function and use it to solve the Dirichlet problem in a region; • CO2: construct analytic function from the upper half plane onto a polygon; • CO3: know about some special functions and its various applications.					

Course Content	**No. of lectures**
Harmonic Functions, Mean Value Property, Poisson Integral Formula, Schwarz's Theorem, Harnack's Inequality, Harnack's Principle.	12
Normal family, equicontinuity, Montel's theorem, Riemann Mapping Theorem, Automorphisms of unit disk.	12
Infinite Products, Necessary condition for convergence of a product, Weierstrass' Product Theorem, gamma function, Mittag-Leffler Theorem.	12
Analytic Continuation, Monodromy Theorem, Gamma and Zeta functions – a brief introduction	10
Schwarz reflection principle, Schwarz-Christoffel transformation, Julia sets.	10

Total Number of Lectures	**56**

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Complex Variables with Applications	S. Ponnusamy and H. Silverman	Birkhauser, Boston	2006
2	Complex Analysis	T. W. Gamelin	Springer	2001
3	Complex Variables and Applications	J. W. Brown and R. V. Churchill	McGraw Hill	2008

Reference Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Complex Analysis	L. V. Ahlfors	McGraw-Hill	1979
2	Functions of one Complex Variable	J. B. Conway	Springer-Verlag	1978

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9115	Advanced Modern Algebra	PEL	3	1	0	4	4
Prerequisite		Elementary ideas of algebraic structures and basic modern algebra.					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: Explain the fundamental concepts of advanced modern algebra such as groups and rings and their role in modern mathematics and applied contexts CO2: Demonstrate accurate and efficient use of advanced modern algebraic techniques CO3: Apply problem-solving using advanced modern algebraic techniques applied to various situations in other mathematical contexts.					

Course Content	**No. of lectures**
Group: Finite Simple Groups, Normal and Subnormal Series, Composition Series, Solvable Groups and Nilpotent Groups, Jordan-Hölder Theorem and its applications.	12
Rings: Quotient Field of an Integral Domain, Polynomial and Power Series Rings. Noetherian and Artinian Rings, Semisimple, Orders in simple Artinian rings, Hilbert Basis Theorem, Cohen's Theorem.	14
Modules: Modules and module homomorphisms, Submodules and quotient modules, Operations on submodules, Direct sums and Direct product, Finitely generated modules, Free modules, Exact sequences, Tensor product of modules and its properties. The functors Hom and tensor product.	14
Field Extensions: Normal Extension, Separable Extension, Impossibility of some constructions by straightedge and compass. Finite Fields and their properties, Galois Group of automorphisms and Galois Theory, Solution of polynomial equations by radicals, Insolvability of the general equation of degree 5(or more) by radicals.	16
Total Number of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1.	Abstract Algebra Theory and Applications	Thomas W. Judson	Orthogonal Publishing	2019
2	Abstract Algebra	P. A. Grillet	Springer	2006
3	Topics in Abstract Algebra	I. N. Herstein	Wiley Eastern Limited	1975

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Algebra	T. W. Hungerford	Springer	2009
2	Fundamentals of Abstract Algebra;	D. S. Malik, J. N. Mordeson and M. K. Sen	McGraw-Hill	1997
3	Abstract Algebra	D. S. Dummit and R. M. Foote	John Wiley & Sons, Inc.	1999

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9116	Automata and Algorithms	PEL	3	1	0	0	4
Prerequisite		Elementary ideas about automata and basic of algorithm.					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: Understand basics of automata and closure properties of languages; CO2: Understand different acceptors; CO3: Understand basics algorithms and design techniques and time complexity analysis.					
Course Content							**No. of lectures**
Fundamentals: Methods of Proof, Basic Concepts of Languages, Definitions and classification of Grammers, Alphabet, Strings, Languages, Finite Representation of Languages.							5
Finite Automata (FA): Deterministic Finite State Automata, Non-deterministic Finite State Automata, Regular Expressions, Regular Grammar, Ambiguity of Regular Languages, Pumping Le Closure Properties of Regular Language: Closure under Boolean operations, reversal,							6
Closure Properties of Regular Language: Closure under Boolean operations, reversal, homomorphism, inverse homomorphism, etc. Pumping lemma.							5
Context Free Grammars (CFG): Pumping Lemma of Context Free Language (CFLs),							4
Closure properties of CFL: closure under union, concatenation, Kleene closure, substitution, homomorphism, reversal, intersection with regular set, Normal Forms, Derivation trees and ambiguity							5

Pushdown Automata: Pushdown Automaton, Equivalence between acceptance by Final State, Equivalence of Context Free Grammar and Pushdown Automaton.	8
Turing Machine ™: Turing Machine as an Acceptor and as a Computing device, Techniques for Turing Machine construction, Equivalence between Turing Machine and Type 0 Language, The Halting problem.	5
Context-sensitive languages, Recursive and Recursive Enumerable sets, Chomsky Hierarchy.	5
Algorithms: Analysis of Algorithms: Analysis of Algorithms, Asymptotic notations-big ohm, omega and theta. Average case analysis of simple programs like finding of a maximum of n elements. Recursion and its systematic removal.	5
Design of Algorithms: (Divide and Conquer, Greedy method, Dynamic programming, Back tracking, Branch and Bound). Lower bound theory, Non–deterministic algorithm–Non–deterministic programming constructs. Simple non-deterministic programs. NP – hard and NP – complete problems.	4
Different types of Algorithms: Quicksort – Non – recursive implementation with minimal stack storage. Sorting and Searching Algorithms, Interpolation and Binary Search	4
Total Number of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Automata Theory, Languages and Computation	Hopcroft, Ullman	Pearson Education.	2007
2	Theory of Computer Science: Automata, Languages and Computation	K.L.P. Mishra and N. Chandrasekaran	PHI Learning Private Limited, Delhi India	2006

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	An Introduction to Formal Language and Automata	Peter Linz	Narosa Publishing house	2016
2	Elements of the Theory of Computation	Papadimitrou, C. and Lewis	Narosa Publishing house	2015

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9117	Differential Geometry	PEL	3	1	0	4	4
Prerequisite		Topology, Basic Geometry					

Course Outcomes	Upon successful completion of this course students will be able to: CO1: develop arguments in the geometric description of curves and surfaces in order to establish basic properties of geodesics, parallel transport, evolutes, minimal surfaces CO2: identify and solve problems that require the use of vector calculus and differential geometry CO3: know the notion of Serret-Frenet frame for space curves and the involutes and evolutes of space curves with the help of examples.

Course Content	**No. of lectures**
Vector Fields: Height of the level set, level curves, Integral curve, smooth vector field, The tangent Space: tangent to the level set, gradient, Surfaces: Hyperplane, Lagrange multiplier, Vector Fields on Surfaces, maximal integral curve, orientation and its consistency, Osculating plane, Serret Frenet formula, Singular points and their classification Gauss, The Gauss map spherical image, one-sheeted hyperboloid.	18
Geodesics: Maximal geodesic, great circle, Parallel Transport, covariant derivative and acceleration, Fermi derivative, The Weingarten Map: shape operator, geodesic flow.	12
Curvature of plane curves: Center of curvature, radius of curvature, Isometries, Intrinsic differentiation, Gauss-Kronecker curvature, translation, rotation, Fundamental theorem on curves.	12
Riemannian metrics: Hyperbolic metric, Stereographic projection, Poincare metric, affine and Riemannian connection and covariance derivation, Applications of differential geometry in engineering and sciences.	14
Total no of Lectures	56

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Elementary Topics in Differential Geometry	J. A. Thorpe	Springer, India	1979
2	Elementary Differential Geometry	B. O'Neill	Academic Press, New York	1966

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Differential Geometry of Curves and Surfaces	M. DoCarmo	Prentice Hall of India, New Delhi	1976
2	Elementary Differential Geometry	A.N. Pressley	Springer, New Delhi	2010

Department of Mathematics				
			Total Number of contact hours	Credit

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9118	Optimization Techniques	PEL	3	1	0	4	4
Prerequisite		Elementary ideas of linear algebra, Probability and multivariate statistics, numerical methods					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: The concept of non-linear programming, different types of non-linear programming techniques and solution methodologies; CO2: The concept of goal programming and apply the knowledge to solve real-life problems with more than one objective; CO3: The theory of stochastic linear and non-linear programming and chance constrained methods; CO4: The methods of geometric programming to solve different optimization problem; CO5: The basics of direct and indirect search methods to solve unconstrained programming.					

Course Content	**No. of lectures**
Non-linear programming: Lagrangian function, NLPP with equality constraint, NLPP with inequality constraint, Kuhn-Tucker conditions, Quadratic programming, Convex Programming, Separable Programming.	16
Goal Programming: General goal programming models, Model with single goal, Model with multiple goals-equally ranked, Model with multiple goals-priority ranked, Graphical method of goal programming, Simplex method in goal programming.	10
Stochastic Programming: Chance constrained programming technique, Stochastic linear programming, Stochastic non-linear programming, Two stage programming technique.	08
Geometric Programming: Posynomial, Unconstrained GPP using differential Calculus, Unconstrained GPP using Arithmetic – Geometric Inequality, Constrained GPP.	10
Unconstrained Optimization Techniques: Rate of convergence, Direct search method, Indirect search method.	12

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Engineering Optimization- Methods and Applications	A. Ravindran, K. M. Ragsdell and G. V. Reklaitis	Wiley-India Edition	2006
2	Engineering Optimization - Theory and Practice	Singiresu S. Rao	New Age International (P) Limited.	2013

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Practical Methods of Optimization	R. Fletcher	2ed. Academic Press	2000
2	Introduction to Linear and Nonlinear Programming	D. G. Luenberger	Addison Wesley	1973
3	Mathematical Programming Techniques	Z.S. Kambo	East West Press	1997

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9119	Fuzzy Mathematics	PCR	3	1	0	4	4
Prerequisite		Elementary ideas of basic probability theory					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: the theory of Fuzzy set, set theoretic operations on fuzzy set and way to represent imprecise data through fuzzy set. CO2: the concept of fuzzy numbers and arithmetic operations on fuzzy number. CO3: the concept of linguistic variable, fuzzy relation, fuzzy reasoning and fuzzy rule base. CO4: the theory of fuzzy logic, possibility and necessity measures and probability of fuzzy events. CO5: the techniques of decision making in fuzzy environment.					

Course Content	**No. of lectures**
Basic concepts of fuzzy sets and fuzzy logic, Motivation, Fuzzy sets and their representations, Membership functions and their designing, Operations on fuzzy sets, Convex fuzzy sets, Alpha-level cuts, Geometric interpretation of fuzzy sets.	14
Fuzzy extension principle and its application.	02
Fuzzy numbers, Fuzzy numbers in the set of integers, Arithmetic operations on fuzzy numbers.	08
Linguistic variables, Linguistic modifiers, Fuzzy rules, Fuzzy relations, Basic properties of fuzzy relations, Composition of fuzzy relations, Fuzzy reasoning.	06
Fuzzy mapping rules and fuzzy implication rules, Fuzzy rule-based models for function approximation, Types of fuzzy rule-based models (the Mamdani, TSK, and standard additive models), Fuzzy implications and approximate reasoning.	08
Fuzzy logic, Truth, Propositions of fuzzy logic, Fuzzy logic and probability theory, Possibility and Necessity, Possibility versus probability, Probability of a fuzzy event, Baye's theorem for fuzzy events, Probabilistic interpretation of fuzzy sets.	06

Decision making in Fuzzy environment, Fuzzy Multi criteria analysis, Multistage decision making, Decision making using Fuzzy ranking methods, Fuzzy Linear programming, Fuzzy goal programming, Fuzzy Multi-objective decision making.	12

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Fuzzy Set Theory and its Applications	H. J. Zimmermann	Second Edition, Kluwer Academic Publishers	1991
2	First Course on Fuzzy Theory and Applications	K. H. Lee	Springer	2005

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Fuzzy sets Engineering	W, Pedrycz	CRC Press	1995
2	Fuzzy sets, Uncertainty and Information	G. J. Klir and T. A. Folger	Prentice Hall, Englewood Cliffs	1988
3	Fuzzy Set Theory: Foundation and Application	G. J. Klir, U. S. Clair and B. Yuan	Prentice Hall	1997
4	Fuzzy Sets, Fuzzy Logic Applications	G. Bojadzieve and M. Bojadzieve	World Scientific	1995

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9120	Nonlinear Analysis	PEL	3	1	0	4	4
Prerequisite		Topology and Functional Analysis					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand how to use the Banach Fixed Point theorem to nonlinear differential equations, nonlinear integral equations, real and complex implicit functions theorems and system of nonlinear equations. CO2: understand the classical theorems of fixed point theory and their applicability in different fields including the differential and integral equations CO3: understand how to determine uniqueness of solutions to dynamical systems and matrix equations.					
Course Content							**No. of lectures**

Fixed Point Theorems with Applications: Properties of linear and nonlinear operators, Banach contraction mapping theorem, Picard's theorem, and applications of contraction principle.	16
Topological Methods: Brouwer fixed point theorem, Contractible sets, Schauder fixed point theorem; fixed point theorem for non-compact operators; classical solution to PDEs, functional setting; classical solution, applications of fixed-point theorems.	20
Degree theory and condensing operators with applications.	10
Approximation of fixed points: convergence of successive iterates, Mann iteration, modified Mann iteration, Ishikawa iteration process, convergence of such iteration process, nonexpansive and quasi-nonexpansive mappings.	10
Total Number of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Functional Analysis: Theory and applications	R.E. Edwards	Dover Publications	1995
2	Topological Methods for Set-Valued Nonlinear Analysis	E. Tarafdar, Mohammad S R Chowdhu	World Scientific	2008

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Topological degree Theory and Applications	Yeol Je Cho, Yu-Qing Chen	Chapman and Hall/CRC	2006
2	Iterative Approximation of Fixed Points	V. Berinde	Springer	2007

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9121	Advanced Operations Research	PCR	3	1	0	4	4
Prerequisite		Fundamental concepts of optimization techniques					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: The concepts of different queuing models and probabilistic Inventory management models. CO2: The concept of replacement models in different scenario and reliability models of maintained and non-maintained system. CO3: The concept of sequencing and scheduling problem.					

	CO4: different simulation techniques to solve problems like random number generation.

Course Content	No. of lectures
Queuing Theory: Introduction of Basic Concepts in Stochastic Processes. Markov Chain and Markov Processes. Introduction to waiting line models steady state behaviour of M/M/1 and M/M/C queueing systems, Erlangian Queueing Systems: $M/E_k/1$ and $E_k/M/1$. Bulk Queueing Systems. Basic idea of priority systems. Imbedded Markov chain models: M/G/l, G/M/l, M/D/C.	12
Probabilistic Inventory Management: Single period inventory models, newspaper boy problems with or without salvage value, Periodic and Continuous review models, Inventory management of items with deterioration, Inventory management of items with inflation.	08
Replacement, Reliability & Maintenance: Replacement of items that deteriorate, Equipments that suddenly fail, chain of improving equipment's, assuming (1)same life for each member in the chain and (2)increasing life, equal to that of deterioration only at infinity. Replacement of items that fail stochastically-individual and common preventive replacements, Renewal theory. Basics of reliability. Classes of life distributions based on notions of ageing, Reliability models of non-maintained & maintained systems, Availability theory and it's modelling for various configurations.	16
Sequencing Analysis: Two machine and n jobs (no passing) problem and three machine and n jobs (no passing) problems: different routing, 2 jobs and m machines, n jobs and m machines, branch and bound algorithms.	06
Simulation: Implementation of simulation modeling, Design of simulation models. Generation of random deviates, the uniform distribution and its importance to simulation, Generation of random numbers (Properties of uniformly distributed numbers, Mid-square technique, Mid-product, technique, Fibonacci method). Generating uniform random variates via a congruential method (Mixed method, Multiplicative method, Quadratic congruential method), testing a random number generator (Frequency test, Gap test, Runs test, Poker test). Inverse transform method, (Exponential distribution, Weibull distribution, Geometric distribution), Rejection Techniques (Beta distribution, Gamma distribution), Composition method (Poisson distribution, Erlang distribution, Binomial distribution), Approximation techniques, Special probability distributions (Chi-square distribution, Student's T-distribution, F-distribution).	14
Total No of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Operations Research	Prem Kumar Gupta & D. S. Hira	7th ed., S Chand publication	2014
2	Quantitative techniques in management	N.D. Vohra	5th ed., Mc Graw Hill	2017

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Operations Research – Principles & Practice	Ravindran, Phillips and Solberg	John Wiley & Sons	2007
2	Introduction to Operations Research	F. S. Hiller & G. J. Leiberman	McGraw Hill	1990

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9122	Algebraic Coding Theory	PEL	3	1	0	4	4
Prerequisite		Ideas of basic linear algebra and abstract algebra.					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: State and prove fundamental theorems about error-correcting codes CO2: Calculate the parameters of given codes and their dual codes using standard matrix and polynomial operations CO3: Compare the error-detecting/correcting facilities of given codes for a given binary symmetric channel CO4: Design simple linear or cyclic codes with required properties.					

Course Content	No. of lectures
Source Coding: Introduction to Information Theory, Uncertainty and Information, Average Mutual Information and Entropy, Information Measures, Information Rate.	6
Introduction to Coding Theory: Basic Assumptions, Correcting and Detecting Error Pattern, the Effects of Error Correction and Detection, Maximum Likelihood Decoding (MLD), Reliability of MLD, Error-Detecting Codes, Error-Correcting Codes.	8
Finite Fields: Finite Fields: the basic theory, Field Extension: a brief idea, Irreducible Polynomial and how to find irreducible polynomial, The number of irreducible polynomials, Vector Space over finite field, Minimal Polynomial, primitive elements, Bases of GF(p^m) over GF(p).	8
Linear Codes: Block Codes, Linear Codes, Weight and Distance of a Linear Code, Bases for code C = <S> and $C^{\perp}$, Generating Matrices and Parity-Check Matrices, Encoding and Decoding, Equivalent Codes.	8
Bounds on Codes: Sphere-covering bound, Hamming bound, Singleton bound.	4
Some Good Codes: Hamming Codes, Golay Codes, BCH Codes, Reed–Solomon codes, Preparata Codes, Kerdock codes.	6
Cyclic Codes: Generator Polynomials, Generator and Parity-check matrices, Polynomial Encoding and Decoding.	8
Codes over Z_4: Quaternary Codes, Binary Codes Derived from Quaternary Codes, Galois Codes over Z_4, Cyclic Codes over Z_4. **Total No of Lectures**	8 56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Coding Theory	J. H. van Lint	Springer	1999

2	Introduction to the theory of error-correcting codes	Vera Pless	A Wiley-Interscience Publication	1998
3	Coding Theory	S. Ling and C. Xing	Cambridge	2004

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Coding Theory and Cryptography	D. R. Hankerson, D. G. Hoffmann, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger and J. R. Wall	CRC	2006
2	Coding and Information Theory	S. Roman	New York, Springer-Verlag	1992
3	The Theory of Error Correcting Code	F. J. Macwilliams and N. J. A. Sloane	North-Holland	1977

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9123	Dynamical Systems and Chaos Theory	PEL	3	1	0	4	4
Prerequisite		Basics of ordinary differential equations					
Course Outcomes		Upon successful completion of this course students will be able to understand: CO1: fundamentals of continuous and discrete dynamical systems CO2: basics of bifurcation theory and its applications CO3: basics of chaos theory					

Course Content	**No. of lectures**
Introduction: Continuous dynamical systems and discrete dynamical systems.	2
One dimensional systems: Existence and uniqueness, Bifurcations and Flow on the circle.	8
Two dimensional systems: Linearization and stability, Liapunov functions. Nonlinear Oscillations: Limit cycles in two dimensions, Poincaré-Bendixson theorem, Linear stability of limit cycle, Floquet theory, Poincaré sections, circle-maps and mode-locking, Relaxation & Coupled oscillators, Perturbation methods.	14
Introduction to Chaos: Lorenz equations, Liapunov exponents, Strange and chaotic attractors, fractal boundaries, Logistic map.	12
Bifurcations: Saddle-node, transcritical, pitchfork, Hopf, homoclinic and heteroclinic connections. Bifurcation analysis using MATCONT/XPPAUT softwares	12
Routes to chaos: Period doubling, quasiperiodic and intermittency	8
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Nonlinear Dynamics and Chaos	S. H. Strogatz	Westview Press	2000
2	Chaos: An Introduction to Dynamical Systems	K. T. Alligood, T. D. Sauer, and J. A. Yorke	Springer	1996

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Nonlinear Ordinary Differential Equations	D. W. Jordan, and P. Smith	Oxford University Press	1999
2	Stability, instability and chaos	P. Glendinning	Cambridge University Press	1994
3	Chaos in Dynamical Systems	E. Ott	Cambridge University Press	2002

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9124	Computational Fluid Dynamics	PEL	3	1	0	4	4
Prerequisite		MA 2105: Numerical Analysis, MA 3103: Fluid Dynamics					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand basic properties of computational methods –accuracy, stability, consistency CO2: learn the basic computational methods for solving linear/ non-linear differential equations CO3: learn how to computationally solve the governing equations for fluid flow problems in simple/ complex geometries CO3: acquire basic programming and graphic skills to conduct the flow field calculations and data analysis					

Course Content	**No. of lectures**
Brief introduction to Computational Fluid Dynamics (CFD) with possible applications in real life problems, Review of various conservation principles: General description of conservation of mass, momentum and energy.	4
Overview of various types of partial differential equations (PDE), Brief discussion on the Initial Value Problems (IVP) and Boundary Value Problems (BVP), Overview of basic numerical tools.	4
Introduction to grid generation: various grid generation techniques, Finite difference (FDM) and Finite volume (FVM) methods for typical elliptic, parabolic and hyperbolic equations, Navier-Stokes (N-S) and energy equations, explicit and implicit methods, convergence and stability	12
Solutions of simultaneous equations: iterative and direct methods, Gauss-Seidel iteration, CGS, Bi-CGSTAB and GMRES (m) matrix solvers	4

Governing equations for fluid dynamics in complex geometries: Transformation of governing equation in ξ-η−plane, basic facts about transformation, grid transformation on complex geometries. N-S equations in transformed plane, matrices and Jacobians.	4
Incompressible Flow: Upwind scheme, Exponential scheme, Hybrid scheme, Power law scheme; Higher order upwind schemes: second order convective schemes, QUICK. Solution of N-S equations using explicit methods: MAC and SMAC (staggered and collocated grids), semi-implicit methods: SIMPLE and SIMPLER Compressible flow: Various schemes for solution of Euler equation (Lax-Wendroff, MacCormark, Beam and Warming schemes) & Solution of N-S equations (MacCormack, Jameson algorithm in finite volume formulation and transformed coordinate system).	22
Implementation of a CFD code- The basic structure of a CFD code: Pre-processor, Solver and Post-processor, User-defined-subroutines, Solution to some basic problems in heat transfer and fluid flow	6
Total Number of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Computational Fluid Dynamics: The Basic with Applications	J.D. Anderson, Jr	McGraw Hill, Inc.,	1995
2	Computational Fluid Mechanics and Heat Transfer	J. C. Tannehil, D. A. Anderson, and R. H. Pletcher	Taylor & Francis	1997

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Numerical Heat Transfer and Fluid Flow	S. V. Patankar	Hemisphere Series on Computational Methods in Mechanics and Thermal Science	1980
2	Computational Fluid Dynamics	Chung T. J.	Cambridge University Press	2003

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9125	Soft Computing	PEL	3	1	0	4	4
Prerequisite		(i) Rudimentary concepts of statistics and probability (ii) Proficiency with algorithms. (ii) Programming skills in C, C++, or Java, MATLAB, etc. (iii) Critical thinking and problem solving skills.					

Course Outcomes	Upon successful completion of this course students will be able to: CO1: the architecture and learning paradigms of artificial neural network. CO2: different learning algorithms to train different ANN. CO3: different metaheuristic algorithms like, GA, ACO, PSO, etc. CO4: the concepts needed to manipulate imprecise data using fuzzy set, fuzzy logic and rough set theory. CO5: the concepts of different hybrid approaches to solve engineering optimization problems.

Course Content	**No. of lectures**
Introduction of Soft Computing, Concepts and applications.	04
Biological and artificial neuron, Neural networks, Adaline, Perceptron, Madaline and BP (Back Propagation) neural networks, Adaptive feedforward multilayer networks, RBF and RCE neural networks, Topologic organized neural networks, competitive learning, Kohonen maps, Solving optimization problems using neural networks, Stochastic neural networks, Boltzmann machine.	16
Fuzzy sets, fuzzy arithmetic, fuzzy logic and fuzzy inference, fuzzy decision-making.	14
Ant colony optimization and Particle swarm optimization.	06
Hybrid approaches (neural networks, fuzzy logic, genetic algorithms and rough sets), Engineering optimization problem solving using genetic algorithm, Neural network approaches, fuzzy and rough approaches.	16

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Soft Computing	D. K. Pratihar	Narosa	2008
2	Genetic Algorithms in Search, Optimization and Machine learning	D. E. Goldberg	Pearson Education, Inc.	1989

Reference Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Principles of Soft Computing	S.N. Sivanandam and S. N. Deepa	Wiley	2012
2	Ant Colony Optimization	M. Dorigo and T. Stutzle	Prentice Hall India Pvt. Ltd.	2005
3	Swarm Intelligence: From Natural to Artificial Systems	E. Bonabeau, M. Dorigo and G. Theraulaz	Oxford University Press, New York	1999

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9126	Cryptography	PEL	3	1	0	4	4

Prerequisite	Elementary ideas of linear algebra and modern algebra.
Course Outcomes	Upon successful completion of this course students will be able to: CO1: Classify the symmetric encryption techniques CO2: Illustrate various Public key cryptographic techniques CO3: Evaluate the authentication and hash algorithms CO4: Discuss authentication applications

Course Content	**No. of lectures**
Secure communications, shift ciphers, affine ciphers, vigenere cipher, symmetric key, public key, block ciphers (DES, AES), Shannon's Notion of perfect secrecy, one time pads, secure random bit generator, linear feedback shift register sequences, stream ciphers (LFSR based, RC4), Block cipher modes of operations.	16
Differential cryptanalysis, Linear cryptanalysis.	10
Prime number generation, RSA, attack on RSA, Diffie-Hellman key exchange, El Gamal public key cryptosystem, cryptographic hash function, RSA signature, El Gamal signatures, hashing and signing, digital signature algorithm.	12
Elliptic Curves, Basic facts. Elliptic curve cryptasystems.	10
One-way functions, PRG, PRP.	8
Total Numbers of Lectures	**56**

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Cryptography	Johnnes A Buchmann	Springer	2001
2	Cryptography: Theory and Practice	D R Stinson	CRC Press	2006

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Cryptography with coding Theory	W. Trappe and L. C. Washington	Prentice-Hall	2006
2	Classical and Contemporary Cryptology	Richard J. Spillman	Prentice-Hall	2005

Department of Mathematics

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9127	Decision Theory	PEL	3	1	0	0	4

Prerequisite	Elementary ideas of optimization techniques and decision theory
Course Outcomes	Upon successful completion of this course students will be able to: CO1: Understand basics of decision analysis and multi objective optimization;

	CO2: Understand basics of multi criteria decision making; CO3: Understand data envelopment analysis.

Course Content	**No. of lectures**
Randomization, Optimality, Bayes rules, Minimax rules, Admissiable rules, Invariance and sufficiency, Complete class and essential complete class of rules	5
Decision analysis under Risk-Probability: Decision analysis without sampling, Decision analysis with sampling.	5
Decision Analysis under Risk Utility: St. Petersburg Paradox. Construction of Utility Functions, Risk Attitudes	5
Decision Analysis under Risk Utility: St. Petersburg Paradox. Construction of Utility Functions, Risk Attitudes.	6
Decision Trees and Sequential Decision Making	4
Multi-criteria decision methods	8
Multi-objective optimization: Lexicographic optimality, Interactive procedures, efficient and properly efficient solutions.	8
Data Envelopment Analysis: Chames, Cooper and Rhodes (CCR) model. Banker, Charnes and Cooper (BCC) model.	8
Analytic Hierarchy Process: Ranking and weighting information using Eigen Vector Method (EVM) and Approximation Methods.	7
Total Number of Lectures	**56**

Text Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	An Introduction to Decision Theory, Cambridge University Press	Martin Peterson Itzhak Gilboa	Cambridge University Press	2008

Reference Books:

Sl. No.	**Name of the Book**	**Authors**	**Publisher**	**Year**
1	Decision Theory: Principles and Approaches	Giovanni Parmigiani, Lurdes Inoue	Wiley	2009

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9128	Measure Theory	PEL	3	1	0	4	4
Prerequisite		Real Analysis					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: understand the basics concepts about measure and integration theory CO2: use abstract methods to solve approximation problems in different fields especially in Lebesgue integral theory CO3: understand the main connections between the notions of measure and probability.					

Course Content	No. of lectures
Lebesgue Measure and Measurable Functions: Recapitulations of Lebesgue measure and measurable functions, the structure of measurable sets, construction of non-measurable sets, approximation of measurable functions.	18
Lebesgue Integral: Recapitulations of definitions and different properties. Approximations of integrable functions, convergence in measure. L^p spaces and L^∞ space, approximation of L^p functions, convergence and completeness.	26
Lebesgue's differentiation theorem, Lebesgue fundamental theorem of calculus, and Lebesgue's last theorem.	12
Total no of Lectures	56

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Real Mathematical Analysis	Charles Chapman Pugh	UTM, Springer International Publishing	2015
2	Real Analysis	N.L. Carothers	Cambridge University Press	2018

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Real Analysis-Theory of Measure and integration	J Yeh	World Scientific	2014
2	Principles of Real Analysis	Aliprantis C. D., Burkinshaw O.	Harcourt Asia Pte Ltd.	1998

Department of Mathematics				
			Total Number of contact hours	Credit

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA 9129	Multivariate Statistical Analysis	PEL	3	1	0	4	4
Prerequisite		(i) Rudimentary concepts of Linear Algebra, Calculus of Several Variables, a course in probability, a course in statistics (ii) Familiar with at least one of the following three software packages, MATLAB, R and SPSS.					
Course Outcomes		After completing the course the student should be able to: • Compute the characteristic functions of some well-known distributions and use multivariate characteristic functions to investigate properties of various distributions. • Derive various multivariate sampling distributions and use exterior forms where appropriate to make the necessary changes of variables. • Understand how to use various multivariate statistical methods (for example: test for significant differences between populations, use principal component analysis and factor analysis, discriminant analysis and cluster analysis) • Implement these methods using an appropriate statistical software package and draw appropriate conclusions.					

Course Content	**No. of lectures**
Multivariate Analysis: Basic concepts, Measurement scales, Measurement error and Multivariate Measurement, Classification of Multivariate Techniques, Types of Multivariate Techniques, Structured Approach to Multivariate Model building.	04
Examining Data for Multivariate Analysis: Bivariate Profiling, Multivariate Profiles, Missing Data, Outliers, Detecting and Handling Outliers, Testing the assumptions of Multivariate Analysis.	04
Multivariate Normal Distribution: Multivariate Normal Density & its properties**,** Sampling from a multivariate Normal Distribution and maximum Likelihood estimation, sampling distribution of mean & standard deviation, Detecting outliers ,Transformation to near Normality.	06
Principal Component Analysis: Population Principal Components, Principal components for covariance matrices with special structures, Sample Variation by Principal Components, Large sample inferences, monitoring quality with Principal components.	10
Factor analysis: What is Factor analysis, Objectives of Factor analysis, designing a Factor analysis, Assumptions in Factor analysis, Deriving factors and assessing overall fit, 3 process factor interpretations, Validation of Factor Analysis.	08
Multiple Discriminant Analysis and Logistic Regression: What are Discriminant Analysis and Logistic Regression, Objectives of Discriminant Analysis, assumptions of Discriminant Analysis, estimation of the Discriminant Model and assessing overall fit, Logistic Regression: Regression with a binary dependent variable	12
Cluster Analysis: What is cluster analysis, Objectives of cluster analysis, Assumptions of cluster analysis, deriving clusters and assessing overall fit, Interpretation of the clusters, hierarchical & non-hierarchical clustering techniques.	12

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Multivariate Data Analysis	J.F.Hair, W.C.Black, B.J.Babin, R.E.Anderson, R.L.Tatham	Pearson Education, Inc.	2014
2	Applied Multivariate Statistical Analysis	R. A. Johnson, D. W. Wichern	Pearson Education, Inc.	2012

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Applied Multivariate Statistical Analysis	W.K. Härdle, L. Simar	Springer	2012
2	An introduction to multivariate statistical analysis	T.W. Anderson	Wiley	2003

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MA9130	Commutative algebra	PEL	3	1	0	4	4
Prerequisite		Modern algebra and advanced modern algebra.					
Course Outcomes		Upon successful completion of this course students will be able to: CO1: Know constructions like tensor product and localization, and the basic theory for this CO2: Know basic theory for noetherian rings and Hilbert basis theorem CO3: Know basic theory for support and associated prime ideals of modules, and know primary decomposition of ideals in noetherian rings CO4: Know the theory of Gröbner bases and Buchbergers algorithm.					

Course Content	**No. of lectures**
Rings and Ideals: Rings and ring homomorphisms, Nilradical and Jacobson radical.	4
Algebras: Algebras over commutative rings, Examples. Polynomial algebras and its universal property. Unique Factorization domains (UFDs).	4
Spectrum and Zariski Topology: The K-spectrum of an algebra over a field K, Prime Spectrum and Maximal Spectrum of a commutative ring, Algebraic Sets in Spectrums and their properties, Examples. Zariski topology on Spectrums.	6
Finite and Finite type algebras: Algebraic and Integral elements over commutative rings. Classical Hilbert's Nullstellensatz and its equivalent forms.	6
Rings and Modules with Chain Conditions: Ascending and Decending chain conditions on modules, Noetherian and Artinian Modules, Noetherian and Artinian rings, Hilbert's Basis Theorem.	6
Rings and Modules of Fractions: Definition and Universal property, Ideal structure in the rings of fractions, Local-Global principle.	8
Primary Decomposition: Primary decomposition for modules, Uniqueness of isolated primary components. Associated prime ideals, Support of a module.	6

Integral Extensions: Integral dependence, Lying over, Going-up and Going-down theorems. Integrally closed domains, Transcendence degree, Noether's Normalisation Lemma (NNL) and its consequences.	8
Integrally closed Noetherian rings: Discrete valuation rings and Dedekind domains, Fractionary ideals, Integral extensions of Noetherian domains, Galois groups and prime ideals.	8

Text Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Commutative Algebra	F. M. Atiyah and I. G. Macdonald	Addison-Wesley Publishing Company	1969
2	Basic Commutative Algebra	B. Singh	World Scientific Publications	2011

Reference Books:

Sl. No.	Name of the Book	Authors	Publisher	Year
1	Introduction to Algebraic Geometry and Commutative Algebra	D. P. Patil and U. Storch	World Scientific Publications	2010
2	Homological Methods in Commutative Algebra	S. Raghavan, B. Singh and R. Sridharan	Oxford University Press	1977
3	Local Algebra (Translated from French)	J. P. Serre	Springer-Verlag	2000
4	Commutative Algebra, Vols. I, II	O. Zariski and P. Samuel	Van Nostrand	1960

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