Learning Outcomes Based Curriculum

Department of Mathematical Sciences
Tezpur University
Integrated M.Sc. in Mathematics

Preamble

Department of Mathematical Sciences, Tezpur University strive to implement LOCF (Learning Outcomes based Curriculum Framework) as suggested by University Grants Commission (UGC) and proposed to be implemented by Tezpur University. The basic structure of the Integrated M.Sc. Programme is designed keeping in mind to prepare the students to learn Mathematics leading to M.Sc. degree and motivate them towards higher learning of mathematics through research in different area of mathematics as well as in multidisciplinary fields including physical sciences, bio sciences, social sciences, engineering and technology etc. The learning outcomes of each paper are designed so that these may help learners to understand the main objectives of studying the course. Elective papers are included to enrich the individual inclinations and contemporary requirements. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.

1. Introduction

The Integrated M.Sc. programme in Mathematics consists of 10 semesters comprising 210 credits in all. Besides the prescribed compulsory papers, each student has to opt for at 3 elective papers of mathematics and 2 open elective papers during the course of study. The course has been designed to equip the students with theoretical knowledge as well as problem solving techniques. The academic curriculum requires each final year student to undertake a project (4 credits) in any branch of mathematics or related to mathematics to facilitate his/her independent thinking.

2. Qualification descriptors for the graduates

Knowledge & Understanding

i. Demonstrate fundamental systematic knowledge of mathematics and its applications in engineering, science, technology and mathematical sciences and research. It also enhance the subject specific knowledge.

Skills & Techniques

i. Demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.

ii. Apply knowledge, understanding and skills to identify the difficult/unsolved problems in mathematics and to collect the required information in possible range of sources and try to analyse and evaluate these problems using appropriate methodologies.

Competence

i. Fulfil one's learning requirements in mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences.

ii. Apply one's disciplinary knowledge and skills in mathematics in newer domains and uncharted areas.

iii. Identify challenging problems in mathematics and obtain well-defined solutions.

iv. Exhibit subject-specific transferable knowledge in mathematics relevant to job trends and employment opportunities.

3. Graduates Attributes

The graduate attributes in mathematics are the summation of the expected course learning outcomes, some of them are stated below.

i. Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines of mathematics.

ii. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.

iii. Ability to use mathematics as a precise language of communication in other branches of human knowledge.

iv. Ability to employ critical thinking in understanding the concepts in every area of mathematics.

v. Ability to analyze the results and apply them in various problems appearing in different branches of mathematics.

vi. Ability to provide new solutions using the domain knowledge of mathematics by framing appropriate questions relating to the concepts in various fields of mathematics.

vii. To know about the advances in various branches of mathematics.

viii. Capability to understand and apply the programming concepts of C to mathematical investigations and problem solving.

ix. Ability to work independently and do in-depth study of various notions of mathematics.

x. Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self learning.

4. Program Outcomes

M.Sc. in mathematics

PO1: Have good knowledge and exposure to basic and contemporary fields of mathematics.
PO2: Have excellent domain knowledge in chosen elective subjects leading to research.
PO3: Inculcated abstract mathematical and higher order logical thinking and aptitude in problem solving.
PO4: Develop good computation, programming, data analysis skills and their applications.
PO5: Competent to succeed in national level competitive examinations for taking up doctoral research and teaching.

5. Programme structure

Programme Name: Integrated M.Sc. in mathematics

Total Credits: 210

Structure of the curriculum

Course category		No of courses	Credits per course	Total Credits
I.	Core courses	40	1 to 4	147
II.	Elective courses			
	Department Specific Elective (DSE)	03	04	12
	Open Elective	02	03	06
	SEC/AEC	05	2 to 4	15
	GE	13	03	30
	Total credits	**62**	**1 to 4**	**210**

6. SEMESTER-WISE SCHEDULE

Semester I

Course Code	Course Name	L-T-P	CH	CR	Remark
PI 101	Physics-I	2-1-0	3	3	GE
CI 101	Chemistry-I	3-0-0	3	3	GE
CI 107	Chemistry-Lab	0-0-3	6	3	GE
BI 101	Biology-I	3-0-0	3	3	GE
MI 103	Foundation of Mathematics	2-1-0	3	3	CORE
MI 105	Real Analysis-I	2-1-0	3	3	CORE
EG 110	Communicative English	3-0-0	3	3	AEC
Total credits				**21**	

Semester II

Course Code	Course Name	L-T-P	CH	CR	Remark
PI 102	Physics-II	2-1-0	3	3	GE
PI 197	Physics-Lab	0-0-3	6	3	GE
CI 102	Chemistry-II	3-0-0	3	3	GE
BI 107	Biology-Lab	3-0-0	3	3	GE
MI 104	Real Analysis-II	2-1-0	3	3	CORE
MI 106	Group Theory	2-1-0	3	3	CORE
ES 103	Environmental Studies	4-0-0	4	4	AEC
Total credits				**22**	

Semester III

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 221	Introductory Statistics & Probability	2-1-0	3	3	CORE
MI 223	Calculus-I	3-1-0	4	4	CORE
MI 225	Combinatorics	3-1-0	4	4	CORE
PI 201	Physics-III	2-1-0	3	3	GE
CI 201	Chemistry-III	3-0-0	3	3	GE
CS 535	Introduction to Scientific computing	2-0-1	3	3	AEC
NS 102	National Service Scheme	1-0-1	3	2	SEC
Total credits				**22**	

Semester IV

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 218	Introductory ODE & PDE	3-1-0	4	4	CORE
MI 220	Linear Algebra-I	3-1-0	4	4	CORE
MI 222	Co-ordinate Geometry	3-1-0	4	4	CORE
MI 224	Numerical Methods and Boolean Algebra	3-1-0	4	4	CORE
MI 226	Introductory Topology	3-1-0	4	4	CORE
DM 301	Fundamentals of Disaster Management	3-0-0	3	3	SEC
Total credits				**23**	

Semester V

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 311	Calculus-II	3-1-0	4	4	CORE
MI 313	Programming, Algorithm and Mathematical Software	2-0-2	6	4	CORE
MI 315	Statics and Dynamics	3-1-0	4	4	CORE
MI 317	Elementary Complex Analysis	3-1-0	4	4	CORE
MI 319	Graph Theory	3-1-0	4	4	CORE
Total credits				**20**	

Semester VI

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 312	Ring Theory	2-1-0	3	3	CORE
MI 314	Elementary Number Theory	3-1-0	4	4	CORE
MI 316	Introduction to Optimization	3-1-0	4	4	CORE
MI 318	Elementary Integral Transforms and Special Functions	3-1-0	4	4	CORE
MI 322	Seminar	0-0-3	6	3	CORE
MI 320	Elementary Codingand Information Theory	3-1-0	4	4	CORE
Total credits				**22**	

Semester VII

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 412	Abstract Algebra	3-1-0	4	4	CORE
MI 417	Linear Algebra-II	3-1-0	4	4	CORE
MI 413	Real Analysis-III	3-1-0	4	4	CORE
MI 414	Computer Programming+	3-1-0	4	4	CORE
MI 415	Lebesgue Measure and Integration	3-1-0	4	4	CORE
MI 421	Computer Lab	0-0-1	2	1	CORE
Total credits				**21**	

+ Course for which there is a separate practical unit assigned as Computer Laboratory

Semester VIII

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 408	Complex Analysis	3-1-0	4	4	CORE
MI 418	Theory of Ordinary Differential Equations	3-1-0	4	4	CORE
MI 419	Topology	3-1-0	4	4	CORE
MI 416	Numerical Analysis+	3-1-0	4	4	CORE
MI 424	Computer Lab	0-0-1	2	1	CORE
	Open Elective-I[#]	2-1-0	3	3	Open Elective
Total credits				**20**	

List to be notified by the CoE from time to time

Semester IX

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 507	Partial Differential Equations	3-1-0	4	4	CORE
MI 510	Functional Analysis	3-1-0	4	4	CORE
	DSE-I	3-1-0	4	4	DSE
	Open Elective II[#]	2-1-0	3	3	Open Elective
MI 517	Project	0-2-2	6	4	CORE
Total credits				**19**	

Semester X

Course Code	Course Name	L-T-P	CH	CR	Remark
MI 599	Probability Theory	3-1-0	4	4	CORE
MI 508	Mathematical Methods	3-1-0	4	4	CORE
MI 509	Classical Mechanics	3-1-0	4	4	CORE
	DSE-II	3-1-0	4	4	DSE
	DSE-III	3-1-0	4	4	DSE
Total credits				**20**	

DSE-I, II, III are to be chosen from the following currently offered courses:

Course Code	Course Name	L-T-P	CH	CR
MI 538	Theory of Partial Differential Equation	3-1-0	4	4
MI 539	Advanced Numerical Analysis	3-1-0	4	4
MI 541	Fluid Mechanics	3-1-0	4	4
MI 543	Relativity	3-1-0	4	4
MI 552	Operator Theory-I	3-1-0	4	4
MI 554	Commutative Algebra	3-1-0	4	4
MI 558	General Theory of Relativity	3-1-0	4	4
MI 561	Stochastic processes-I	3-1-0	4	4
MI 565	Fuzzy Sets and Applications-I	3-1-0	4	4
MI 566	Fourier Analysis	3-1-0	4	4
MI 567	Continuum Mechanics	3-1-0	4	4
MI 568	Theory of Distribution and Sobolev Spaces	3-1-0	4	4
MI 569	Coding Theory-I	3-1-0	4	4
MI 570	Coding Theory-II	3-1-0	4	4
MI 572	Operator Theory –II	3-1-0	4	4
MI 573	Analytic Number Theory	3-1-0	4	4
MI 574	Galois Theory	3-1-0	4	4
MI 581	Stochastic Processes –II	3-1-0	4	4
MI 585	Fuzzy Sets and Applications-II	3-1-0	4	4
MI 588	Applied Matrix Theory	3-1-0	4	4
MI 591	Computational Fluid Dynamics	3-1-0	4	4
MI 594	Advanced Topology-I	3-1-0	4	4
MI 596	Advanced Topology-II	3-1-0	4	4

7. Mapping of course with program outcomes (POs)

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5
PI 101	Physics-I				√	√
CI 101	Chemistry-I	√				√
CI 107	Chemistry Laboratory	√				√
BI 101	Biology-I	√	√	√		
MI 103	Foundation of Mathematics	√		√	√	√
MI 105	Real Analysis-I	√	√	√		√
EG 110	Communicative English					
PI 102	Physics-II	√			√	√
PI 197	Physics-Lab		√		√	
CI 102	Chemistry-II	√				√
BI 107	Biology-Lab	√	√	√	√	
MI 104	Real Analysis-II	√	√	√		√
MI 106	Group Theory	√		√	√	√
ES 103	Environmental Studies		√			√
MI 221	Introductory Statistics & Probability	√		√		
MI 223	Calculus-I	√	√	√		√
MI 225	Combinatorics	√	√		√	
PI 201	Physics-III					
CI 201	Chemistry-III	√				√
CS 535	Introduction to Scientific computing					
NS 102	National Service Scheme					
MI 218	Introductory ODE & PDE	√	√	√		√
MI 220	Linear Algebra-I	√	√			√
MI 222	Co-ordinate Geometry	√			√	√
MI 224	Numerical Methods and Boolean Algebra	√	√	√	√	√
MI 226	Introductory Topology	√	√	√	√	√

DM301	Fundamentals of Disaster Management		√			
MI 311	Calculus-II	√	√	√		√
MI 313	Programming, Algorithm and Mathematical Software	√	√		√	√
MI 315	Statics and Dynamics	√	√		√	
MI 317	Elementary Complex Analysis	√	√	√		√
MI 319	Graph Theory	√	√	√	√	√
MI 312	Ring Theory	√	√	√	√	√
MI 314	Elementary Number Theory	√	√	√	√	√
MI 316	Introduction to Optimization	√	√	√	√	√
MI 318	Elementary Integral Transforms and Special Functions	√	√	√		√
MI 322	Seminar					√
MI 320	Elementary Coding and Information Theory	√	√	√	√	√
MI 412	Abstract Algebra	√	√	√		√
MI 417	Linear Algebra-II	√	√	√	√	√
MI 413	Real Analysis-III	√	√	√		√
MI 414	Computer Programming+			√	√	√
MI 415	Lebesgue Measure and Integration	√	√	√		√
MI 421	Computer Lab			√	√	√
MI 408	Complex Analysis	√	√	√		√
MI 418	Theory of Ordinary Differential Equations	√	√	√	√	√
MI 419	Topology	√	√	√		√
MI 416	Numerical Analysis+	√	√	√	√	√
MI 424	Computer Lab			√	√	√
MI 507	Partial Differential Equations	√	√	√	√	√
MI 510	Functional Analysis	√	√	√	√	√
MI 517	Project	√	√	√	√	√
MI 508	Mathematical Methods	√	√	√	√	√
MI 509	Classical Mechanics	√	√	√	√	√

MI 538	Theory of Partial Differential Equations	√	√	√		√
MI 539	Advanced Numerical Analysis	√	√	√	√	√
MI 541	Fluid Mechanics	√	√	√		√
MI 543	Relativity	√	√	√		√
MI 552	Operator Theory-I	√	√	√		√
MI 554	Commutative Algebra	√	√	√		√
MI 558	General Theory of Relativity	√	√	√		√
MI 561	Stochastic Process-I	√	√	√	√	√
MI 565	Fuzzy Sets and Applications-I	√	√	√		√
MI 566	Fourier Analysis	√	√	√	√	√
MI 567	Continuum Mechanics	√	√	√		√
MI 568	Theory of Distribution and Sobolev Spaces	√	√	√		√
MI 569	Coding Theory I	√	√	√	√	√
MI 570	Coding Theory -II	√	√	√	√	√
MI 572	Operator Theory -II	√	√	√		√
MI 573	Analytic Number Theory	√	√	√	√	√
MI 574	Galois Theory	√	√	√		√
MI 581	Stochastic Process-II	√	√	√	√	√
MI 585	Fuzzy Sets and Their Applications-II	√	√	√		√
MI 588	Applied Matrix Theory	√	√	√	√	√
MI 591	Computational Fluid Dynamics	√	√	√	√	√
MI 594	Advanced Topology –I	√	√	√		√
MI 596	Advanced Topology –II	√	√	√		√
MI 599	Probability Theory	√	√	√	√	√

8. Evaluation plan:

There shall be minimum two Sessional Tests and two Examinations for each Theory Course, and two Examinations for a Practical Course having L-T-P structure. Details as follows:

Evaluation plan for Theory Courses:

Sessional Test/ Examination		Course Credit ≤ 2		Course Credit ≥ 3		Semester period
Nomenclature	Type	Marks	Duration	Marks	Duration	
Sessional Test-I	Written	20	30 min	25	45 min	Within 5th week
Mid-Semester Examination	Written	30	90 min	40	2 hours min	Within 10th week
Sessional Test-II	Written /Assignment/Seminar etc.	20	XX	25	XX	Within 14th week
End-Semester Examination	Written	50	2 hours	60	3 hours	Within 18th week

Evaluation plan for Practical Courses:

Examination		L-T-P Structure-wise Marks		Semester period
		L-T-P: 0-0-z	L-T-P: x-y-z	
Nomenclature	Type	Marks	Marks	
Mid-Semester (Practical) Examination	Viva, Report	30	-	Before Mid Semester
End-Semester (Practical) Examination	Practical Examination, Viva, Report	70	50	Before End Semester

9. DETAILED SYLLABUS

MI 103: Foundation of Mathematics

L 2 T1 P0 CR2

Course outcomes

1. It will build the fundamental concepts of mathematics in different branches mathematics to be offered in the subsequent semesters and will work as foundations.

Course content

- Statements, quantifiers, negation, compound statements (conjunction, disjunction, conditional and bi-conditional), contra-positive statement, proofs in Mathematics.
- Set, subset, superset, operations viz. union, intersection, complement etc. of sets; power set, cartesian product.
- Equivalence relations, equivalence classes, partition, fundamental theorem of equivalence relation.
- Functions, injection, surjection and bijection; image and pre-image of set under function, composition of functions, invertible function.
- Partial order relation, poset, chain, upper & lower bounds in poset, greatest & least elements, maximal & minimal elements, supremum & infimum, Zorn's lemma, introduction to lattice theory.
- Peano's axioms, principle of mathematical induction, well ordering principle, axiom of choice.
- Finite and infinite sets, countable and uncountable sets, Schroeder Bernstein Theorem, Continuum hypothesis.
- Ordinal numbers, sum and product of ordinal numbers, structure of ordinal numbers.

Textbook(s):

- Halmos, P. R., *Naive Set Theory* Springer, 2009.
- Kumar, A., Kumaresan, S. and Sarma, B. K., *A foundation course in Mathematics*, Narosa, 2018.

Suggested readings:

- Hrbacek, K. and Jech, T., *Introduction to Set Theory* , 3rd edition, CRC press, 1999.
- Bartle, R. G. and Sherbert, D. R., *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons, 2005 (reprint, Wiley India, 2011).

MI 104: Real Analysis-II

L 2 T1 P0 CR3

Course outcomes

1. Students will understand the fundamental concepts of real analysis and apply these concepts to other fields of science.
2. Students will be able to compete at the national and international level.

Course content

- Limits of functions, sequential criterion of limits, squeeze theorem, one sided limits, infinite limits and limits at infinity, continuity of a function, sequential criterion, algebra and composition of continuous functions.
- Continuous functions on intervals, maximum-minimum theorem, location of roots and Bolzano's intermediate value theorem. Uniformly continuity. Lipshitz function. Continuous extension theorem.
- Differentiability, Rolle's Theorem, Mean value theorems and applications, Taylor's theorem, Expansion of functions by Maclaurin's theorem.
- Weierstrass approximation theorem. Bernstein Approximation theorem. Monotone and inverse functions, continuous inverse theorem.
- Riemann Integration: definition and properties up to fundamental theorem of integral calculus.

Textbook(s):

- Bartle, R. G. and Sherbert, D. R., *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons, 2005 (reprint, Wiley India, 2011).
- Kumar, A. and Kumaresan, S. *A Basic Course in Real Analysis*, CRC Press, 2014.

MI 105: Real Analysis-I

L 2 T1 P0 CR3

Course outcomes

1. Towards the end of the course students would develop an aptitude for logic and deductive arguments.
2. They will be well versed with proper way of thinking/analyzing and writing.
3. Apart from these, students will not only understands the topics but also able to apply them in their upcoming analysis courses.

Course content

- Real Numbers: algebraic and ordered properties, completeness property, supremum and infimum and applications. Absolute value and triangle inequality.
- Archimedean property and its applications, density theorem. Intervals, nested interval property. Binary and decimal representation, Cantor's proof of unaccountability of [0,1]. Cantor set.
- Sequences, bounded sequences, tails of a sequence, Cauchy sequence, convergent sequence and its limit, algebra of limits. Monotone sequences, monotone convergence theorem. Subsequences, divergence criterion. Construction of R.
- Infinite series, sequence of partial sums. Convergent and absolutely convergent series. Test of convergence. Alternating series. Rearrangement of infinite series.

Textbook(s):

- Bartle, R. G. and Sherbert, D. R., *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons, 2005 (reprint, Wiley India, 2011).
- Kumar, A. and Kumaresan, S., *A Basic Course in Real Analysis*, CRC Press, 2014.

MI 106: Group Theory

L 2 T1 P0 CR3

Course outcomes

1. At the end of the course the students will have a clear knowledge of basic group theory and they will be able to apply fundamental concepts of groups in solving various algebraic problems.
2. Students will get solid background for learning other courses on algebra to be offered in the subsequent semesters.

Course content

- Binary operation, semigroup, monoid, group, elementary properties of groups, subgroup, order of an element, coset, Lagrange's theorem and its applications.
- Conjugacy class, class equation, normal subgroups and quotient groups.
- Subgroup generated by a set, cyclic subgroups, properties of cyclic groups, fundamental theorem of cyclic group.
- Permutation, cycle notation, even and odd permutation, order of a permutation, symmetric group and alternating group. Dihedral group and presentation of group.
- Homomorphism and isomorphism of groups, isomorphism theorems, Cayley's theorem.
- Direct product of groups, properties of direct products.

Textbook(s):

- Gallian, J. A., *Contemporary Abstract Algebra*, 4th edition, Narosa Publishing house, New Delhi, 2009.
- Dummit, D. S. & Foote, R. M., *Abstract Algebra*, 3rd edition (John Wiley & Sons, Indian reprint, New Delhi, 2011.

Suggested readings:

- Fraleigh, J. B., *A First Course in Abstract Algebra*, 7th edition (Pearson Education India, New Delhi, 2008.

- Herstein, I. N., *Topics in Algebra*, 2nd edition (John Wiley & Sons, Indian reprint, New Delhi, 2006.

MI 218: Introductory ODE & PDE

L 2 T1 P0 CR3

Course outcomes

1. Students are expected to be proficient in solving basic ordinary and partial differential equations using analytical techniques.
2. They should be able to model some physical problems and apply knowledge thus earned in other areas of mathematics.

Course content

- First order linear and nonlinear ODE: Exact differential equations and integrating factors, separable equations and equations reducible to this form, Bernoulli equation, integrating factors and transformations, Clairaut form, singular solution. Orthogonal and oblique trajectories, rate problems.
- Explicit methods of solving higher order linear differential equations: Basic theory of linear differential equations, homogeneous linear differential equations with constant coefficients, method of undetermined coefficients, variation of parameters, Cauchy-euler equation, Wronskian. Statements and proofs of theorems on second order homogeneous linear equations.
- Laplace Transforms: Laplace Transforms of some elementary functions, Linearity property, First and second translational or shifting theorem. Change of scale property, Laplace transforms of derivatives, multiplication by powers of t, and related problems. Laplace transform of periodic functions. Inverse Laplace transforms, Convolution theorem. Solution of ordinary differential equations by Laplace transform.
- Series Solutions for ODE, Types of singularity, Solution at an Ordinary Point, Solution at a Singular Point. Method of Frobenius. General solution of Bessel and Legendre equation.
- Introduction, Origins of First order PDE, Cauchy Problem for First order equations, Linear equations of first order, Lagrange equation, Integral Surface passing through a given curve, surface orthogonal to a given system of surfaces.
- Nonlinear PDE of first order, Compatible systems of first order equation, Charpit's Method, special types of first order equations, solution satisfying given conditions

Textbook(s):

- Ross, S.L., *Differential equations*, 3rd edition, (Wiley, 2016).
- Sneddon, I., *Elements of Partial Differential Equations*, (Dover, 2006).

Suggested readings:

- Fraleigh, J. B., *A First Course in Abstract Algebra*, 7th edition (Pearson Education India, New Delhi, 2008.

MI 220: Linear Algebra-I

L 3 T1 P0 CR4

Course outcomes

1. It is expected that at the end of the course the student will be able to apply the techniques of Linear Algebra to other branch of mathematics and practical problems.

Course content

- Matrices and System of linear equations, Reduced Row-Echelon form and its relevance to Linear systems, Elementary operation, Gaussian reduction.
- Vector spaces and Subspaces, Direct sum of subspaces, Quotient space.
- Linear combination and Span, Linear Independence, Exchange lemma, Basis of a vector space and Dimension Theory.
- Linear transformation, Linear transformations and Linearly Independent Sets, Matrix representation of linear transformations, Transition matrix and similar matrices, Rank of a linear Transformation and Rank of a matrix.
- Determinants, Multilinear Transformations, Determinant of a Family of Vectors, of a Matrix, and of a Linear Transformation.
- Eigenvalues and eigenvectors, Characteristic polynomial, Cayley-Hamilton Theorem, Diagonalizable Matrices and Linear Transformations .
- **Textbook(s):**
- Stephen H. F., Arnold J. I. and Lawrence E. S., *Linear Algebra*, 4th edition, Prentice Hall, 2003
- Hoffman, K. and Kunze, R., *Linear Algebra*, Prentice Hall, 1984.
- **Suggested readings:**
- Halmos, P. R., Finite dimensional vector spaces, Springer Verlag, New York, 1987.
- Poole, David, Linear Algebra: A modern introduction, 3rd edition, Brroks/Cole Cengage learning, 2011.

MI 221: Introductory Statistics & Probability

L 2 T1 P0 CR3

Course outcomes

1. Students learn the basic tools/concepts of collection and analysis of statistical data, without rigorous probability theory.

Course content

- Definitions of Statistics, population, sample, data and characteristics of data. Measures of central tendency, dispersion. Histogram, frequency curve and boxplot.
- Skewness and its measures. Normal and student's-t curves. Kurtosis and its measures. Effects of change of origin and scale. Definition of Probability and some properties of the probability function.

- Random variable, Probability distribution and distribution function. Discrete and continuous distribution. Some important discrete and continuous distributions.
- Random sampling and sampling fluctuation, Simple random sampling, variance of sample mean under SRS WOR, Estimation of population size (capture-release- capture method), Correlation and simple linear regression. Rank correlation.

Textbook(s):

- Medhi, J., *Statistical Methods: An introductory Text*, (New Age International (P) Ltd, 2000).
- Gupta, S.C. and Kapoor, V. K., *Fundamentals of Mathematical Statistics*, (S. Chand & Co., 2007).
- Cochran, W.G., *Sampling Techniques*, third edition (John Wiley & Sons, 1977).

Suggested readings:

- Feller, W., *An Introduction to Probability Theory and Its Applications*, Vol. I, (Wiley, 2005).
- Uspensky, J.V., *Introduction to Mathematical Probability*, (McGraw Hill, 2005).

MI 222: Co-ordinate Geometry

L 3 T1 P0 CR4

Course outcomes

1. At the end of the course the student will have a concrete understanding of conic sections both in 2D and 3D, and would be able to apply the concepts and solve problems.

Course content

- Transformation of co-ordinate axes. Pair of straight lines. General equation of second degree and the conditions for representing a pair of straight lines, a parabola, an ellipse, a hyperbola and a circle.
- Reduction to standard forms: The centre of a conic, Reduction of the equation of a central conic, Equation of the axes and length of the axes, Reduction of the equation of a non-central conic. The equation of tangent, Condition of tangency of line, Equation of normal, Pair of tangents and director circle, Chord of contact, Pole and polar, Chord in terms of middle points, Diameter and conjugate diameters, Asymptotes.
- Polar equation of a conic, tangent and normal, properties. Circle and its parametric form, Orthogonal circle, condition of orthogonality of circles.
- Change of axes: shift of origin, rotation of axes. Sphere, Cone and Cylinder.
- Central Conicoids: Ellipsoid, Hyperboloid of one and two sheets. Intersection of a conicoid and a line: Tangent line, tangent plane, condition of tangency, Director sphere. Normal: Equation of the normal, number of normals from a given point, cubic curve through the feet of the normal, cone through six normal. Polar plane and polar lines, Enveloping cone, Enveloping cylinder, Diameters and diametral planes, conjugate diameters and diametral planes.
- The paraboloid. Reduction of second degree equations.

Textbook(s):

- Jain, P.K. and Ahmad, K., *Text Book of Analytical Geometry of two & three Dimensions*, New Age Publications, 2014.
- Das, B., *Analytical Geometry and Vector Analysis*, (Orient Book Company, 1995).

Suggested readings:

- Khan, R.M., *Analytical Geometry & Vector Analysis*, (New Central Book Agency Pvt. Ltd., 2004).
- Askwith, E. H., *A Course of Pure Geometry*, Michigan Historical Reprint Series (University of Michigan Library, 2005).
- Askwith, E. H. and Askwith, E., *A Course of Pure Geometry* (Hard Press, 2007).
- Spain, B., *Analytical Conics* (Dover, 2007).
- McCrea, W. H., *Analytical Geometry of Three Dimensions* (Dover, 2006).

MI 223: Calculus I

L 3 T1 P0 CR4

Course outcomes

1. Students will learn how to apply the tools of calculus to a variety of problem situations.
2. Students will be able to interpret the geometric meaning of differential calculus.
3. This topic will work as a foundation for mathematical analysis courses.

Course content

- Indeterminate forms, L'Hospital's Rule, Successive differentiation.
- Convexity and point of inflexion; Tangent and Normal; Curvature of plane curves; Asymptotes; Envelopes; Singular points.
- Curve tracing: tracing of catenary, cissoids, asteroid, cycloid, folium of Descartes, cardioid, lemniscate.
- Functions of two variables: Limit, Continuity, Partial derivatives, Directional derivatives, Euler's theorem on homogeneous functions, Total Derivative and total differentials, Chain rule, Directional derivatives, Gradient vectors and equations of Tangent planes.
- Partial derivatives of higher order, Taylor's theorem, Criteria for Maxima/ Minima/ Saddle points, Lagrange's method of multipliers.
- The relation between integration and differentiation: the derivative of an indefinite integral, the first fundamental theorem of calculus, primitive functions and the second fundamental theorem of calculus, the Leibniz notation for primitives, integration by substitution, integration by parts.

Textbook(s):

- Thomas and Finney, *Calculus and Analytic Geometry*, (Pearson Education, Eleventh (Indian) Edition), 1998.
- Bartle, R. G. and Sherbert, D. R., *Introduction to Real Analysis*, (John Wiley and Sons, Third (Indian) Edition), 2007.

Suggested readings:

- Apostol, T. M. *Calculus*, Vol I & II, (John Wiley and Sons, Second (Indian) Edition), 2007.
- G. A. Osborne, *Differential and Integral Calculus with examples and applications*, Forgotten Books' Classic Reprint Series, 2011.
- B. C. Das and B. N. Mukherjee, *Differential Calculus*, U N Dhur & Sons Private Ltd, (19^{th} Editions) 1957
- R. Cournat, *Differntial and Integral Calculus*, John Wiley & Sons, 1970.

MI 224: Numerical Methods and Boolean Algebra

L 3 T1 P0 CR4

Course outcomes

1. Students will learn some of the basic methods and tools of Numerical Analysis.

Course content

- Finite Difference operators and their operations on functions of a single variable. Existence and uniqueness of interpolating polynomial, Lagrange interpolation, Newton divided difference, forward and backward interpolation, central difference interpolation and associated error terms. Extrapolation and inverse interpolation. Properties of divided differences.
- Roots of algebraic and transcendental equations: Bisection method, Secant method, Regula-Falsi method, Newton-Raphson method, their geometrical interpretation and derivation.
- Numerical differentiation, Richardson's extrapolation. Numerical integration: Newton –Cotes quadrature formula, Trapezoidal rule, Simpson's 1/3rd and 3/8th rule of integration. Use, interpretation and derivation. Composite Trapezoidal and Simpson's rules. Double integration.
- Solution of system of linear algebraic equations: Direct methods- Gauss elimination, pivoting and Gauss-Jordan methods. LU-factorization.
- Boolean ring and Boolean algebra, principle of duality, fields of sets, elementary relations.

Textbook(s):

- Atkinson, K.E., *An introduction to Numerical Analysis*, 2nd edition (John Wiley and Sons. 2004).
- Burden, R.L., and Faires, J.D., *Numerical analysis theory and applications*, (Cengage Learning, 2005).
- Jain, R.K., and Iyenger, S.R.K., *Advanced Engineering Mathematics* (CRC Press, 2002).
- Givant, S., Halmos, P., *Introduction to Boolean algebras,* (Springer, 2009).

Suggested readings:

- Jain, M.K., Iyengar, S.R.K. and Jain R.K. *Numerical methods for Scientific and Engineering Computation*, 5th edition (New Age International (P) Ltd., New Delhi, 2006).
- Sastry, S.S., *Introductory methods of Numerical Analysis* (Prentice Hall of India, New Delhi, 1997).

MI 225: Combinatorics

L 3 T1 P0 CR4

Course outcomes

After completing the course student will

1. learn different combinatorial techniques and will be able to apply these techniques in solving problems in other branches of Mathematics.
2. increase their mathematical skill.
3. be mathematically matured.

Course content

- Basic counting rules, Permutations: Allocation Problem, Circular and Ring Permutations, Generalized Permutations, Combinations: Allocation Problem, Pascal's formula, Generalized combinations, The Multinomial Theorem, Properties of Binomial Coefficients.
- Partitioning of a set, The pigeonhole Principle: simple form, strong form, The inclusion-Exclusion principle, Calculating in two ways: Fubini's Principle, Derangements.
- Generating Functions: Ordinary generating Functions, Exponential generating Function.
- Recurrence Relations: Homogeneous Recurrence Relations, Inhomogeneous Recurrence Relation.

Textbook(s):

- Richard A. Brualdi, *Introductory Combinatorics*, 5th Edition, Pearson, 2010.
- V. K. Balakrishnan, *Introductory Discrete Mathematics*, Dover Publications, New York, 1996.

Suggested readings:

- K. H. Rosen, *Discrete Mathematics & its Applications*, 6th Edition., Tata McGraw- Hill, 2007.
- S. Lipschutz, M. Lipson, *Theory and Problems of Discrete Mathematics*, 3rd Edition, Schaum's Outline Series, McGraw-Hill.

MI 226: Introductory Topology

L 3 T1 P0 CR4

Course outcomes

At completion of the course, students will

1. demonstrate an understanding of the concepts of metric spaces and topological spaces, and their role in mathematics
2. demonstrate an understanding of the basic of convergence of sequences, continuity of functions in metric Spaces and topological spaces.
3. apply the theory in the course to solve a variety of problems at an appropriate level of difficulty.

Course content

- Definition and examples of metric spaces, Neighborhoods, Limit points, Interior and boundary points, Open and closed sets, Closure and interior of a set, Equivalent metrics.
- Subspaces, Cauchy sequences, Completeness, Cantor's intersection theorem, Baire's category theorem.
- Continuous functions, Uniform continuity, Isometry.
- Topological spaces, examples, basis and sub-basis, subspaces, closure, interior, exterior and boundary.
- Continuity, open functions, homeomorphisms, embeddings, strong and weak topologies.

Textbook(s):

- O'Searcoid, M., *Metric Spaces*, Springer, 2006.
- Shirali, S. and Vasudeva, H. L., *Metric Spaces*, Springer, 2007.
- Munkres, J. R. *Topology : A first course* (2/e), Pearson Education, 2000

Suggested readings:

- Kumersan, S., *Topology of Metric Spaces*, Narosa, 2011.
- Simmons, G. F., *Topology and Modern Analysis*, McGraw Hill Education, 2017.

MI 311: Calculus II

L 3 T1 P0 CR4

Course outcomes

At completion of the course, students will be able to

1. evaluate integrals involving reduction techniques.
2. identify and evaluate Improper integrals and use beta gamma functions.
3. use techniques of vector calculus in physical problems.
4. evaluate double and triple integrals and use them to calculate area, length, volume and surface area of solids of revolution.
5. identify where and how to apply Green, Gauss and Stokes theorem.

Course content

- Reduction formulae for integration. Improper Integral, Beta and Gamma functions.
- Line integral, Double integral, triple integral, Jacobian, Surface integral and their applications. Volume, Area, length, volume and surface area of solids of revolution.
- Vector Calculus, vector point function, continuity and differentiation of vector point function, partial derivative of vectors, Curl, Gradient, Divergence. Vector Integration.
- Green, Gauss and Stokes Theorems and their applications

Textbook(s):

- Apostol, T. M. *Calculus*, Vol I & II, (John Wiley and Sons, Second (Indian) Edition), 2007.

Suggested readings:

- Spiegel, M. R., *Vector Analysis, Schaum's outline series, (*Publishing House India), 2009.
- Thomas and Finney, *Calculus and Analytic Geometry,* (Pearson Education, Eleventh (Indian) Edition), 1998.
- B. C. Das and B. N. Mukherjee, *Integral Calculus,* U N Dhur & Sons Private Ltd, (19th Editions) 1977.
- R. Cournat, *Differntial and Integral Calculus,* John Wiley & Sons, 1970.
- G. A. Osborne, *Differential and Integral Calculus with examples and applications*, Forgotten Books' Classic Reprint Series, 2011.

MI 312: Ring Theory

L 2 T1 P0 CR3

Course outcomes

1. It is expected that at the end of the course the student will be able to understand the advanced algebra courses easily in the subsequent semesters.

Course content

- Ring, properties of rings, subring, ideal and quotient ring.
- Integral domain, division ring, field, characteristic of ring.

- Ideal generated by a set, principal ideals, prime ideals, maximal ideals.
- Homomorphism, isomorphism and isomorphism theorems.
- Polynomial rings, Division algorithm and consequences, factorization of polynomials, reducibility and irreducibility tests.

Textbook(s):

- Gallian, J. A., *Contemporary Abstract Algebra*, 4th edition (Narosa Publishing house, New Delhi, 2009).
- Dummit, D. S. & Foote, R. M., *Abstract Algebra*, 3rd edition (John Wiley & Sons, Indian reprint, New Delhi, 2011).
- Musili, C., *Introduction to rings and modules*, 2nd revised edition, Narosa, 2010.

Suggested readings:

- Fraleigh, J. B., *A First Course in Abstract Algebra*, 7th edition (Pearson Education India, New Delhi, 2008).
- Herstein, I. N., *Topics in Algebra*, *2nd* edition (John Wiley & Sons, Indian reprint, New Delhi, 2006).

MI313: Programming, Algorithm and Mathematical Software

L 2 T0 P2 CR4

Course outcomes

1. Towards the end of the course the student would be able to use Mathematica/MATLAB for solving various problems of mathematics.

Course content

- Algorithms and flowcharts. Divide and conquer strategy.
- Fundamentals of C: Data types in C, variables in C, input output statements, constant declaration, arithmetic operators in C, arithmetic expressions, assignment statements, arithmetic assignment operators, increment and decrement operators, type conversions, operator precedence.
- Basic techniques: sum of numbers, swapping contents of variables, computing area, simple interest etc. Decision making: if statement, if…else statement, the break statement, the continue statement, the go-to statement.
- Looping techniques: for loop, while loop, do…while loop.
- Basic operations through Matlab, Input through keyboard and its illustration, Flow Control statements.
- Iterative Method for Solving Non-linear Equation, Numerical Integration, Numerical Solution of 1st order IVP.
- Numerical Differentiation and BVP.
- Introduction to Mathematica, Symbolic Computation.

Textbook(s):

- Rajaraman, V., *Fundamentals of Computers*, (PHI, 2002).
- Venkateshmurthy, M.G., *Programming Techniques through C-A Beginner's Companion*,

(Pearson Education, 2002).

- Pratap, R., *Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers* (Oxford University Press, USA , 2005)
- Otto, S.R. & Denier, J. P., *An Introduction to Programming and Numerical Methods in MATLAB* (Springer, 2009).
- Torrence, Bruce F. & . Torrence, Eve A., *The student's introduction to Mathematica*, 2nd edition (Cambridge University Press, 2009).

Suggested readings:

- Hunt, B. R., Lipsman, R. L., Osborn, John E. & Rosenberg, J., *Differential Equations with Matlab*, (Wiley, 2005).
- Wolfram, S., *The Mathematica Book* (Wolfram Media, 2008).
- Gray, T. W. & Glynn, G., *The Beginners Guide to Mathematica*, Version 4, Addision-(Wesley, 2008).

MI 314: Elementary Number Theory

L 3 T1 P0 CR4

Course outcomes

1. At the end of the course the student will be able to go for higher courses in number theory.
2. They will be more logical and careful in finding proofs of mathematical results.
3. They will be able to answer the questions related to number theory in NET/GATE examinations.

Course content

- Divisibility, greatest common divisor, least common multiple, Euclidean Algorithm.
- Prime numbers, factorization in prime numbers, fundamental theorem of arithmetic.
- Divisor functions, perfect numbers, Mersenne numbers, Fermat numbers.
- Greatest integer function (Gauss function), Mobius function, Euler function.
- Concept of congruences and its elementary properties, congruences in one unknown, complete residue system, reduced residue system.
- Diophantine equations, linear Diophantine equations, Pythagoras equation, sum of two squares.
- Quadratic residues and congruences of second degree in one unknown, Legendre symbol, Jacobi symbol, congruences of second degree with prime modulus and with composite modulus.
- Primitive roots and indices, order, necessary and sufficient condition for the existence of primitive roots, construction of reduced residue system.
- Continued fractions, simple continued fractions, approximation of irrational numbers by continued fractions, solution of Pell's equation.

Textbook(s):

- Burton, D. M., *Elementary Number Theory*, 6th Edition (Tata McGraw-Hill, New Delhi, 2007).
- Niven, I. and Zuckerman, H., *An Introduction to the Theory of Numbers*, 5th Edition (Wiley Eastern, New Delhi, 2000).

Suggested readings:

- Hardy, G.H. and Wright, E. M., *An Introduction to the Theory of Numbers*, 4th edition (Oxford University Press, 1960).
- Andrews, G.E., *Number Theory* (Hindustan Publishing Corporation, New Delhi, 1992).
- Telang, S. G., *Number Theory* (Tata McGraw-Hill, New Delhi, 1996).
- Hsiung, Y., *Elementary Theory of Numbers* (World Scientific, 1992; First Indian Reprint, Allied Publishers Limited, 1995).

MI 315: Statics and Dynamics

L 3 T1 P0 CR4

Course outcomes

1. It is expected that at the end of the course the student will be able to apply knowledge of Statics and Dynamics wherever needed further.

Course content

- Centre of Mass, Radius of gyration, Centre of gravity of a plane area, arc and sector of acurve. Centre of gravity of solids and surface of revolution.
- Friction, laws of friction, limiting friction, equilibrium of a particle in rough inclined plane.
- Buoyancy, Hydrostatic equilibrium, Archimedes' Principle, Capillary rise, Surface Tension.
- Principle of virtual work in two dimensions, Neutral, Stable and Unstable equilibrium.
- Velocities and acceleration, Newton's laws of motion, velocity and acceleration in curvilinear coordinates, tangential and normal components of velocity, acceleration, momentum, force etc.
- One dimensional motion in resisting medium; motion of particles of variable mass, Rocket motion. Two dimensional motion, motion of a projectile.
- Central force reduced mass, angular momentum; motion under central force, inverse square law of motion, polar equation of orbit, Keplar's laws of motion.
- Periodic motion; Simple harmonic motion, Differential equation of simple harmonic motion and solution, Kinetic and Potential energies of Simple harmonic motion, Compound pendulum.
- Kinematics of rigid bodies, Euler's theorem, moments and products of inertia. Parallel axes theorem, theorem of six constants. Principal axes.

Textbook(s):

- Whittaker, E.T. and McCrea, W., *A Treatise on the Analytical Dynamics of Particles and Rigid Bodies: with an Introduction to the Problem of Three Bodies* (Cambridge University Press, 1988).
- Loney, S. L., *Elements of Statics & Dynamics*, Part I (Maxford Books, 2003).
- Rao, S., *Engineering Mechanics - Statics and Dynamics* (Pearson Education, 2008).

Suggested readings:

- Spiegel, M. R., *Schaum's Outline of Theory and Problems of Theoretical Mechanics: with an Introduction to Lagrange's Equations and Hamiltonian Theory* (McGraw-Hill, 2007).
- Ramsey, A. T., *Dynamics*, 2nd Edition (The University Press, 2007).
- Chorlton, F., *Textbook of Dynamics*, 2nd edition (Horwood, 1983).
- Loney, S. L., *An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies*, (AITBS Publishers, 2016).

MI 316: Introduction to Optimization

L 3 T1 P0 CR4

Course outcomes

1. After completion of the course, we expect that the student will be able to formulate fairly complex optimization problems and will be able to solve.

Course content

- General linear programming problems, Standard form of L.P.P., Graphical method for L.P.P.
- Geometry of linear programming: Polyhedra and Convex sets, Extreme point, vertices and basic solutions, basic feasible solutions,, Convex function, Convex hull of a set, Convex polyhedrons, Existence of extreme points, optimality of extreme points.
- Supporting hyperplanes and extreme points, Development of Simplex method, Applications of Simplex Technique, Column geometry and the simplex method, Solution of Simultaneous Equations, Inverse of a Matrix By Simplex Method, Problem of Degeneracy.
- The dual Problem, duality theorem, comparison of solutions of primal and its dual. Standard form problems and the dual simplex method along with its limitations, Farkas' lemma and linear inequalities, Separating hyperplane and duality General linear programming duality.
- Formulation of LP problem in revised simplex form. Computational procedure (algorithms). Advantage of revised simplex over simplex.

Textbook(s):

- Hadley, G., Linear Programming, (Narosa Publishing House, New Delhi, 1987).
- Kanti Swaroop, P.K. Jain and Man Mohan, Operation Research: An Introduction, (S. Chand & Company, New Delhi, 1996).

Suggested readings:

- Taha, H.A., *Operation Research: An Itroduction*, (Macmilllan, New York., 1992)
- Kambo, N.S., *Mathematical Programming Techniques*, (Affiated East West Press, New Delhi., 1990).

MI 317: Elementary Complex Analysis

L 3 T1 P0 CR4

Course outcomes

At completion of this course students will learn

1. the concept of analytic functions
2. complex integration over curves, and contours
3. connection between analytic functions and their integration over closed contour

Course content

- Complex numbers as ordered pairs, Geometric representation of complex numbers, Riemann sphere and Stereographic Projection.
- Continuity and differentiability of complex functions, Analytic functions, Cauchy-Riemann equations, harmonic functions.
- Elementary analytic functions (exponential function, trigonometric functions and logarithm function) and their mapping properties.
- Complex integration, Cauchy-Goursat theorem, Cauchy's integral formula.
- Cauchy's Integral formula for derivatives, Cauchy's inequality and Liouville's theorem, the fundamental theorem of algebra, Maximum-modulus theorem, Morera's theorem.

Textbook(s):

- Churchill R. V. and Brown, J. W., *Complex variables and applications*, McGraw-Hill International edition, 2006.
- Mathews, J. H. and Howell, R. W., *Complex Analysis for Mathematics and Engineering*, 3rd Edition, Narosa, 1998.
- Ponnusamy, Foundations of Complex Analysis. 2nd Edition , Narosa Book Distributors Pvt Ltd , 2008.

Suggested readings:

- Saff, E. B. and Snider, A. D., *Fundamentals of Complex Analysis with applications to Engineering and Science*, 3rd Edition, Pearson, 2003 (ISBN 978-81-317-2019-6)

MI 318: Elementary Integral Transforms and Special Functions

L 3 T1 P0 CR4

Course outcomes

1. Students are expected to be proficient in solving basic ordinary and partial differential equations using analytical techniques.
2. They will able to model some physical problems and apply knowledge thus earned in other areas of mathematics.

Course content

- Bessel function and recurrence relations, Orthogonal sets of Bessel functions, Modified Bessel functions, Applications.
- Orthogonal polynomials: Legendre polynomials, Associated Legendre polynomials, Hermite polynomials, Laguerre polynomials, Chebyshev polynomial.
- The Hypergeometric functions and confluent hypergeometric functions.
- Fourier Series, Generalized Fourier series, Fourier Cosine series, Fourier Sine series, Fourier integrals.
- Definition of Fourier Transform and Examples, Basic Properties of Fourier Transforms. Fourier sine Transform, Fourier cosine Transform. Linearity, Change of scale property, Shifting property, modulation theorem. Convolution Theorem for Fourier transform, Parseval's Identity. Finite Fourier Sine Transform, Finite Fourier Cosine Transform, Inversion formula for sine and cosine Transforms only statement and related problems.
- Mellin transform, Hankel transform, Z-transform

Textbook(s):

- Whittaker E.T., Watson G.N., *A course of Modern Analysis*, Cambridge Mathematical Society.
- Andrews L.C., Shivamoggi B.K., *Integral Transform for Engineers*, PHI.
- Debnath L., Bhatta, D., *Integral transforms and their applications*, 3rd edition, (CRC Press, 2015).

MI319: Graph Theory

L 3 T1 P0 CR4

Course outcomes

Towards the end of the course students will able to

1. apply theories and concepts to test and validate intuition and independent mathematical thinking in problem solving.
2. improve the proof writing skills.
3. use graph theory as a modelling tool.
4. apply graph theory based tools in solving practical problems.

Course content

- Preliminaries: Graphs, subgraphs, Isomorphism, degree, degree sequence, operations on graphs.
- Walk, Trail, Path, Cycle, circuit, Connected graphs, component, distance between vertices, Bipartite graph, eccentricity, radius, diameter.
- Tree, Bridge, Center of a tree, Forest, Spanning tree.
- Cut-vertices, Block, vertex-connectivity, edge-connectivity, Eulerian graph and its properties, Hamiltonian graph and its Properties.
- Planarity: Basic Concepts, Plane Graphs, Interior face, exterior face, Euler Identity, Maximal Planar graph.
- Coloring: vertex coloring, chromatic number, The Four Color Theorem, independence number, Brook's theorem, edge Coloring, edge chromatic number, The Five color Theorem.
- Digraph, oriented graph, indgree, outdegree, strong digraph, tournament, transitive tournament.

Textbook(s):

- G. Chartrand and P. Zhang, *A First Course in Graph Theory*, Dover Publication, NewYork, 2012.
- J. A. Bondy, U.S. R. Murthy, *Graph Theory with Applications*, London: Macmillan Press; 1976.

Suggested readings:

- D. B. West, *Introduction to Graph Theory*, 2nd Edition, Pearson Education, 2015.
- R, J. Wilson, *Introduction to Graph Theory*, 4th Edition, Longman, England, 1996.
- F. Harary, *Graph Theory*, Narosa Publishing House, New Delhi, 2001.

MI 320: Elementary Coding and Information Theory

L 3 T1 P0 CR4

Course outcomes

At completion of the course students will learn

1. the basic idea about encoding and decoding of data.
2. the ideas of entropy and information content.
3. the idea of data compression and channel coding.
4. how different coding techniques will perform in different situations.

Course content

- Coding and Decoding: Coding, Unique Decoding, Block Codes and Instantaneous Codes, Some Important Block Codes, Construction of Instantaneous Codes, Kraft's Inequality, McMillan's Theorem.
- Huffman Codes : Information Source, Huffman Codes, Construction of Binary Huffman Codes, Construction of General Huffman Codes.
- Data Compression and Entropy: An Example of Data Compression, The Idea of Entropy, The Definition of Entropy. Maximum and Minimum Entropy, Extensions of a Source, Entropy and Average Length, Shannon's Noiseless Coding Theorem.
- Reliable Communication Through Unreliable Channels: Binary Symmetric Channels, Information Rate, Hamming Distance, Detection of Errors, Correction of Errors, Channel Capacity, Shannon's Fundamental Theorem.
- Error-Correcting Codes: Binary Addition and Multiplication, Codes Described by Equations, Binary Linear Codes, Parity Check Matrix, The Probability of Undetected Errors.

Textbook(s):

- Jiří Adámek, *Foundations of Coding: Theory and Applications of Error-Correcting Codes with an Introduction to Cryptography and Information Theory*, John Wiley & Sons, INC, 1991.
- Richard W. Hamming, *Coding and Information Theory (2nd Ed.)*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 1986.

Suggested readings:

- Steven Roman, *Coding and Information Theory*, Springer-Verlag New York, 1992.
- Raymond Hill, *A First Course in Coding Theory*, Oxford University Press, 1990.

MI 408: Complex Analysis

L 3 T1 P0 CR4

Course outcomes

At completion of this course students will be

1. acquainted with the theory of functions of a single complex variable.

2. introduced to the theory of residues in evaluating real improper integrals and definite integrals involving sine and cosie functions, locating zeros of functions, and so on.
3. introduced the conformal mapping and Mobius transformation which have many applications in other fields of science and engineering.

Course content

- Convergence of sequences and series, Absolute and uniform convergence of power series, Integration and differentiation of power series, uniqueness of series representations.
- Taylor series, Zeros of analytic functions, Limit points of Zeros, Singularities and their classification, Behaviour of the function in a neighbourhood of isolated singularities, Laurent's series, Residues, Cauchy Residue Theorem.
- Evaluation of improper integrals and definite integrals involving sines and cosines, integration through a branch cut.
- The winding number, Logarithmic residues and Rouche's theorem, the Argument Principle.
- Mapping by elementary functions, Linear fractional transformations, cross ratios, mappings of the half planes and circles, conformal mapping, Statement of Riemann Mapping Theorem.
- Schwarz Reflection Principle, Analytic continuation, Riemann Surfaces.

Textbook(s):

- Mathews, J. H. and Howell, R. W., *Complex Analysis for Mathematics and Engineering*, 3rd Edition, Narosa, 1998.
- Conway, J. B. *Functions of One Complex Variable*, 2nd Edition, Narosa Publishing House, India, 1994.
- Churchill, R. V. and Brown, J. W. *Complex Variables and Applications*, McGraw-Hill, Education (India) Edition, 2014.

Suggested readings:

- Ahlfors, L. V. *Complex Analysis*, 3rd Edition (McGraw-Hill Publishing Company, New Delhi, 1979.
- Priestly, H.A. *Introduction to Complex Analysis*, 2nd Edition, Cambridge, 2008.
- Gamelin, T. W., *Complex Analysis*, UTM, Springer, 2003.
- Narasimhan, R. and Nievergelt, Y., *Complex Analysis in One Variable*, 2nd Edition, Springer (India), New Delhi, 2004.

MI 412: Abstract Algebra

L 3 T1 P0 CR4

Course outcomes

Towards the end of the course students will understand

1. basic concepts in group theory, cyclic groups, permutation groups, subgroups, normal subgroups and group homomorphisms

2. structures of finite groups, Sylow Theorems, finite Abelian groups, normal series, and solvable groups
3. rings, fields, homomorphisms, embedding theorems, polynomial rings, factorization theory in integral domains, Euclidean domains, and Gaussian domain
4. separable and inseparable extension of fields, finite fields, and elements of Galois theory

Course content

- External direct product of groups, properties of external direct products, internal direct products, fundamental theorem of finite abelian groups and applications.
- Group action, properties of group action, class equation of finite groups, Sylow's theorems, applications of Sylow's theorems.
- Subnornmal, normal series, derived group, solvable groups, composition series, nilpotent groups, Jordan-Holder theorem.
- Word, reduced word, free group, rank of a free group, fundamental theorem of free groups, presentation of groups.
- Polynomial rings, rings of formal power series, embedding theorems, field of fractions.
- Factorization theory in integral domains, PID, UFD and Euclidean domains.
- Field extensions, algebraic and transcendental elements, geometrical constructions, splitting field, finite fields, structure of finite fields, normal, separable and inseparable extension of fields.

Textbook(s):

- Gallian, J. A., *Contemporary Abstract Algebra*, 4th edition, Narosa Publishing house, New Delhi, 2009.
- Dummit, D. S. & Foote, R. M., *Abstract Algebra*, 3rd edition (John Wiley & Sons, Indian reprint, New Delhi, 2011.
- Herstein, I. N., *Topics in Algebra*, 2nd edition (John Wiley & Sons, Indian reprint, New Delhi, 2006.

Suggested readings:

- Fraleigh, J. B., *A First Course in Abstract Algebra*, 7th edition (Pearson Education India, New Delhi, 2008.
- Lang, S., *Algebra*, 3rd edition (Springer India, New Delhi, 2006).

MI 413: Real Analysis-III

L 3 T1 P0 CR4

Course outcomes

In this course student will

1. learn some of the basic but fundamental concepts of real analysis

2. develop the analytical thinking by solving problems

3. familiarize the process of generalization (real line to any metric space)

Course content

- Sequence of functions, pointwise and uniform convergence, interchange of limits. Functions of bounded variation. Reimann Stieltjes integral. Integration by parts.
- Compactness, Sequential compactness, Bolzano-Weierstrass Property, Totally bounded spaces, compactness and completeness, finite intersection property. Continuous functions on compact spaces. Characterization of complete metric spaces. Arzela Ascoli Theorem.
- Connectedness, intermediate value theorem, Completeness, Bolzano Weierstrass Theorem, nested set theorem. Fixed point theorem. Completion.
- Functions of several variables, directional derivatives, differentiability and total derivative. Jacobians, chain rule, higher order partial derivatives, Taylor's theorem. Inverse function theorem, Implicit function theorem, extremum problem with constraints, Lagrange's method of multiplier.

Textbook(s):

- Carothers, N. L., *Real Analysis.*
- Fleming, w., *Functions of several variables*.

Suggested readings:

- Apostol, T. M., *Mathematical Analysis, Narosa Publishing House,* 1985.
- Simmons, G. F., *Introduction to Topology and Modern Analysis* (Tata McGraw Hill Book Co. Ltd.,1963).

MI 414: Computer Programming^{+}

L 3 T1 P0 CR4

Course outcomes

In this course student will

1. develop programming skills.
2. learn basic techniques of C-language.
3. develop some expertise in developing programs to solve various mathematical problems

Course content

- Revision of fundamentals of C: Data types in C, variables in C, input output statements, constant declaration, arithmetic operators in C, arithmetic expressions, assignment statements, arithmetic assignment operators, increment and decrement operators, type conversions, operator precedence. for loop, while loop, do…while loop, if statement, if…else statement, switch statement, conditional operators. The break statement, the continue statement, the go-to statement.
- Arrays: Arrays, declaration of one dimensional arrays, two dimensional arrays. Structures and Unions: User defined data types, structures, array of structures, unions, enumerated data type.
- Searching and Sorting: Bubble sort, selection sort, insertion sort, linear search and binary search.

- Function in C: Simple functions, passing arguments to functions with return value, call by value, call by reference, overloaded functions, inline functions, default arguments.
- Pointers: Introduction; accessing address of a variable; pointer declaration, initialization, accessing variable through pointer, chain of pointers; pointer expressions, increment and scale factor. Pointers and Arrays. Array of pointers. Pointers as function arguments.
- Files in C: Defining and opening a file, closing a file. Input/Output operations on files.
- Dynamic Memory Allocation and Linked list: Dynamic memory allocation, Malloc, Calloc, Free, Realloc. Concepts of linked list, advantages of linked list, types of linked list. Creating a linked list.

Textbook(s):

- Rajaraman, V., *Fundamentals of Computers*, Prentice Hall of India, New Delhi,2002.
- Balaguruswamy, E., *Programming in ANSI C*, Tata McGraw-Hill, 2004.

Suggested readings:

- Kanetkar, Y. P., *Let us C* (BPB Publication, 2001).
- Venkateshmurthy, M. G., *Programming Techniques through C*, Pearson Education, 2002.

+ *Practical unit for the course MS 411 to be done in the course MS 421 Computer Laboratory*

MI 415: Lebesgue Measure and Integration

L 3 T1 P0 CR4

Course outcomes

1. At the end of the course the student would be able to have a better idea of the theory of integration and contribute to this classical field of knowledge by solving various problems.

Course content

- Algebra of sets, Borel sets, Extended real numbers.
- Lebesgue measure on the Real Line: Lebesgue outer measure, Lebesgue Measurable sets and Lebesgue measure, Non-measurable sets.
- Lebesgue Measurable functions, Simple functions, Littlewood's principles.
- Lebesgue integral of simple functions, Lebesgue integral of bounded functions, Bounded convergence theorem, Comparison of Riemann and Lebesgue integral.
- Lebesgue integral of non-negative functions, Fatou's Lemma, Monotone convergence theorem, Lebesgue general integral, Lebesgue dominated convergence theorem.
- Convex function and Jensen’s inequality, L^p spaces, Young, Holder and Minkowski inequalities, Completeness of L^p spaces, Bounded linear functionals on L^p spaces.

Textbook(s):

- Royden, H.L. and Fitzpatrick, P. M., Real Analysis, 4th Edition, Pearson, 2010.

- Barra, G. De., *Measure Theory and Integration*, New Age International(P) Ltd, Publishers, New Delhi 2003.

Suggested readings:

- Rana, I. K., *An Introduction to Measure and Integration*, 2nd edition, Narosa Publishing House India, 2000.
- Halmos, P. R., *Measure Theory*, Springer-Verlag, 1974.
- Jain, P. K. and Gupta, V. P., *Lebesgue Measure and Integration*, New Age International (P) Limited, New Delhi, 1986.

MI 416: Numerical Analysis +

L 3 T1 P0 CR4

Course outcomes

1. Towards the end of the course the student would be able to apply the concepts taught in various research problems as well as develop analytical capability in numerical analysis.

Course content

- Definition and sources of errors, Propagation of errors, Error analysis, Sensitivity and conditioning, Stability and accuracy, Floating-point arithmetic and rounding errors.
- Solution of system of linear algebraic equations: Iterative methods- Jacobi, Gauss-Seidel, Successive over-relaxation (SOR), symmetric SOR (SSOR). Numerical solution of non-linear simultaneous equations, Newton's method, General iteration method.
- Review of interpolation, Hermite interpolation. Spline interpolation, B-splines. Special emphasis on cubic spline.
- Approximation of function: The Weierstrass and Taylor theorem, Minimax and least square approximations, Orthogonal polynomials.
- Numerical solution of algebraic and transcendental equations: Methods based on first and second degree equations, rate of convergence. Theory of one point iterative methods and its convergence analysis, multipoint iterative methods. Numerical evaluation of multiple roots.
- Overview of Nwton-Cotes method. Composite integration. Gaussian quadrature, one point, two point and three point formulae. Orthogonal polynomials, Gauss-Legendre, Gauss-Hermite and Gauss-Laguerre quadrature formulae. Romberg integration.
- Solution of ordinary differential equations. Picard method, Euler method, backward Euler method, modified Euler method, Runge-Kutta class of methods.
- Solving problems with C codes.

Textbook(s):

- Atkinson, K.E. *Introduction to Numerical Analysis*, John Wiley, 1989.
- Jain, M.K., Iyengar, S.R.K. and Jain R.K. *Numerical methods for Scientific and Engineering Computation*, 5th edition, New Age International (P) Ltd., New Delhi, 2006.

Suggested readings:

- Sastry, S.S., *Introductory methods of Numerical Analysis*, Prentice Hall of India, New Delhi, 1977.
- *Hilderbrand*, F. B., *Introduction to Numerical Analysis,* Tata McGraw Hill, New Delhi, 1974.
- Conte, S. D., Boor, Carl de., *Elementary Numerical Analysis - An Algorithmic Approach*, 3rd Edition, McGraw Hill, 1980.

MI 417: Linear Algebra-II

L 3 T1 P0 CR4

Course outcomes

In this course student will

1. learn the analytic and geometric techniques of Linear Algebra.
2. understand the beautiful interplay between abstract theory and concrete applications of Linear Algebra.

Course content

- Matrix representation of a linear transformation, Annihilating polynomial of a linear transformation; Elementary Canonical forms: diagonalization and triangulation of linear operators. Gerschgorin's disk theorem.
- Primary Decomposition theorem; rational and Jordan forms.
- Inner product spaces: inner product, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalization process.
- Linear functionals and adjoints; self adjoint, positive definite, normal and unitary operators.
- Linear functionals and adjoints; self adjoint, positive definite, normal and unitary operators; orthogonal projections; spectral theorem for normal operators on a finite dimensional vector space, Singular value decomposition.
- Bilinear forms, Matrices of bilinear forms, Symmetric bilinear forms, Diagonalization of symmetric matrices, positive and quadratic forms, Sylvester's law of inertia.

Textbook(s):

- Stephen H. F., Arnold J. I. and Lawrence E. S., *Linear Algebra*, 4th edition, Prentice Hall, 2003.
- Halmos, P. R., *Finite dimensional vector spaces,* Springer Verlag, New York, 1987**.**
- Hoffman, K. and Kunze, R., *Linear Algebra*, Prentice Hall, 1984.

Suggested readings:

- Halmos, P. R., *Linear Algebra Problem Book,* The Mathematical Association of America (MAA), USA, 1995.

- Williams, G., *Linear Algebra with Applications,* Jones and Burlet Publishers, 2001.

MI 418: Theory of Ordinary Differential Equations

L 3 T1 P0 CR4

Course outcomes

At the end of the course student will able to

1. understand the qualitative behaviour of various initial and boundary value problems for ordinary differential equations which arise in applications.
2. solve ordinary differential equations by series solution method.
3. solve systems of differential equations.
4. draw the phase portraits and study the stability of solutions
5. solve the solutions of Strum Liouville problems.

Course content

- *Review of fundamentals of ODEs, Some basic mathematical models, direction fields, classification of differential equation, Solutions of some differential equation. 1st order non-linear differential equation.* Existence and Uniqueness problem, Gronwall's inequality, Peanao existence theorem, Picard existence and uniqueness theorem, interval of definition.
- Second order linear differential equation, General solution for homogeneous equation, superposition of solutions, Methods of solution for non-homogeneous problem: undetermined coefficients, variation of parameters.
- n^{th} order differential equation, system of equation, homogeneous system of equation, fundamental matrix, Abel-Liouvelle formula, System of non-homogeneous equations, Stability of linear systems.
- Theory of two point BVP, Greens function, Greens matrix, properties of greens functions, adjoint and self adjoint BVP.
- Strum-Liouvilles problem, Orthogonal functions, eigen values & eigen functions, Completeness of the Eigen functions.
- Orthogonal trajectory of a system of curves on a surface solution of pfaffian differential equations in three variables.
- Stability of linear and non-linear system: Classification of critical points, Lyanpunov *stability.*

Textbooks:

- Boyce, W. E. and DiPrima, R. C., *Elementary Differential Equation and Boundary Value Problems*, 7th Edition, John Wiley & Sons (Asia), 2001.
- Ross, S. L., *Differential Equations*, 3rd edition (Wiley 1984).

Suggested readings:

- Simmons, G. F., *Differential Equations with Applications and Historical Notes*, McGraw Hill 1991.
- Coddington, E. A., *An Introduction to Ordinary Differential Equations,* Prentice- Hall, 1974.

- Farlow, S. J., *An Introduction to Differential Equations and Their Applications*, McGraw-Hill International Editions, 1994.

MI 419: Topology

L 3 T1 P0 CR4

Course outcomes

In this course student will learn

1. basic structures and constructions of topology.
2. countability and separation axioms and their applications.
3. properties of compact and connected spaces and their localized variations.

Course content

- Metric topology, Product and Box topology, Order topology, Quotient spaces
- Countability axioms: First countable spaces, Second countable spaces, separable spaces, Lindelof spaces.
- Separation axioms: Hausdorff, Regular and Normal spaces, Urysohn's characterization of normality, Urysohn's metrization theorem, Tietze's extension theorem, Completely Regular spaces.
- Compactness, limit point compactness, local compactness, one-point compactification.
- Tychonoff's product theorem, Stone-Cech compactification, Baire Spaces, Baire Category Theorem.
- Connectedness, Local connectedness, Path connectedness, Components, Products of connected spaces.

Textbook(s):

- Munkres, J. R., *Topology : A first course* (2/e), Pearson Education, 2000.
- Willard, S., *Topology,* Dover, 1970.

Suggested readings:

- Joshi, K. D.**,** *Topology*, Wiley-Eastern, 1988.
- Kelley, J. L.**,** *General Topology,* Graduate texts in Math., Springer, 1991.
- Adams C. and Franzosa, R., *Introduction to Topology: Pure and Applied*, Pearson, 2009.

MI 421 Computer Laboratory+

L 0 T0 P1 CR1

+ *Practical unit for the course MI 414 Computer Programming*

Course outcomes

1. At the end of the course student will able to write Computer program to solve some mathematical problem.

MI 424 Computer Laboratory+

L 0 T0 P1 CR1

+ *Practical unit for the course MI 416 Numerical Analysis+*

Course outcomes

1. At the end of the course student will able to formulate and solve certain mathematical problems numerically.

MI 507: Partial Differential Equations

L 3 T1 P0 CR4

Course outcomes

1. It is expected that at the end of the course the student will be able to apply knowledge of partial differential equations wherever needed further and will be able to solve partial differential equations appearing in diverse context.

Course content

- Linear and nonlinear partial differential equation of the first order. Cauchy's method of characteristics, Compatible systems of first order equations, Charpit's and Jacobi's method.
- Linear PDE with constant coefficients, reducible and irreducible equations. Different methods of solution.
- Second order PDE with variable coefficients. Characteristic curves of second order PDE. Reduction to canonical forms. Solutions of PDE of second order by the method of separation of variables.
- Fourier transform, Laplace transform. Solution of partial differential equation by Laplace and Fourier transform methods.
- Solutions of PDE of second order by the use Riemann's method. Adjoint operators. Solutions of PDE of second order by the method of integral transforms.
- Elliptic differential equations. Occurrence and detailed study of the Laplace and the Poisson equation. Maximum principle and applications, Green's functions and properties.
- Parabolic differential equations. Occurrence and detailed study of the heat equation. Maximum principle. Existence and Uniqueness of solutions of IVPs for heat conduction equation. Green's function for heat equation.
- Hyperbolic differential equations. Occurrence and detailed study of the wave equation. Solution of three dimensional wave equation. Method of decent and Duhamel's principle. Solutions of equations in bounded domains and uniqueness of solutions.

Textbook(s):

- Sneddon, I.N., *Partial Differential Equations*, Diver, 2006.
- Rao, K.S., *Introduction to partial differential equations* (Prentice Hall of India, New Delhi, 2006.

Suggested readings:

- John, F., *Partial Differential Equations*, 3rd edition, Narosa, 1979.
- Haberman, R., *Elementary Applied Partial Differential equations*, Prentice-Hall, New Jersey, 1987.
- Willams, W.E., *Partial Differential Equations*, Oxford University Press, 1980.
- Strauss, W.A., *Partial Differential Equations: An Introduction*, John Wiley, 1992.
- McOwen, R., *Partial Differential Equations Methods and Applications*, Prentice Hall, New Jersey, 1996.

MI 508: Mathematical Methods

L 3 T1 P0 CR4

Course outcomes

1. Towards the end of the course the student would be able to solve basic application-oriented problems. Students also would be able to develop problem solving skills useful in research works.

Course content

- Calculus of variations: Linear functionals, minimal functional theorem, general variation of a functional, Euler-Lagrange equation. Variational problems with fixed boundaries. Sufficient conditions for extremum.
- Integral equations: Linear integral equations of the first and second kind of Fredholm and Volterra type, solution by successive substitutions and successive approximations, solution of equations with separable kernels. Fredholm alternative.
- Nonlinear programming: formulation of NLPP, General NLPP, Kuhn-Tucker condition. Saddle point and NLPP. Graphical solutions of NLPP, quadratic programming. Wolfe's modified simplex method, Beale's method.
- Game theory: Two-person zero-sum games, maximum criterion, dominance rules, mixed strategies, mini-max theorem, solutions of 2x2 and 2xm games.

Textbooks:

- Watson G. N., *A Treatise on the Theory of Bessel Functions*, Cambridge University Press, 1944.
- Brown J. W. and Churchill, R., *Fourier Series and Boundary Value Problems*, McGraw Hill, 1993).
- Roach, G. F., *Green's Functions*, Cambridge University Press, 1995.
- Swarup, K., *Gupta*, P.K., Mohan, M., *Operations Research*, Sultan Chand & Sons, 2007.

Suggested readings:

- Gupta, A, S., *Calculus of Variations with Applications*, Prentice Hall of India, New Delhi 2003.
- Mikhlin, S. G., *Integral equations*, The MacMillan Company, New york, 1964.

MI 509: Classical Mechanics

L 3 T1 P0 CR4

Course outcomes

Towards the end of this course student will

1. have a sound idea of the Newtonian, Lagrangian and Hamiltonian dynamics.
2. able to work out Canonical transformation to classical mechanical equations.
3. able to write down equations in classical mechanics in terms of the Poisson's Bracket formulation

Course content

- Momentum and kinetic energy, motion about a fixed point, Euler's equation, General equation of motion for a single particle and a system of N number of particles, General Solution.
- Motion of a heavy sphere in a cylinder and a cone, motion under no force, Torque, Poinst's representation of motion.
- Lagrange's equation of motion for holonomic systems, Velocity dependent potential, conservation theorem and symmetric properties, Lagrange's multiplier for holonomic and nonholonomic systems, Lagrange's equation for impulsive motion.
- Hamiltonian of a dynamical system, Hamilton's canonical equation of motion, Cyclic coordinate, The Routhian, Conservation of energy and momentum.
- Lagrange's method for small oscillation, Normal modes, Equations and examples.
- Integral invariants of poincare, Lagrange's and Poisson's brackets and their properties, Equation of Motion and conserved quantities using Poisson's brackets, Infinitesimal contact transformation.
- Euler's equation of calculus of variations, Brachistochrone problem, extremes under constraints, Hamilton's principle for conservative and non-conservative system, Holonomic and non-holonomic system.
- Derivation of Lagrange's and Hamilton's equations from Hamilton's principle of least action, Hamilton Jacobi theory, Hamilton's Principal Function.

Textbook(s):

- Goldstein, H. *Classical Mechanics*, 2nd edition, Narosa Publishing House, New Delhi, 2000.

- Rana, N. C. & Joag ,P. C. *Classical Mechanics*, Tata-McGraw Hill, 1991.

Suggested readings:

- Takwale, R. G. & Puranik, P. S., *Classical Mechanics,* Tata-McGraw Hill, 1979, 41st reprint, 2010.
- Yung-Kuo, L., *Problems and Solutions on Mechanics,* World Scientific, 1994.
- Calkin, M. G., *Lagrangian and Hamiltonian Mechanics,* World Scientific, 1996.
- Landau, L. & Lifshitz, E.M., *Mechanics: Course of Theoretical Physics, Vol. 1,* 3rd edition Pergamon Press, 1976.

MI 510: Functional Analysis

L 3 T1 P0 CR4

Course outcomes

It is expected that at the completion of the course students will

1. be illuminated by abstract approach to analysis and the strong theory which is developed here helps to bring out the essence of a problem by clearing out unnecessary details, hence giving a unified approach to apparently unrelated topics
2. understand major links between mathematics and its applications.
3. able to apply the various concepts to solve numerical problems.
4. get sufficient background to understand the more advanced concepts to undertake further research.

Course content

- Recap pre-requisite topics: Sets and relations, Linear spaces and linear maps, Metric spaces and continuous functions.
- Introduce normed linear spaces with examples. Properties of nls, Riesz lemma, particular study of finite dimensional normed linear spaces, Discuss the interplay between linear structure and metric structure.
- Define stronger, weaker and equivalent norms. Continuity and boundedness of linear maps, introduce complete normed linear spaces with examples. Function spaces and operator norm, bounded linear functional. Definition of Schauder basis. Dual spaces.
- Hahn Banach separation and extension theorems. Applications of HBT.
- Refer to the Ascoli-Arzela theorem and the definitions of uniform continuity, uniform boundedness, equicontinuity of a family of functions. Uniform boundedness theorem.
- Closed graph theorem, open mapping theorem, bounded inverse theorem. Examples and applications of above theorems.
- Inner product and Hilbert spaces, Bessel's inequality, Riesz-Fisher theorem, orthonormal basis. Fourier expansion and relation to orthonormal basis, Parseval formula, Separable Hilbert spaces.
- Approximations, projection theorem, Riesz representation theorem. Hilbert adjoint operator, normal, self adjoint and unitary operators.

Textbooks:

- Limaye B. V., *Functional Analysis,* Wiley Eastern Ltd., New Delhi, 1989.
- Kreyszig E., *Introductory Functional Analysis with Applications*, John Wiley and Sons, New York, 1978.

Suggested readings:

- Rudin W., *Functional Analysis*, McGraw Hill, 2000.
- Yosida K., *Functional Analysis*, Springer, 1995.
- MacCluer B., *Elementary Functional Analysis*, GTM 253, AMS, 2009.
- Siddiqi, A. H., Ahmad K and Manchanda P., *Introduction to Functional Analysis with Applications*, Real World Education Publishers, New Delhi, 2014.

MI 517: Project

L 0 T2 P2 CR4

Course outcomes

At the end of the course student will

1. Able to compile existing work
2. Learn to prepare review report using LaTex
3. Develop skill of presention

MI 538: Theory of Partial Differential Equations

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will

1. understand the fundamental concepts of partial differential equations.
2. able to work out problems in abstract spaces.
3. create the basic knowledge required for research in partial differential equations.

Course content

- Overview of PDE. Laplace equation, mean-value fomulas, strong maximum principle. Heat and wave equations, uniqueness by energy methods.
- Theory of distributions: test functions, distributions, generalized derivatives, Sobolev Spaces, imbedding theorems, Rellich-Kondrasov theorem, trace theory.
- Elliptic Boundary Value Problems: abstract variational problems, Lax-Milgram Lemma, weak solutions, regularity result, maximum principles, eigen value problems.

- Semigroup Theory and Applications: exponential map, C0-semigroups, Hille-Yosida and Lummer-Phillips theorems, applications to heat and wave equations.

Textbooks:

- Kesavan, S., *Topics in Functional Analysis*, New Age International (P) Ltd. 1989, reprint 2003.
- Evans, L.C., *Partial Differential Equations,* AMS, Providence, 1998.

Suggested readings:

- John, F., *Partial Differential Equations,* 3rd ed., (Narosa Publ. Co., New Delhi, 1979.
- Gilbarg, D. and Trudinger, N., Elliptic *Partial Differential Equations of Second Order,* Springer-Verlag, Berlin Heidelberg, 2001.
- Jost, J., *Partial Differential Equations,* Springer-Verlag New York, 2002.
- Renardy, M. and Rogers, R.C., *An Introduction to Partial Differential Equations*, 2nd ed., Springer Verlag International Edition, New York, 2004.

MI 539: Advanced Numerical Analysis

L 3 T1 P0 CR4

Course outcomes

1. It is expected that at the end of the course the student will be able to understand fundamental concepts of mathematics in different branches mathematics to be offered in the subsequent semesters. This topic will act as the foundations.

Course content

- Finite Difference method: Explicit and Implicit schemes, consistency, stability and convergence, Lax equivalence theorem. Numerical solutions of elliptic, parabolic and hyperbolic partial differential equations.
- Optimization: Problem formulation, single variable optimization, multi variable optimization.
- Krylov subspace methods, Conjugate-Gradient (CG), BiConjugate-Gradient (BiCG), BiCG Stabilised (BiCGStab), Generalised Minimum Residual (GMRES). Preconditioning Techniques, parallel implementations.
- Approximate method of solution: Galerkin method, properties of Galerkin aproximations, Petrov-Galerkin method, Generalised Galerkin method.
- Review of Sobolev spaces. Weak solution of elliptic boundary value problem, regularity of weak solutions, maximum principle. Finite Element method: Definition and properties. Element types triangular, rectangular, quadrilateral. Application of finite element method for second order problems, one and two dimensional problems. Isoparametric finite element, non-conformal finite element. Mixed finite element.

Textbooks:

- Watkins, D. S., *Fundamental of Matrix Computations*, 2nd edition Wiley-Interscience, 2002.
- Smith, G. D., Numerical *Solution of Partial Differential Equations: Finite Difference Methods*, 3rd edition (Oxford University Press, 1986)

- Reddy, J. N., *An Introduction to the Finite Element Method*, 3rd Edition (McGraw Hill India, 2006.

Suggested readings:

- Trefethen, L. N and Bau, D., *Numerical Linear Algebra*, SIAM, 1997.
- Hoffman, Joe D., *Numerical Methods for Engineers and Scientist*, 2nd edition, Mc-Graw Hill 2004.
- Ciarlet, P. G., *The Finite Element Method for Elliptic Problems*, North Holland,1978.
- Johnson, C., *Numerical Solution of Partial Differential Equations by the Finite Element Method*, Cambridge University Press, 1987.

MI 541: Fluid Mechanics

L 3 T1 P0 CR4

Course outcomes

1. It is expected that at the end of the course the student will be able to understand fundamental concepts of fluid mechanics. Subsequently students should be in a position to apply the knowledge in diverse context of modelling. This topic will also help students in clearing UPSC as fluid mechanics is in the syllabus of UPSC.

Course content

- Lagrarian and Eulerian methods, Velocity and acceleration, Particle path, Stream lines, Streak lines velocity potential, Steady and unsteady flows.
- Conservation of mass and momentum, 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.
- Total energy, Circulation, Boundary surface, Impulsive motion. Irrotational motion, Potential flow, Green’s theorem, application of Green’s theorem in fluid mechanics, Kinetic energy of liquid, Uniqueness theorem. Vorticity vector.
- Motion in two dimensions, 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.
- Three dimensional flow, Irrotational motion, Weiss's theorem and its applications.
- Viscous flow, Vorticity dynamics, Vorticity equation, Reynolds number, Stress and strain analysis, Navier-Stokes equation, Boundary layer Equations.

Textbooks:

- Munson, B.R.,Young, D.F. & Okiishi, T.H., *Fundamentals of Fluid Mechanics*, 6thed., John Wiley & Sons, 2009.
- White, Frank M., *Fluid Mechanics,* Mc-Graw Hill, 2005.

Suggested readings:

- Batchelor, G. K., *An Introduction to Fluid Dynamics*, Cambridge University P,1993.
- Panton, R. L., *Incompressible Flow,* John Wiley & Sons, 2005.

- Schlichting, H., *Boundary Layer Theory*, Mc-Graw Hill, 2005.
- Chorlton, F., *Textbook of Fluid Mechanics*, C. B. S. Publishers, Delhi, 1985.
- Besant, W. H & Ramsey, A., *A Treatise on Hydro-mechanics*, ELBS, 1990.

MI 543: Relativity

L 3 T1 P0 CR4

Course outcomes

On completion of this course, a student will

1. get a reasonable idea of Tensor analysis and their applications
2. grasp the elements of special theory of relativity and write down equations in Four-vector formulation
3. get the basics of General Theory of Relativity and it's applications to astrophysics and cosmology.

Course content

- Postulates of Special Theory of Relativity, Lorentz Transformation and consequences, Minkowski Diagram, Four dimensional spacetime continuum, Four vector formulation, Elementary properties of Tensors.
- Rules of Combination of Tensors, Tensor Algebra, Inner and Outer Product Quotient Rule, Metric tensor and Conjugate Metric Tensors, Raising and lowering properties, Christofell symbols of first and second kind, Tranformation properties of Christofell symbols.
- Tensor Analysis, Covariant Derivative of Tensors, Gradient, Divergence and Curl of Tensor, Geodesic Equation, Riemannian Tensor, Ricci Tensor, Bianchi Identities, Einstein Tensor.
- Transition of Special to General Theory of Relativity, Principle of covariance, Equivalence Principle and consequences, Stress Energy Tensor, Einstein Field Equations and Newtonian limit.
- Spherically symmetric solution to Einstein Field Equation in free space and in matter, Schwarzshild line element. Schwarzschild Black Holes.
- Equation of Planetary Orbits, Crucial tests of General Theory of Relativity, Advance of Perihelion, Gravitational bending of light and Gravitational Redshift.
- Cosmology: Large scale structure of Universe, Galactic Densities and the darkness of the Night Sky, Galactic Number Counts, Olber’s paradox, Cosmological principles, Relativistic Universe and models.
- Einstein and de-Sitter models of static universe, Dynamical Universe, Comoving time, Red Shifts and Horizons, Friedmann-Robertson-Walker line element, Open and Closed Universe, Hubbles law, Early Universe.

Textbooks:

- Narlikar, J.V., *An Introduction to Cosmology*, 3rd edition, Cambridge University Press, 2002.
- Landau and Lifshitz, *Classical Theory of Fields*, Pergamon Press, 1975.

Suggested readings:

- Dirac, P. A. M., *General Theory of Relativity,* Prentice Hall of India, reprinted, 2001.
- Weinberg, S., *Gravitation and Cosmology,* John Wiley & Sons, 1972.
- Kenyon, I. R., *General Relativity,* Oxford University Press, 1991.

MI 549: Graph Theory

L 3 T1 P0 CR4

Course outcomes

At the end of the course students are expected to

1. apply theories and concepts to test and validate intuition and independent mathematical thinking in problem solving.
2. improve the proof writing skills.
3. use graph theory as a modelling tool.
4. apply graph theory based tools in solving practical problems.

Course content

- Preliminaries: Graphs, subgraphs, Isomorphism, degree, degree sequence, operations on graphs.
- Walk, Trail, Path, Cycle, circuit, Connected graphs, component, distance between vertices, Bipartite graph, eccentricity, radius, diameter.
- Tree, Bridge, Center of a tree, Forest, Spanning tree.
- Cut-vertices, Block, vertex-connectivity, edge-connectivity, Eulerian graph and its properties, Hamiltonian graph and its Properties.
- Planarity: Basic Concepts, Plane Graphs, Interior face, exterior face, Euler Identity, Maximal Planar graph.
- Coloring: vertex coloring, chromatic number, The Four Color Theorem, independence number, Brook's theorem, edge Coloring, edge chromatic number, The Five color Theorem.
- Digraph, oriented graph, indgree, outdegree, strong digraph, tournament, transitive tournament.

Textbooks:

- G. Chartrand and P. Zhang, *A First Course in Graph Theory*, Dover Publication, NewYork, 2012.
- J. A. Bondy, U.S. R. Murthy, *Graph Theory with Applications*, London: Macmillan Press, 1976.

Suggested readings:

- D. B. West, *Introduction to Graph Theory*, 2nd Edition, Pearson Education, 2015.
- R, J. Wilson, *Introduction to Graph Theory*, 4th Edition, Longman, England, 1996.

- F. Harary, *Graph Theory,* Narosa Publishing House, New Delhi, 2001.

MI 552: Operator Theory I

L 3 T1 P0 CR4

Course outcomes

1. This is an introductory course in Operator Theory. It will introduce the student to terms, concepts and results for bounded linear operators which are commonly used in this particular area of Mathematics.
2. It will also introduce the students which are relevant to current research and prepare the student to persue such a career.

Course content

- Uniform, strong and weak convergences.
- Compact linear operators on normed linear spaces; the ideal of compact operators; the separability of the Range and spectral properties of a compact operator; operator equations involving compact operators.
- Bounded operators on Hilbert spaces; adjoint operators; normal, unitary and self adjoint operators; spectral properties of bounded self adjoint linear operators.
- Positive operators and their square root; projection operators; spectral representation of a bounded self adjoint linear operator.
- Spectral measure.
- Spectral theorem for bounded normal operators.

Textbooks:

- Conway, J. B., *A course in Operator Theory,* AMS., GSM Vol. 21, 1999.
- Kreyszig, E., *Introductory functional analysis with applications,* John Wiley and Sons, 1978.

Suggested readings:

- Halmos, P. R., *Introduction to Hilbert spaces and theory of spectral multiplicity,* Chelsea Publishing Co., New York, 1957.
- Abramovich, Y. A. and Aliprantis, C. D., *An Invitation to Operator Theory,* AMS, GSM Vol. 50, 2002.

MI 554: Commutative Algebra

L 3 T1 P0 CR4

Course outcomes

1. After completion of this course, students are expected to go deeper into the concepts of commutative algebra and apply these concepts to other fields of science and technology. Also

this course is a very good platform for research in Algebraic Number Theory, Algebraic Topology, Algebraic Geometry etc.

Course content

- Ideals in commutative rings, operations on ideals, extension and contraction of ideals, Nilradical and Jacobson radicals, prime spectrum of commutative rings.
- Localization of commutative rings and their basic properties.
- Noetherian and Artinian rings, examples.
- Integral extensions, Dedekind domains.
- Hilbert's Nullstellensatz, Noether's normalisation, valuation rings.
- Modules: Elementary properties of modules, Quotient modules, module homomorphisms, Isomorphism theorems, Generation of modules, Direct sum of modules, finitely generated modules, free modules.
- Tensor product of modules and properties, Exact sequences, projective and injective modules.
- Modules over Principal Ideal Domain.

Textbooks:

- McDonalds, I. G. & Atiyah, M. F., *Introduction to Commutative Algebra,* Levant Books, Kolkata, 2007.
- Dummit, D. S. & Foote, R. M., *Abstract Algebra*, Wiley-India, New Delhi, 2011.

Suggested readings:

- Sharp, R. Y., *Step in Commutative Algebra,* Cambridge University Press, Cambridge, 2000.
- Lang, S., *Algebra,* Springer, GTM Vol. 211, New Delhi, 2006.

MI 558 General Theory of Relativity

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will

1. grasp the idea of Tensor analysis
2. idea of General Theory of Relativity -mathematical Approach
3. idea of General Theory of Relativity -application to stellar Astrophysics and Cosmology

Course content

- Elementary properties of Tensors. Rules of Combination of Tensors, Tensor Algebra, Inner and Outer Product Quotient Rule, Riemannian space, Metric tensor and Conjugate Metric Tensors, Raising and lowering properties.
- Parallel Transport, Christofell symbols of first and second kind, Tranformation properties of Christofell symbols, Covariant Derivative of Tensors, Gradient, Divergence and Curl of Tensors.
- Geodesic Equation, Riemannian Tensor, Ricci Tensor, Bianchi Identities, Scalar Curvature, Einstein Tensor and their properties, Differential Manifolds.
- Transition of Special to General Theory of Relativity, Principle of covariance, Equivalence Principle and consequences, Stress Energy Tensor, Einstein Field Equations and Newtonian limit.
- Spherically symmetric solution to Einstein Field Equation in free space and in matter, Schwarzshild line element. Schwarzschild Singularity, Eddington-Finkelstein co-ordinates, Kruskal-Szekeres co-ordinates.
- Linearised theory of gravity, weak field limit, Hilbert gauge and wave solution to Einstein Field Equations, Gravitational Waves, Polarisation properties, emission of gravitational waves.
- Crucial tests of General Theory of Relativity, Advance of Perihelion, Gravitational bending of light, Gravitational Redshift, Shapiro delay.
- Large scale structure of Universe, Cosmological principles, Einstein and de-Sitter models of static universe, Dynamical Universe, Comoving time, Red Shifts and Horizons, Friedmann-Robertson-Walker line element, Hubbles law, Elements of Quasi-Steady State Cosmology.

Textbooks:

- Narlikar, J.V., *An Introduction to Cosmology*, 3rd edition, Cambridge University Press, 2002.
- Adler, R., Bazin M. & Schiffer, M., *Introduction to General Relativity,* McGraw Hill, 1975.

Suggested readings:

- Landau and Lifshitz, *Classical Theory of Fields,* Pergamon Press, 1975.
- Dirac, P. A. M., *General Theory of Relativity,* Prentice Hall of India (reprinted), 2001.
- Weinberg, S., *Gravitation and Cosmology,* John Wiley & Sons, 1972.
- Kenyon, I. R., *General Relativity,* Oxford University Press, 1991.
- Misner, C., Thorne, K.S. & Wheeler, J.A., *Gravitation,* W.H. Freeman, 1973.

MI 561: Stochastic Processes I

L 3 T1 P0 CR4

Course outcomes

Student will

1. understand the propertise of simple random walk & solve problems using combinatorial methods & generating functions

2. understand discrete Markov Chain, its application and solve problem regading classification of states, periodicity properties
3. understand Poisson process and solve problems
4. understand Renewal theory basics

Course content

- Simple (one dimensional) random walk. (To follow the chapter on simple random walk in Feller (1996) Vol. I)
- Discrete Markov chains: transition probability matrix, classifications of states and chains.
- Introduction to Poisson Processes.
- Introduction to Renewal processes.

Textbooks:

- Feller, W., *An Introduction to Probability Theory and its Applications*, Vol. I, Wiley,1966.
- Medhi, J., *Stochastic Processes,* Wiley Eastern Ltd., New Delhi, 1994.

Suggested readings:

- Bhatt ach ar ya, R. and Waymire, E. C., *Stochastic processes with applications,* SIAM, 1990.

MI 565 Fuzzy Sets and Applications-I

L 3 T1 P0 CR4

Course outcomes

Towards the end of the course, student will

1. understand the motivation for the creation of fuzzy sets
2. able to describe the basic mathematical structure and operations of fuzzy sets

Course content

- Fuzzy sets - basic definitions, α-level sets, convex fuzzy sets.
- Basic operations on fuzzy sets, types of fuzzy sets.
- Cartesian products, algebraic products, bounded sum and difference, t-norms and t-conorms. Fuzzy sets in contrast of probability theory.
- The extension principle - the Zadeh's extension principle, image and inverse image of fuzzy sets.
- Fuzzy numbers, elements of fuzzy arithmetic.
- Fuzzy relations and fuzzy graphs, composition of fuzzy relations, min-max composition and its properties, fuzzy equivalence relations, fuzzy relational equations, fuzzy graphs.

Textbooks:

- Klir, G. J. and Yuan, B., *Fuzzy Sets and Fuzzy Logic : Theory and Applications*, Prentice Hall of India, New Delhi, 1997.

Suggested readings:

- Zimmermann, H. J., *Fuzzy set theory and its Applications*, Allied publishers Ltd., New Delhi, 1991.

MI 566: Fourier Analysis

L 3 T1 P0 CR4

Prerequisite: MS 510

Course outcomes

At the end of this course student will

1. understand the basics of the Fourier series and its applications to the boundary value problems.
2. understand the convergence of the Fourier series.
3. compute the Fourier transform for various class of functions.
4. use the Fourier transform and its properties for singular integrals and various applications to partial differential equations.

Course content

- Fourier series: Orthogonal systems, Trigonometric system, Orthogonal polynomials, Genesis of the Fourier series.
- Convergence of Fourier series: Fejer mean and Cesaro mean, Convergence of the Fourier series, Fejer theorem, Uniqueness and convergence, Approximate identity, Fourier series of continuous and smooth functions.
- L^2 theory of Fourier series: Inversion formula and the Parseval identity.
- Fourier transforms, the Schwartz space,Plancherel formula, Maximal function and distributions, Tempered distribution,, Fourier analysis and filters. Bessel functions.
- Fourier analysis and complex function theory: Paley Wiener's theorem, Tauberian theorem, Dirichlet problem.,Classical Hardy spaces F and M. Reisz theorem.

Textbooks: (max 2)

- Katznelson, Y., *An Introduction to Harmonic Analysis*, Dover, New York, 1976.

Suggested readings:

- Dym, I.H. and Mc Kean, H.P., *Fourier Series and Integrals*, Academic Press,1985.
- Folland G. B., *Fourier Analysis and Applications*, Brooks/Cole Mathematics Series, 1972.
- Korner, T., *Fourier Analysis*, Cambridge, 1989.
- Rudin, W., *Functional Analysis*, Tata Mc. Graw Hill, 1974.
- Elias M. S. and Shakarchi, R., *Fourier Analysis An Introduction*, Princeton University Press, Princeton, 2004.

MI 567: Continuum Mechanics

L 3 T1 P0 CR4

Course outcomes

At the end of this course student will have a fair knowledge on

1. essential mathematical concepts of continum mechanics, especially stress and strain.
2. fundamental laws of continum mechanics, their derivations.
3. analytical study of equation of elasticity and fluids.

Course content

- Analysis of Strain: Lagrangian and Eulerian finite strain tensor. Geometrical interpretation of the components of atrain. Strain quadric of Cauchy. Principall strains and invariants. General infinitesimal deformation. Saint-Venant's equations of compatibility.
- Analysis of stress: Stress tensor. Equations of equilibrium. Transformation of co-ordinates. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses. Two dimensional problems-Plane stress. Generalised plane stress. Airy stress function.
- Fundamental laws of continuum mechanics: Continuity equation, Equation of motion, Moment of momentum principle, Second law of thermodynamics. The Clausius-Duhem inequality.
- Equations of Elasticity. Generalosed Hooks's law. Homogeneous isotropic media, Strain energy function and its connection with Hooke's law. Four basic elastic constants-Young's modulus, Poisson's ratio, modulus of rigidity, bulk modulus. Uniqueness of solution. Saint-Vernant's principle.
- Fluids: Classification, constitutive equations, energy equation, dissipation of energy.

Textbooks:

- Mase, G.E., *Schaum's Outline of Continuum Mechanics*, Schaum's Outline series, Mc- Graw Hill, 1990.
- Chatterjee, R., *Mathematical Theory of Continuum Mechanics*, Narosa, 1999.

Suggested readings:

- Truesdell, C. *The elements of continuum Mechanics (*Springer-Verlag, 2000).

MI 568: Theory of Distribution and Sobolev Spaces

L 3 T1 P0 CR4

Course outcomes

1. Students will be well versed in the theoretical aspects of solutions of pdes and apply the same in solving basic pdes.

Course content

- Test Function and distribution: Definition, operations with distributions, convolution of distributions, Fourier transform of tempered distributions.
- Sobolev spaces: generalized derivatives, Definition and properties, extension theorem, imbedding and completeness theorem, fractional order Sobolev spaces, trace theory.
- Application to Elliptic Problems: Weak solution of elliptic boundary value problem (BVP), regularity of weak solutions, maximum principle, eigenvalue problems, fixed point theorems and their application in semi-linear elliptic BVP.

Textbooks:

- Adams, R.A., *Sobolev Spaces*, Academic Press, 1975.
- Kesavan, S., *Topics in Functional Analysis and Applications*, Wiley Eastern Ltd., New Delhi, 1989.
- Strihartz, Robert S., *A guide to Distribution Theory and Fourier Transforms, Studies in Advanced Mathematics*, CRC Press,USA,1994.

Suggested readings:

- Oden, J.T. and Reddy, J.N., *An Introduction to Mathematical Theory of Finite Elements*, Wiley Interscience, 1976.
- Brennan, K. E. and Scott., R., *The Mathematical Theory of Finite Element Methods*, Springer-Verlag, Berlin, 1994.
- Lieb. Elliot H. and Loss, M., *Analysis*, Narosa Publishing House, New Delhi, 1997.
- Rudin, W., *Functional Analysis*, Tata Mc-Graw Hill, 1974.

MI 569: Coding Theory I

L 3 T1 P0 CR4

Course outcomes

1. Towards the end of the course the student would be able to have a better idea about coding theory and how efficient codes are constructed and applied in different areas of practical interest.

Course content

- Communication channel, Introduction to coding theory, types of codes, ISBN code, Barcodes, Digital codes, Group Theory, Vector spaces over arbitrary fields with examples, linear block codes, Dual codes, Distance of block codes, Standard array, Syndrome decoding and Decoding by coset leaders.
- Error-correction and detection capabilties of linear block codes. Singleton bound, Greismer bound, Plotkin bound, Hamming sphere packing bound, Varshamov-Gilbert-Sacks bound.
- Weight Enumerators and the MacWilliams Theorem, Type of errors, Burst errors, Bounds for burst-error detecting and correcting codes.
- Some Interesting Block Codes and Their Properties: Perect codes, Hamming codes, Golay codes, Hadamard codes, Product codes, Reed-Muller codes, Maximum–Distance Separable (MDS) codes.

Textbooks:

- W.W. Peterson and E.J. Weldon, Jr., *Error-Correcting Codes*, M.I.T. Press, Cambridge, Massachusetts, 1972.
- Torleiv Klove, *Codes for error Dectection, Series on Coding Theory and Cryptology*, vol. 2, World Scientific Publishing Co. Pte. Ltd., 2007.

Suggested readings:

- J.H. Van Lint, *Introduction to Coding theory, Graduate Texts in Mathematics*, 86, Springer, 1998.

- Raymond Hill, *A First Course in Coding Theory,* Oxford University Press, 1990.
- A. Neubauer, J. Freudenberger, V. Kuhn, *Coding Theory: Algorithms, Architectures and Applications,* John Wiley & Sons Ltd, England, 2007.
- L.R. Vermani, *Elements of Algebraic Coding*, Chapman and Hall, 1996.
- W. C. Huffman and V. Pless, *Fundamentals of Error-Correcting Codes*, Cambridge University Press, Cambridge, Reprint, 2010.
- Shu Lin and Daniel J. Costello, *Error Control Coding-Fundamentals and Applications*, Pearson Education India, 2011.

MI 570: Coding Theory II

L 3 T1 P0 CR4

Prerequisite: MS 569

Course outcomes

1. Towards the end of the course the student would be able to handle and manipulate difficult type of codes which can be implemented in diverse

Course content

- Zero of polynomials, Algebraic extension of a field, Galios field, Primitive elements, Minimum polynomials, order, Multiplcative group of a Galios fields, structure of finite fields.
- Error detection with cyclic codes, Error-correction procedure for cyclic codes, Shortended cyclic codes, Pseudo cyclic codes. Code symmetry, Invariance of codes under transitive group of permutations.
- BCH codes, Minimum distance and BCH Bounds, Decoding of BCH codes, Reed-Solomon codes.
- Tree codes, Convolutional codes, Description of linear tree and convolutional codes by matrices, distance for convolutional codes, Maximum likelihood decoding of Convolutional codes, Vitorbi decoding algorithm.

Textbooks:

- W.W. Peterson and E.J. Weldon, Jr., *Error-Correcting Codes*, M.I.T. Press, Cambridge, Massachusetts, 1972.
- Shu Lin and Daniel J. Costello, *Error Control Coding-Fundamentals and Applications*, Pearson Education India, 2011.

Suggested readings:

- Man Young Rhee, *Error Correcting Coding Theory,* McGraw-Hill Publishing, 1989.
- Robert H. Morelos-Zaragoza, *The art of Error Correcting Codes*, 2nd Edition, John Wiley & Sons Ltd, England, 2006.
- A. Neubauer, J. Freudenberger, V. Kuhn, *Coding Theory: Algorithms, Architectures and Applications,* John Wiley & Sons Ltd, England, 2007.
- L.R. Vermani, *Elements of Algebraic Coding,* Chapman and Hall, 1996.

- Jiri Adamek, *Foundations of Coding: Theory and Applications of Error-Correcting Codes with an Introduction to Cryptography and Information Theory,* John Wiley & Sons, USA, 1991.
- W. C. Huffman and V. Pless, *Fundamentals of Error-Correcting Codes,* Cambridge University Press, Cambridge, Reprint, 2010.

MI 572: Operator Theory II

L 3 T1 P0 CR4

Course outcomes

This course will introduce the students

1. special classes of bounded linear operator and study why each of them is important and significant.
2. a parallel study of unbounded linear operator is also done to give the student a complete perspective.

Course content

- Functional calculus and spectral mapping theorem for analytic functions; Riesz decomposition theorem.
- Numerical range of an operator; spectral radius.
- Subnormal and hyponormal operators.
- Partial isometries; polar decomposition.
- Unbounded linear operators and their Hilbert adjoint operators; symmetric and self adjoint linear operators; spectral properties of self adjoint linear operators; closed linear operators; closable operators and their closures, multiplication operator and differentiation operator.
- Spectral representation of unitary and self adjoint linear operators.

Textbooks:

- Conway, J. B., *A course in Operator Theory* (AMS., GSM Vol. 21, 1999).
- Kreyszig, E., *Introductory functional analysis with applications,* John Wiley and Sons, 1978.
- Conway, J. B., *A course in Functional Analysis*, Springer Verlag, New York,1985.

Suggested readings:

- Halmos, P. R., *Introduction to Hilbert spaces and theory of spectral multiplicity,* Chelsea Publishing Co., New York, 1957.
- Abramovich, Y. A., and Aliprantis, C. D. *An Invitation to Operator Theory,* AMS., GSM Vol. 50, 2002.

MI 573: Analytic Number Theory

L 3 T1 P0 CR4

Course outcomes

1. Towards the end of the course the student would be able to understand many of the current literature in Analytic Number Theory and Theory of partitions.

Course content

- Arithmetical functions and Dirichlet multiplication, averages of arithmetical functions.
- Elementary theorems on the distribution of primes, the prime number theorem, Chebyshev's functions and their relations.
- Dirichlet's theorem for primes of the form *4n-1* and *4n+1*, distribution of primes in arithmetic progressions.
- Quadratic residues and quadratic reciprocity law, applications of the reciprocity law, Gauss sums.
- Dirichlet series, Euler products, Riemann zeta function and Dirichlet *L*-functions.
- Introduction to partitions, geometric representation, generating functions, Euler's Pentagonal number theorem, Jacobi triple product identity, recursion formula for *p(n).*
- Partition identities of Ramanujan.

Textbooks:

- Apostol, T. M., *Introduction to Analytic Number Theory*, Springer International Student Edition, Narosa Publishing House, New Delhi, 1993.
- Hardy, G.H. and Wright, E. M., *An Introduction to the Theory of Numbers*, 4th Edition, Oxford University Press, 1960.

Suggested readings:

- Niven, I. and Zuckerman, H., *An Introduction to the Theory of Numbers*, 5th Edition, Wiley Eastern, New Delhi, 2000.
- Andrews, G.E., *Number Theory,* Hindustan Publishing Corporation, New Delhi, 1992.

MI 574: Galois Theory

L 3 T1 P0 CR4

Course outcomes

1. After completion of this course, students are expected to go deeper into the concepts of Galois theory and apply these concepts to other branches of science and technology. Also this course is a very good platform for research in Algebraic Number Theory, Algebraic Geometry etc.

Course content

- Field extensions: Algebraic, normal and separable extensions of field.
- Splitting fields.
- Automorphisms of extensions, the fundamental theorem of Galois theory.
- Finite fields.
- Primitive elements, norm and trace, cyclotomic fields, cyclic extension.
- Solution of polynomial equations by radicals, Kummer theory.

Textbooks:

- Morandi, P., *Field and Galois Theory*, GTM Vol. 167, Springer-Verlag, 1996.
- Lang, S., *Algebra,* Springer Verlag, Indian Edition, 2008.
- Dummit & Foote, *Abstract Algebra,* John Wiley & Sons., 2005.

Suggested readings:

- Cohn, P. M., *Algebra*, Vols. I & Vol. II, John Wiley & Sons, 1985 and 1988.

MI 581: Stochastic Process –II

L 3 T1 P0 CR4

Course outcomes

1. After completion students will understand the basics of Brownian motion process, branching process, weiner process and some basic Queing systems

Course content

- Branching processes- Properties of generating functions of Branching processes, Probability of Extinction, Distribution of the total number of progeny.
- Galton-Watson process. Introduction Brownian motion process.
- Wiener process, first passage time distribution for Wiener process, Ornstein-Ulhenbech process.
- Queueing systems, Single server queueing models (M/M/1/μ, M/M/1/k, M/M/μ/μ, etc.)

Textbooks:

- W. Feller, *An Introduction to Probability Theory and its Applications*, II, Wiley, 1998.
- Bhattacharyya, R. and Waymire, E. C., *Stochastic processes with applications*, SIAM, 1990.

Suggested readings:

- Medhi, J., *Stochastic Processes,* Wiley Eastern Ltd., New Delhi, 1994.

MI 585: Fuzzy Sets and Their Applications-II

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will

1. able to describe the fuzzy logic and the approximate reasoning based on the fuzzy logic
2. understand the application of fuzzy logic based system for decision making processes

Course content

- Fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, inference from conditional fuzzy propositions, compositional rule of inference.

- Approximate reasoning - an overview of fuzzy expert systems, fuzzy implications and their selection, multi-conditional approximate reasoning, role of fuzzy relation equation.
- An introduction to fuzzy control - fuzzy controllers, fuzzy rule base, fuzzy inference engine.
- Fuzzification, defuzzification and the various defuzzification methods.
- Decision making in fuzzy environment - individual decision making, multi-person decision making, multi-criteria decision making, multistage decision making, fuzzy ranking methods.
- Fuzzy logic as a tool in soft computing.

Textbooks:

- Klir, G. J. and Yuan, B. *Fuzzy Sets and Fuzzy Logic : Theory and Applications,* Prentice Hall of India, New Delhi, 1997.

Suggested readings:

- Zimmermann, H. J. *Fuzzy set theory and its Applications,* Allied publishers Ltd., New Delhi, 1991.

MI588: Applied Matrix Theory

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will

1. able to apply the concept of matrix theory to other field
2. be Equipped with various tools of matrix theory

Course content

- Review of basic linear algebra.
- Canonical factorization, Q-forms.
- Courant-Fischer minmax & related theorems. Perron-Frobenius theory. Matrix-stability.
- Inequalities, g-inverse (A^-, A^m, A^+).
- Direct, iterative, projection and rotation methods for solving linear systems & eigenvalue problems.
- Applications.

Textbooks:

- Datta, K. B., *Matrix and Linear Algebra*, PHI, 1991.
- Watkins, D. S., *Fundamentals of Matrix Computation*, Wiley, 1991.
- Golub, G. H. and Loan, C. F. Van., *Matrix Computation*, John Hopkin U. Press, Baltimore, 1996.

Suggested readings:

- Stewart, G. W., *Introduction to Matrix Computations*, Academic Press, 1973.

MI591: Computational Fluid Dynamics

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will be familiar with

1. basic tools used in finite difference and finite volume methods.
2. development of numerical methods for solution of partial differential equations frequently arising in the field of fluid mechanics.
3. theoretical Fluid Dynamics and basic concept of computational Fluid Dynamics in terms of comprehensive theoretical study and computational aspects

Course content

- Basic equations of Fluid Dynamics. Analytical Aspects of PDE. Iterative methods Stationary Methods. Krylov subspace methods.
- Stationary Convection diffusion equations, Non-stationary convection diffusion equations. Conservation laws. Incompressible plane flows, Stream function and vorticity equations, Conservative form and normalizing systems, Method for solving vorticity transport equation, Basic Conservative property.
- Finite volume and finite difference methods. Convergence and stability analysis, Explicit and implicit methods, Stream function equation and boundary conditions, Solution for primitive variables. Finite volume method, Application to Euler equations, Upwind difference scheme, Viscous flow solutions, Total variation diminishing schemes, Godunov-type schemes.
- Simple CFD Techniques, Lax-Wendroff Technique, Mac Cormack's Techniques, Staggered grid, SIMPLE Algorithm. Numerical Solutions of Navier-Stokes equations on collocated and on staggered grids.

Textbooks:

4. Chung, T. J., *Computational fluid Dynamics*, Cambridge University Press, 2005.

5. Fletcher, C. A. J., *Computational Techniques for Fluid Dynamics*, *Volume 1 & 2*, Springer Verlag, 1992.

Suggested readings:

6. Chow, C. Y., *Introduction to Computational Fluid Dynamics*, John Wiley, 1979.

7. Holt, M., *Numerical Methods in Fluid Mechanics*, Springer Verlag, 1977.

8. Wirz, H. J. and Smolderen, J. J., *Numerical Methods in Fluid Dynamics* Hemisphere, 1978.

9. Anderson, J. D., *Computational Fluid Dynamics*, Mc-Graw Hill, 1995.

10. Anderson, D. A., Tannehill, J. C. and Pletcher, R. H., *Computational Fluid Dynamics and Heat Transfer*, McGraw Hill, 1984.

MI594: Advanced Topology –I

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will

1. understand the process of generalization of sequences in topological spaces to deal with their inadequacy.
2. deal with the metrizability problem and have knowledge of some of the metrization results, including application of paracompact spaces.
3. develop basic ideas of homotopy theory and algebraic topology.

Course content

- Nets and filters, convergenge in terms of nets and filters, ultrafilters and compactness.
- Urysohn's Lemma, Tietze Extension theorem.
- Theories of metrization, Urysohn metrization theorem.
- Paracompactness, characterisation in regular spaces, metrization based on paracompactness.
- Nagata-Smirnov theorem, Stone's theorem, Smirnov's metrization theorem.
- Homotopy and the fundamental group, computation of the fundamental group of the circle.

Textbooks:

11. Joshi, K. D., *Topology* (Wiley-Eastern, 1988).

12. Munkres, J. R., *Topology: A first course* (2/e) (Prentice-Hall, 2000).

Suggested readings:

13. Kelley, J. L., *General Topology,* Graduate texts in Mathematics, Vol. 27, Springer,1991.

14. Willard, S., *General Topology,* Addision-Wesley, Reading, 1970.

MS 596: Advanced Topology – II

L 3 T1 P0 CR4

Course outcomes

On completion of this course student will

1. Understand the process of creating uniform structures and know the properties and structures of uniform spaces.
2. Know the basic structure, properties and applications of topological groups.
3. Construct and compare various topologies on spaces of functions.

Course content

- Uniformities, uniform continuity, product uniformities, metrisation.
- Completeness and compactness in uniform spaces.
- Topological groups, subgroups, quotient groups, homogeneous spaces, product groups.
- Uniform structures in topological groups, complete groups, completion of topological groups.

- Function spaces, point-wise convergence, uniform convergence, compact-open topology, k-spaces, equi-continuity, Ascoli theorem.

Textbooks:

15. Joshi, K. D., *Topology,* Wiley-Eastern, 1988.

16. Munkres, J. R., *Topology: A first course* (2/e), Prentice-Hall, 2000.

Suggested readings:

17. Kelley, J. L., *General Topology* (Graduate texts in Mathematics), Vol. 27, Springer, 1991.

18. Willard, S., *General Topology,* Addision-Wesley, Reading, 1970.

19. Engelking, R., *General Topology,* Polish Scientific Publishers, Warshaw, 1977.

20. Bourbaki, N., *Elements of Mathematics: General Topology*, Vols. I & II, Springer-Verlag, 1988.

MS 599: Probability Theory

L 3 T1 P0 CR4

Course outcomes

At the end of the course students

1. have a good concept of the basic of probability, sampling theory and the methods of testing hypothesis and apply the concepts in various problems.

Course content

- Measurable space, Measure and its properties, finite and sigma-finite measures, Axiomatic definition of Probability, Measurable functions , definition of Random Variable.
- Measure induced by a measurable function, definition of Probability distribution and distribution function, properties of distribution function and classification of distributions.
- Some basic theorems Integration theory(integration of measurable functions w. r. t. an arbitrary measure): Fatou's lemma , Monotone Convergence theorem, Dominated convergence Theorem. Definition of Mathematical Expectation of a random variable and its properties. Moments and moment inequalities.
- Convergence of a sequence of random variables (Weak convergence or convergence in probability, almost sure convergence and convergence in Law). Borel-Cantelli-lemma, Weak and Strong law of large numbers, Central limit theorem.

Textbooks:

21. Feller, W., *An Introduction to Probability Theory and its Applications*, Vol. II, Wiley, 1966.

22. Chow, Y. and Teicher, H., *Probability Theory , Independence, Interchangeability, Martingales,* 3rd Edition, Springer, 1997.

Suggested readings:

23. Ash, R. B., *Probability and Measure Theory, Second Edition*, Harcourt/Academic Press, 2000.

Courses Offered By Other Than Mathematical Sciences Department

DM 301: Fundamentals of Disaster Management

L3 T0 P0 CR3

Course outcomes

On completion of this course, learners will be able to -

1. identify the potential threats and vulnerability factors of any system which may lead to significant damage and disruption.
2. contribute in CBDRM process through public awareness and capacity building of vulnerable communities.

Course content

Unit 01: Understanding disaster phenomena and parameters of disaster risk

- Definitions of hazard, vulnerability, risk and disaster.
- Approaches to understand disaster phenomena, disaster risk and its associated parameters.
- Selected models and approaches to study disaster risk.
- Classification, characteristics, causes, and damage potentials of different natural hazards.
- Factors relevant to civil unrest (community conflict, religious conflict, political conflict, terrorism, war, national scarcity).
- Health hazards (biological, radiation and physical).
- Dimensions of vulnerability and examples of hazard specific vulnerability factors (structural and non-structural).

Unit 02: Global disaster scenario and disaster risk mitigation mechanisms

- Disaster trends (Global, national and regional).
- Methods of hazard, vulnerability and capacity assessment (HVCA).
- Scopes of and criteria for disaster risk mitigation measures (prevention, mitigation and preparedness).
- Capacity building for disaster risk mitigation (structural and non-structural measures).
- Alternative adjustment processes for damage mitigation.
- Community based disaster risk reduction mechanism.
- Counter disaster resources and their roles.

Unit 03: Safety norms and practices for damage mitigation

- Importance of safety measures in risky systems for damage mitigation.
- Industrial hazards, vulnerability and safety norms.
- Concept of fire, elements of fire (Fire triangle) and products of fire.
- Types of heat sources and fuels that may ignite fire.

- Different types of fire extinguishers and their applications.
- Fire detection and suppression facilities (isolated or integrated).
- Common fire protection tools and devices.
- Electrical safety norms for prevention of fire.

Unit 04: Environment and disasters

- Environment, ecosystem and disasters.
- Climate change – issues and concerns.
- Air, water and soil pollution.
- Post disaster impact on environment.
- Impact of developmental projects on disaster risk.
- Aspects of environmental management for disaster risk reduction.
- Environmental Impact Assessment *(EIA).*
- Role of NGT on environmental management.

Unit 05: Disaster management mechanism, policies and legislations

- Community-hazard profiles in India.
- Different phases of Disaster Management.
- Relief mechanism.
- Objectives, provisions and recommendations of DM Act 2005 and NPDM 2009.

Unit 06: Field work / Case studies (Group assignment)

- Risk assessment, hazard and vulnerability mapping of vulnerable systems or areas.
- Case studies on past disaster events.

Textbooks:

24. Etkin, D. *Disaster Theory: An Interdisciplinary Approach to Concepts and Causes,* Elsevier Science & Technology, 2015.

25. Chakrabarty, U. K. *Industrial Disaster Management and Emergency Response,* Asian Books Pvt. Ltd., New Delhi 2007.

Suggested readings:

26. Raju, N. V. S. *Disaster Management: Hazard and Risk Awareness - A Comprehensive Approach*, B. S. Publications, BSP Books Pvt. Ltd., Hyderabad, 2019.

27. Alexander, D. *Natural Disasters,* ULC press Ltd, London, 1993.

28. Carter, W. N. *Disaster Management: A Disaster Management Handbook,* Asian Development Bank, Bangkok, 1991.

BI 101: Biology – I

L3 T0 P0 CR3

Course outcomes

On completion of this course, learners will be able to -

1. understand different life forms in biology.
2. gain fundamental knowledge about bacteria, viruses, algae, fungi, bryophytes, pteridophytes, Gymnosperms

3. gain fundamental knowledge on genetics, theories of evolution and conservation

Course content

- **Introduction to the living world:** Description of living and non-living with comparison of differences; unicellular, colonial and multicellular organisms and their living behaviors.
- **Microorganisms**: Types of microorganism and their characteristics; characteristics of archaea, eubacteria, green algae, blue-green algae, red algae, lichen, microalgae, diatom, amoeba, protozoa, fungus, bacteria and viruses-viroids and prions.
- **Plant Kingdom**: Description on lower and higher groups of plants; characteristics of (i) Thallophyta, (ii) Bryophyta, (iii) Pteridophyta, (iv) Gymnosperm, and (v) Angiosperm.
- **Animal Kingdom**: Nonchrodates and chordates-description and classification with examples. Description of domestic and wild animals; animals in different ecosystems and their migratory behavior.
- **Genetics:** Fundamentals of genetics, Mendelian and non-Mendelian inheritance, Chromosome types, chromosome theory of inheritance and mutation.
- **Evolution of living world:** Theories of evolution: Lamarckism; Darwinism and Neo-Darwinism; evolution, extinction, and human health.
- **Forestry:** Direct and indirect benefits from forests, forest dwellers and their responsibilities, and sustainable forest management.
- **Conservation biology**: Presence of biodiversity; biodiversity scenario and hot spots, sub-tropical, temperate and tropical biodiversity, economics of biodiversity, threatened and endangered species, conservation of wild life both plant and animal types; conservation and maintenance of crop plants; deforestation and consequences, social forestry, forest management, Indian case studies on conservation and management strategies (Lions of Gir forest, Rhinos of Kaziranga, Swamp deer of Manipur, Project Tiger, Biosphere reserve).

Textbooks:

29. Campbell, N.A. and Reece, J. B., *Biology*, 8th edition, Pearson Benjamin Cummings, San Francisco, 2008.

30. Raven, P.H et al., *Biology*, 7th edition, Tata McGrawHill Publications, New Delhi, (2006)

31. Griffiths, A.J.F et al., *Introduction to Genetic Analysis*, 9th edition, W.H. Freeman & Co. NY, 2008.

Suggested readings:

32. Tamarin, H. Robert, *Principles of Genetics*, TATA McGRAW-HILL Edition.

33. Hartl, L.D. and Jones W.E., *Essential Genetics:A Genomics Perspective*, 6th Edition, Jones & Bartlett Learning, 2012.

34. Fairbank J.D. and *Andersons, R.W., Genetics: the continuity of life*, 1999

35. Stansfield, D. W., Colome, S.C. J., Cano J.R. and Sharan, N.R., *Molecular and Cell Biology* (Schaum's Outlines series special Indian edition), McGraw Hill Education, 2010.

BI 107: Biology-Lab

L3 T0 P0 CR3

Course outcomes

On completion of this course, learners will be able to -

1. gain knowledge for identification of plants and animals.
2. learn media preparation for isolation of pure culture of microbes for identification and characterization.
3. gain knowledge in preparation of buffers and other solution required in biological laboratory.

Course content

- Observation of animals/plants from nature and preparation of herbarium.
- Observation and identification of permanent slide/specimens of different species.
- Dissection and construction of floral diagram belonging to different families.
- Observation of microorganisms by microscope
- Preparation of buffers routinely used in biological experiments
- Culture of bacteria through serial dilution of samples.

Textbooks:

36. Verma, S.P., *A Manual of Practical Zoology: Invertebrates,* ISBN: 9788121908290
37. Verma, S.P., *A Manual of Practical Zoology : Chordates.* ISBN 9788121908306

Suggested readings:

38. Tortora, G.J., Funke, B.R., Case, C.L., *Microbiology: An Introduction*, Pearson,Benjamin Cummings, U.S.A., 10th edition, 2010.
39. Kumar, H.D., *Introductory Phycology,* Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition, 1999.
40. Vashishta, P.C., Sinha, A.K., Kumar, A., *Pteridophyta*, S. Chand. Delhi, India, 2010.
41. Bhatnagar, S.P. and Moitra, A., *Gymnosperms*. New Age International (P) Ltd Publishers, New Delhi, India, 1996.
42. Parihar, N.S., *An introduction to Embryophyta.* Vol. I. Bryophyta. Central Book Depot, Allahabad, 1991.

PI 101: Physics - I

L2 T1 P0 CR3

Course outcomes

On completion of this course, learners will be able to -

1. understand the basics of vectors and matrices, introductory mechanics and properties of matter.
2. learn the detail of the coordinate systems: plane polarized, cylindrical and spherical; along with various vector and scalar properties.
3. Learn the extensive use of vectors and matrices in solving various problems in an intended learning outcome.
4. understand the basic mechanics in both inertial and non-inertial frames, motion under a central force and the mechanics of a system of particles.

Course content

- **Coordinates, Vectors and Matrices:**Coordinate systems, plane polar, cylindrical and spherical polar; line element, surface element and volume element; gradient, divergent and curl. Line, surface and volume integrals.
- Properties of matrices; complex conjugate matrix, transpose matrix, hermitian matrix, unit matrix, diagonal matrix, adjoint of a matrix, self-adjoint matrix, cofactor matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix, eigenvalue, diagonalization of matrices.

- **Mechanics:** Work-energy theorem, conservative forces and potential energy; energy diagram; non-conservative forces; motion in non-inertial frames; uniformly rotating frame; centrifugal and Coriolis forces.
- Motion under a central force. System of particles; centre of mass, equation of motion of the centre of mass; laboratory and centre of mass frame of references; elastic and inelastic collisions; linear and angular momentum and their conservation laws; fixed axis rotation; moment of inertia; theorem of parallel and perpendicular axes; compound pendulum, Kater's and bar pendulum.

- **Properties of Matter:** Elasticity; elastic constants; Hooke's law; torsional oscillation; bending of a beam; cantilever; surface tension; viscosity; kinematics of moving fluids.

Textbooks:

43. Spiegel M., *Vector Analysis: Schaum's Outlines Series*, 2nd edition, McGraw Hill, 2017.
44. Potter M. C., Goldberg J., *Mathematical methods*, 2nd edition, Phi Learning Pvt. Ltd., 2008.
45. Mathur, D. S., *Mechanics*, S. Chand & Co. Ltd., 2000.
46. Kleppner, D. and Kolenkow, R., *Introduction to Mechanics*, McGraw-Hill, 1973.

Suggested readings:

47. Harper C., *Introduction to Mathematical Physics*, 1st edition,Phi Learning Pvt. Ltd., 2008.
48. Chow, T. L., *Mathematical Methods for Physicists: A concise introduction*, 1st edition, Cambridge Univ. Press, 2000.
49. Takwale R., Puranik P., *Introduction to Classical Mechanics*, McGraw Hill, 2017.
50. Young, H. D. and Freedman, R. A., *University Physics*, 12th edition, Pearson, 2009.

PI 102: Physics - II

L2 T1 P0 CR3

Course outcomes

On completion of this course,

1. it is expected that after successfully completing the course, the student has a good idea on relativity, electricity, magnetism and electronics.
2. student will be able to study the advanced courses like General relativity, Electrodynamics, Digital electronics etc..

Course content

- Special Theory of Relativity:Frames of reference, relative velocity and accelerations, Concept of ether, Michelson-Morley experiment, elements of special theory of relativity, the postulates, Galilean and Lorentz transformations, equivalence of mass and energy, time dilation, length contraction, simultaneity, Doppler effect, twin paradox.
- Electromagnetism: Coulomb's law (electric), electric field due to a system of charges, Gauss's law in differential and integral forms, electric dipole, its electric field and potential, capacitance of parallel plates. Coulomb's law (magnetic), Biot-Savart law, force on a current and on moving charges in a B-field.
- Electronics: Kirchhoff's law, network theorem, nodal analysis, mesh analysis, maximum power transfer theorem, series circuits, parallel circuits (DC analysis only), semiconductors, p-type, n-type semiconductors, p-n junction, diode, triode.

Textbooks:

51. Beiser A., *Concepts of Modern Physics*, 6th edition, Tata McGraw Hill, 2008.
52. Rakshit, P. C. and Chattopadhaya, D., *Electricity and Magnetism*, New Central Book Agency, 2012.
53. Robbins, A. H. & Miller, W. C., *Circuit Analysis*, Delmar Cengage Learning, 2003.

Suggested readings:

54. Resnick, R., *Introduction to Special Relativity*, 1st edition, Wiley, 2007.
55. Griffith, D. J., *Introduction to Electrodynamics*, 3rd edition, Prentice Hall of India, 1999.
56. *Edminister, J. A., Electrical Circuits- Schaum's Outline series*, 2nd edition, McGraw Hill,1983.

PI 197: Physics - Lab

L2 T1 P0 CR3

Course outcomes

1. After completion of the course students will be able to use the different components and equipment in physics practical.
2. Students will also able to work effectively and safely in the laboratory environment independently and as well as in teams.

Course content

- Laboratory related components: Laboratory safety measures; handling of chemical; electrical and electronics items and instruments; handling of laser and laser related instruments and experiments; handling of radioactive samples and related instruments; general safety measures etc.

- Familiarization with equipment and components: Familiarization of different Electrical and Electronics components and hence identification & determination of values of unknown components Familiarization of different optical and hence show different optical behavior & pattern by using different optical components and optical sources (white light, laser, sodium light etc.). Familiarization of Microsoft excel, Origin and other software for data analysis Soldering and de-soldering of components in a circuit board.

- Use of equipment:Multimeter and its uses, Function generator and its uses, CRO and its use to measure the wavelength, frequency, amplitude etc. of a given electrical signal.
- Study the variation of time period with distance between center of gravity and center of suspension for a bar pendulum, determine radius of gyration of the bar about its axis through its center of gravity and perpendicular to its length and, value of g.
- Determine the moment of a given magnet and horizontal component of Earth's magnetic field using magnetometers
- Determine g through Kater's Pendulum
- Find the refractive index of a given prism with the help of a spectrometer.
- To determine the surface tension of the given liquid (water/CC14) by capillary tube method.
- To measure the focal length of a given lens using (a) Bessel's method and (b)Magnification method.
- To study elastic and inelastic collisions using suspended spherical balls of different materials.
- Determination of Young's modulus of the given wire by torsional oscillation (Searl's method)

PI 201: Physics – III

L2 T1 P0 CR3

Course outcomes

1. It is expected that after successfully completing the course, the student has a good idea on quantum mechanics.

Course content

- Particle properties of waves: Wave particle duality, Photoelectric effect, Black body radiation, Plank radiation law, Rayleigh-Jeans law, Stefan's law.

- Atomic physics: Rutherford model, Bohr model, hydrogen atom (quantum numbers and spectral series; qualitative), X-ray, Moseley's law, Basics of Lasers. Basics particle physics: elementary forces and particles.

- Limitations of classical physics: Qualitative discussions of the problem of the stability of the nuclear atom. The photo-electric effect. Franck-Hertz experiment and the existence of energy levels. Experimental evidence for wave-particle duality, X-ray diffraction and Bragg law. Compton scattering. Electron and neutron diffraction. Einstein and de Broglie's relations ($E = h\gamma$, $p = h/\lambda$).

- Schrodinger equation: The concept of the wave function as a probability amplitude and its probabilistic interpretation. Plane wave solutions of the one-dimensional time-dependent Schrodinger equation for a particle in free space and elementary derivation of the phase and group velocities (quantitative discussion of wave packets is not required).

- Uncertainty relation: The position-momentum uncertainty relation and simple consequences. Solutions of the one-dimensional Schrodinger's equation for an infinite square well potential; qualitative treatment of the finite well (derivation not required). Linear harmonic oscillator.

Textbooks:

57. Beiser, A., *Concepts of Modern Physics*, McGraw-Hill, 2002.
58. Krane, K. S., *Modern Physics,*Wiley.

Suggested readings:

59. Beiser, A., Perspectives *of Modern Physics*, McGraw-Hill Inc., US.
60. Thornton, S. T. and Rex, A., Modern Physics for Scientists and Engineers, Cengage Learning; 4th edition.
61. Gautreau, R. Schaum's Outline of Modern Physics, McGraw-Hill, 2nd edition.
62. Young, H.D. and Freedman, R.A., *University Physics*, 12th edition, Pearson, 2009**.**

CS 535: Introduction to Scientific Computing

L2 T0 P1 CR3

Course outcomes

After completion of this course,

1. students will be able to write programs with a better understanding of the language constructs, common abstraction mechanisms, and efficiency considerations.
2. they will be able to perform practical implementation of solutions to scientific and engineering problems.

Course content

- Introduction to scientific computing.
- Representing numbers in a computer: scalar data types;
- Variables and constants: guidelines for variable names;
- Assignment statements: mathematical and logical operators;
- Keyboard input and screen output;
- Writing a simple, linear program.
- Conditional statements; arrays and subscripts; loops. File 110; plotting;
- Functions and subroutines;
- Program design; writing well structured programs; debugging techniques;
- Scientific applications of computer programs; Introduction to Matlab;
- Solving nonlinear equations;
- Numerical integration;
- Data analysis, plotting and smoothing;
- Simulating simple physical, chemical and/or mathematical systems;
- Simulation: the simple programming approach to difference equations;
- Differential Equations.

Textbooks:

63. Christian Hill, *Learning Scientific Programming with python*, 2nd Ed, Cambridge University Press.

64. Quarteroni, Alfio and Saleri, Fausto and Gervasio, Paola, *Scientific Computing with MATLAB and Octave*, 4th Edition, Springer.

Suggested readings:

65. R. G. Dromey, *How to Solve it by Computer*, Prentice-Hall Inc.

66. Gerald, Curtis F and Wheatley, Patrick O, *Applied Numerical Analysis*, 6th/7h Edition, Pearson Education India.

CI 101: Chemistry-I

L3 T0 P0 CR3

Course outcomes

After completion of this course, the students will be able to understand

1. Atomic theory and its evolution
2. Periodic propertied of elements
3. Basic of organic molecules, structure, bonding and organic reaction mechanisms
4. Synthesis of hydrocarbons
5. Basics of Chemical thermodynamics and thermodynamic laws
6. Fundamentals of solutions and colligative properties

Course content

- Structure of atom, Hund's rule, Aufbau principle, Pauli's exclusion principle.
- Periodic Properties: Periodicity of the elements, shielding, effective nuclear charge, Slater's rule, the size of the atoms, atomic, covalent and van der Waals radii, ionization energy, electron affinity, electronegativity.
- Basics of organic chemistry-1 : Bonding, structure and physical properties of organic compounds: Valence bond theory: Concept of hybridization of organic compounds and shapes of molecules; MO theory: Acyclic π orbital system and cyclic π orbital systems;
- Physical properties: Melting point, boiling point, solubility, dipole moment.
- Basics of organic chemistry-2: Electronic and steric effects: Inductive effect, resonance, hyperconjugation, steric effect, steric inhibition of resonance.
- Basics of organic chemistry-3: Thermodynamics and kinetics of organic reactions:
- Free energy and equilibrium, enthalpy and entropy factor, intermolecular & intramolecular reactions, rate constant and free energy of activation, free energy profiles for one step and multi-step reactions, catalyzed reactions, kinetic control and thermodynamic control, kinetic isotopic effect, principle of microscopic reversibility, Hammond postulate.

- Alkanes: Synthesis by: Decarboxylation, reduction of alkyl halides and tosylates, Kolbe electrolysis, Wurtz reaction, Corey–House synthesis; Reactions of alkanes: Halogenation, nitration, sulphonation, oxidation and cracking of alkanes.
- Alkenes and alkynes: Synthesis, Dehydration of alcohols, pyrolysis of esters, Cope reaction, Elimination of alkyl halides, germinal- and vicinal dihalides, Hofmann elimination; Reactions: Addition of X_2 (X = halogen), H-X, HO-X, interhalogens, water, Oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, catalytic reduction, dihydroxylation, epoxidation, polymerization, alkylation of alkynes, oxidation of alkynes to 1,2-diketones, allylic and benzylic halogenation of alkenes mediated by radicals.
- First Law of Thermodynamics: Thermodynamics terms, state and path functions, concept of heat and work, internal energy, enthalpy, first law of thermodynamics; w, q, °U and °H for expansion and compression of ideal gases, heat capacities, physical change, standard enthalpies of physical and chemical changes, Hess's law, Kirchhoff's law.
- Second Law of Thermodynamics: Spontaneous processes, Carnot cycle, entropy, criteria of spontaneity, statements of the second law of thermodynamics, entropy changes, Clausius inequality, Gibbs energy, Helmholtz energy, Third law of thermodynamics.
- Solutions: Ideal and non-ideal solutions
- Colligative properties

Textbooks:

67. Lee, J. D., *Concise Inorganic Chemistry*, 5th Edn., Chapman & Hall, 2002.

68. Atkins, P. and Paula, J., de. *Atkins' Physical Chemistry*, 10th Edn., Oxford University Press, 2014.

69. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2nd Edn., Oxford University Press, 2012.

70. Finar, I. L., *Organic Chemistry*, Volume 1, 6th Edn., Pearson Education, 2002.

Suggested readings:

71. Levine, I. N., *Physical Chemistry*, 6th Edn., McGraw Higher Edn., 2008.

72. Carey, F. A., Sundberg, R. J., *Advanced Organic Chemistry, Part A: Structure and Mechanisms*, 5th Edn., Springer, New York, 2007.

73. March, J., Smith, M. B., *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edn., Wiley, 2007.

CI 107: Chemistry LaboratoryI

L0 T0 P3 CR3

Course outcomes

After completion of this course, the students will be able to do

1. anlysis of inorganic mixures
2. estimation of compunds
3. measurement of some physical properties.

Course content

- Qualitative Analysis of Inorganic Mixtures (excluding interfering radicals)
- Preparation of Mohrs salt
- Estimation of Glucose
- Nitration of organic compounds
- Reduction of functional groups
- Preparation of buffer solution and measurement of pH.
- Viscosity measurement of solution
- Conductometric acid-base titration
- Measurement surface tension of liquid by stalagmometer
- Verification of Beer-Lamberts law
- Titration of a mixture of AcOH, HCl and $CuSO_4$ by conductometric method and $CuSO_4$ by conductometric method

Textbooks:

74. Furniss, B. S., Ford, A. J. H., Smith, P. W. H., Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry*, 5th Edn., Wiley, 1989.

75. Jadav, J. B. *Advanced Practical Physical Chemistry*, Krishna Prakashan, 2015.

Suggested readings:

76. Mendham, J., Danney, R. C., Barnes, J. D., Thomas, M., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edn., Prentice Hall, 2009.

77. Gurdeep, R., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, 2013.

CI 102: Chemistry -II

L3 T0 P0 CR3

Course outcomes

After completion of this course, the students will be able understand

1. Structure and bonding of homonuclear diatomic molecules
2. Polarizability of ions
3. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
4. Aromatic compound and aromaticity

5. Organic Intermediates, their generation and reactivity
6. Properties of gases and liquids
7. Kinetics of simple reactions
8. Fundamentals of electrochemistry

Course content

- Structure and Bonding: Valence Bond and LCAO-MO theory, bonding in homonuclear diatomic molecules (e.g.: H_2, N_2, O_2, F_2), covalent and ionic bonding, bond order, resonance, formal charge, VSEPR model, Polarizability of cations and anions, Fazan's rules.
- Basics organic chemistry-4: Nucleophiles, electrophiles, keto-enol tautomerism, acidity and basicity of organic compounds, Frost diagram, Hückel's rules for aromaticity, antiaromaticity, homoaromaticity.
- Stereochemistry-1: Representation of organic molecules in Fischer, saw horse, Newman, and flying-wedge, projection formulae and their interconversion, symmetry elements, molecular chirality, optical activity, optical purity, meso compounds, racemic mixture, resolution, enantiomers, diastereomers, epimers, anomers, atropisomers, basic concepts of stereochemical nomenclatures: *threo*/*erythro*, *syn*/*anti*, *R*/*S*, *cis*/*trans* and *E*/*Z*).
- Reactive intermediates: Carbocation, carbanion, carbene, nitrene, free radical and benzyne: Generation, stability and reactions.
- Properties of gases and liquids: Equations of state, kinetic model of gases, collision theory, real gases, Maxwell distribution of molecular speeds, qualitative description of the structure of liquids, surface tension and viscosity.
- Electrochemistry: Conduction in electrolyte solutions, ionic mobility, Kohlrausch law, Ostwald's dilution law, transport number, Debye-Huckel Limiting Law, electrochemical cells, EMF, Nernst equation.
- Rate of reactions: Rate equations of zero, first, second, pseudo 1st order reactions, determination of order of a reaction, activation energy, activated complex theory, collision theory.

Textbooks:

78. Atkins, P., Paula, J. de. *Atkins' Physical Chemistry*, 10th Edn., Oxford University Press, 2014.

79. Overton, T., Armstrong, F., Rourke, J., Weller, M. *Inorganic Chemistry,* 6th Edn., Oxford University Press, 2015.

80. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2nd Edn., Oxford University Press, 2012.

81. Sengupta, S. *Basic Stereochemistry of Organic Molecules*, 1st Edn., Oxford University Press, 2014.

Suggested readings:

1. Laidler, K. J., Meiser, J. H., Sanctuary, B. C., *Physical Chemistry,* 4th Edn., Brooks Cole, 2002.
2. Carey, F. A., Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis*, 5th Edn., Springer, New York, 2007.
3. March, J., Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edn., Wiley, 2007.

4. Eliel, E. L., Wilen, S. H., Doyle, M. P. *Basic Organic Stereochemistry*, 1st Edn., Wiley-Interscience, 2001.

CI 201: Chemistry -III

L3 T0 P0 CR3

Course outcomes

After completion of this course, the students will be able understand

1. Concepts of acids and bases, and their strength
2. Fundamentals of coordination chemistry
3. Aromatic compounds and aromaticity
4. Synthesis and properties of hydrocarbons
5. Weak electrolyte and ionic equilibrium.

Course content

- Acid -Base concept: Arrhenius concept, Brønsted-Lowry acids and bases, Lewis acids and bases, Hard Soft acids - bases and HSAB principle, Acid and base strength, levelling effect.
- Coordination chemistry: Werner's theory, classification of ligands, coordination number, nomenclature of coordination compounds, isomerism.
- Aromaticity and Hückel Rule, Orientation of substituents, Directive influence of substituents, o/p ration, kinetically and thermodynamically controlled reactions.
- Alkynes: Preparation, properties and reactions.
- Alkyl halides: Preparation, properties and reactions.
- Ionic equilibrium: Arrhenius theory of electrolytic dissociation, Ostwald dilution law, Dissociation constant of week acids and bases, Ionization of water, pK_w and pH, Salt effect, pH expressions for various neutralization reaction, Henderson- Hasselbalch equation, solubility product, common ion effect, Buffer solutions, theory of acid base indicators, acid base titration curves (pH variation).

Textbooks:

82. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., Pearson Education, 2006.

83. Barrow, G. M. *Physical Chemistry*, 5th Edn., McGraw Hill, 2007.

84. Finar, I. L. *Organic Chemistry,* Volume 1, 6th Edn., Pearson Education, 2002.

85. Ghosh, S. K., *Advanced General Organic Chemistry,* 3rd Edn., New Central Book Agency (P) Ltd., 2008.

Suggested readings:

86. Smith, M. B., March, J. *March's Advanced Organic Chemistry, Reaction Mechanism and Structure* 6th Edn., Wiley, 2007.

87. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2nd Edn., Oxford University Press, 2012.

ES 103: Environmental Studies

L4 T0 P0 CR4

Course outcomes

1. Recognize the need for learning environmental studies and develop foundational knowledge on the topic.
2. Appreciate the environment around us, spread awareness on environment degradation, promote environment protection and sustainable mitigation strategies.
3. Develop critical thinking and analytical ability to resolve interdisciplinary issues related to the environment around us.

Course content

- Introduction to environmental studies

  Multidisciplinary nature of environmental studies

  Scope and importance; Concept of sustainability and sustainable development.

- Ecosystems

  What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems:

  a) Forest ecosystem

  b) Grassland ecosystem

  c) Desert ecosystem

  d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

- Natural Resources: Renewable and Non-renewable Resources

  Land resources and landuse change; Land degradation, soil erosion and desertification.

  Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.

  Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).

  Energy resources: Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

- Biodiversity and Conservation

  Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots.

  India as a mega-biodiversity nation; Endangered and endemic species of India.

Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

- Unit 5: Environmental Pollution

Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution.

Nuclear hazards and human health risks.

Solid waste management: Control measures of urban and industrial waste.

Pollution case studies.

- Unit 6: Environmental Policies & Practices

Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture.

Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).

Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

- Unit 7: Human Communities and the Environment

Human population growth: Impacts on environment, human health and welfare.

Resettlement and rehabilitation of project affected persons; case studies.

Disaster management: floods, earthquake, cyclones and landslides.

Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan.

Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.

Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

- Unit 8: Field work

Visit to an area to document environmental assets: river/forest/flora/fauna, etc.

Visit to a local polluted site-Urban/Rural/Industrial/Agricultural.

Study of common plants, insects, birds and basic principles of identification.

Study of simple ecosystems-pond, river, Delhi Ridge, etc.

Textbooks:

1. E. Bharucha, *Textbook of Environmental Studies*, Orient Black Swan, 2015.

Suggested readings:

- R. Carson, *Silent Spring*, Houghton Mifflin Harcourt, 2002.
- M., Gadgil, & R. Guha, *This Fissured Land: An Ecological History of India*, Univ. of California Press, 1993.
- B. Gleeson and N. Low, *Global Ethics and Environment*, London, Routledge, 1999.
- P. H. Gleick, *Water in Crisis. Pacific Institute for Studies in Dev.*, Environment & Security. Stockholm Env. Institute, Oxford Univ. Press, 1993.
- Martha J. Groom, Gary K. Meffe, and Carl Ronald Carroll, *Principles of Conservation Biology, Sunderland*, Sinauer Associates, 2006.
- Grumbine, R. Edward and M.K. Pandit, *Threats from India's Himalaya dams*, Science, 339: 36-37, 2013.
- P. McCully, *Rivers no more: the environmental effects of dams*, Zed Books, 1996.
- McNeill and R. John, *Something New Under the Sun: An Environmental History of the Twentieth Century*, W. W. Norton & Company, 2000.
- E.P. Odum, H.T. Odum and J. Andrews, *Fundamentals of Ecology*, Philadelphia: Saunders, 1971.
- I.L. Pepper, C.P. Gerba and M.L. Brusseau, *Environmental and Pollution Science*, Academic Press, 2011.
- M.N. Rao and A.K. Datta, *Waste Water Treatment*, Oxford and IBH Publishing Co. Pvt. Ltd.,1987.
- P.H. Raven, D.M. Hassenzahl and L.R. Berg, *Environment*, 8th edition, John Wiley & Sons, 2012.
- A. Rosencranz, S. Divan, and M.L. Noble, *Environmental law and policy in India*, Oxford, 1992.
- R. Sengupta, *Ecology and economics: An approach to sustainable development*, OUP, 2003.
- J.S. Singh, S.P. Singh, and S.R. Gupta, *Ecology, Environmental Science and Conservation*, S. Chand Publishing, New Delhi, 2014.
- N.S., Sodhi, L. Gibson, and P.H. Raven, *Conservation Biology: Voices from the Tropics*, John Wiley & Sons, 2013.
- V. Thapar, *Land of the Tiger: A Natural History of the Indian Subcontinent*, India Book House, 1998.
- C. E. Warren, *Biology and Water Pollution Control*, WB Saunders, 1971.
- E. O. Wilson, *The Creation: An appeal to save life on earth*, New York: Norton, 2006.
- World Commission on Environment and Development, *Our Common Future*, Oxford University Press, 1987.

NS 102: National Service Scheme

L1 T0 P1 CR3

Course outcomes

After the completion of course the student will be able to:

1. Define the aims and objectives of National Service Scheme.
2. Understand the positive aspects of community service, good health and hygiene
3. Develop civic and social responsibility and democratic spirit

4. Explain the problems and needs of the community
5. Demonstrate leadership quality

Course content

- **Unit - 01: Introduction and Basic Concepts of NSS**

  History, philosophy, aims & objectives of NSS
  Emblem, flag, motto, song, badge
  Organizational structure, roles and responsibilities of various NSS functionaries

- **Unit - 02: Understanding Youth and Volunteerism**

  Definition, profile of youth, categories of youth
  Issues, challenges, and opportunities for youth
  Youth as an agent of social change, Importance and role of youth leadership
  Indian Tradition of volunteerism, Needs & importance of volunteerism

- **Unit - 03: Community Mobilisation**

  Mapping of community stakeholders
  Designing the message in the context of the problem and the culture of the community
  Identifying methods of mobilisation, Youth-adult partnership

- **Practicum**

  Community service
  Practice of volunteerism
  Special camp and national integration camp

Textbooks:

1. E. Panwar, JDS et. *National Service Scheme: A Youth Volunteers Programme for Under Graduate Students*, New Delhi, Daya Publishing House, 2020.
2. Rao, P. Ramachandra and Sampath Kumar, R.D. *Training of Trainers in National Service Scheme*, Visakhapatnam , Uday Publishing House, 2017.

Suggested readings:

- Devendra, Agochiya *Life Competencies for Growth and Success: A Trainer's Manual*, New Delhi, SAGE Publications, 2018
- Prasad, R.R. *Community Mobilisation: Methods & Models*, New Delhi, Discovery publishing House, 2015.
- Sanghi, Seema *The Handbook of Competency Mapping - Understanding, Designing and Implementing Competency Models in Organizations*, New Delhi, Sage Publications, 2007.
- Silbereisen, Rainer K. and Lerner, Richard M. *Approaches to Positive Youth Development*, LA, Sage Publications, 2007.
- Stallings, Betty B. and Ellis, Susan J. *Leading the Way to Successful Volunteer Involvement: Practical Tools for Busy Executives*, Philadelphia: Energize Books, 2010.

- Villarruel, Francisco A. et al. *Community Youth Development: Programs, Policies, and Practices*, LA, Sage Publications, 2003.

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