SMIT SIKKIM MANIPAL UNIVERSITY

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

(Constituent College of Sikkim Manipal University)

Syllabus

3 years B.Sc. Programme /4 Years B.Sc. in Mathematics(Honors) / 5 years Integrated M.Sc./ 2 years M.Sc. in Mathematics/ 1 year M.Sc. in Mathematics

(2023-24)

Department of Mathematics
Sikkim Manipal Institute of Technology
Sikkim Manipal University

Sikkim Manipal University

Vision: Global Leadership in Human Development, Excellence in Education and Healthcare.

Mission: Develop professionals of excellent technical calibre in the field of Health Sciences, Engineering, Management and Social Sciences with a humane approach capable of shouldering the responsibility of building the nation and be globally competent.

Sikkim Manipal Institute of Technology

Vision: To achieve eminence in the field of quality technological education and research.

Mission: To develop SMIT into an Institution of Excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society.

Department of Mathematics

Vision: Emerge as a center of excellence in Mathematics and its technological applications.

Mission:

- To train students in fundamental and applied Mathematics so as to emerge as competent professionals in diverse fields.
- To provide an environment where students can enjoy mathematics, and understand its use in interdisciplinary fields.
- To inculcate the spirit of research and its importance among students through innovative teaching and research methodologies.
- To cater to the development of the nation, through innovative research, training activities and quality education.

Description of the Programme:

The department is proposing a graduate program in mathematics with multiple entry and exit options. The entire academic structure is designed on the line of NEP-2020 guidelines and followed by the common regulation set by the institute/ university. The proposed program has exit points at the end of every even semester; promotion/exit criteria is applied at the end of each even semester.

The programme is well blended with courses in pure & applied mathematics, statistics and computer science. This will enable students to pursue higher studies in M.Sc. Mathematics program of this university or any other university/institute of repute. The exposures in courses on computer science will also make the students industry ready for software, finance and banking. It will be beneficial for those who wish to go for jobs straightway after the completion of the program.

- ENTRY POINTS: There are two entry points to this program.
  - ENTRY I: First Semester(Eligibility: 10+2 pass with 50% marks and mathematics as one of the subjects.)
  - ENTRY II: Seventh Semester(Eligibility: Three years degree course with at least 50% marks(or 6 CGPA) and mathematics as one of the subjects.)–For Two years M.Sc. in Mathematics.
  - ENTRY III: Ninth Semester(Eligibility: Four years degree course with Honors/Honors with Research in Mathematics.)–For one year M.Sc. in Mathematics.
- EXIT POINTS: There are five exit points to this program with certificates, diploma or degrees.
  - EXIT I: After successful completion of first year courses. A student will be awarded a Certificate Course in Mathematics.
  - EXIT II: After successful completion of first two year courses. A student will be awarded a Diploma in Mathematics.
  - EXIT-III: After successful completion of first three year courses. A student will be awarded a Bachelor of Science(B.Sc.) Degree in Mathematics.
  - EXIT-IV: After successful completion of first four year courses. A student will be awarded a Bachelor of Science(B.Sc.) Degree in Mathematics(Honors) or Bachelor of Science(B.Sc.) Degree in Mathematics(Honors with research).
  - EXIT-V: After successful completion of five year courses. A student will be awarded an Integrated Master of Science(M.Sc.) Degree in Mathematics(applicable for students with Entry I). A student entering through ENTRY-II will be awarded a Master of Science(M.Sc.) Degree in Mathematics after successful completion of all the courses. A

student entering through ENTRY-III will be awarded a Master of Science(M.Sc.) Degree in Mathematics after successful completion of all the courses.

COURSE CURRICULUM

3 years B.Sc. Program /4 Years B.Sc. in Mathematics(Honors/ Honors with research) / 5 years Integrated M.Sc./ 2 years M.Sc. in Mathematics/1 year M.Sc. in Mathematics

Code	Title	L-T-P	Credit	Teaching Dept	Remarks
Semester I(ENTRY-I)					
MA131A1	Foundation Course in Mathematics	3-1-0	4	MATH	Major
MA132A1	Single Variable Calculus	3-1-0	4	MATH	Major
BA10101A	English	2-0-0	2	MGT	AEC
GN201A1	Universal Human Values	3-0-0	3	—	VAC
******	Elective-I/MOOC	4-0-0/ 3-0-1	4	—	MLTD/ Minor
******	C-Programming	3-0-0	3	—	SEC
******	C-Programming Lab	0-0-1	1	—	SEC
Total Credits in Semester I			**21**		
Semester II					
MA133A1	Solid Geometry & Vector Calculus	3-1-0	4	MATH	Major
MA134A1	Discrete Mathematics	3-1-0	4	MATH	Major
MA135A1	Linear Algebra	3-1-0	4	MATH	Major
******	English Literature/ Functional English/ MIL/ Hindi/ Foreign Language/ Elective-II/MOOC	2-0-1	2	—	AEC
CH107A1/ BP101A1	Environmental Studies/ Constitution of India	1-0-0	1	—	VAC
******	Elective-III/MOOC	3-1-0/ 3-0-1	4	—	MLTD/ Minor
PE108A4	Fitness and Yoga	1-0-2	2	PHE	VAC
Total Credits in Semester II			**21**	EXIT-I(Certificate)	
Semester III					
Summer internship/Vocational (2 - 4 CR): Workshop skills, Carpentry, Plumbing, Web design, Surveying, Electrical Wiring, Financial s/w, digital photography & editing, Video editing for social media, Computer assembling and networking, Research & Technical writing etc.					
MA231A1	Algebra I: Group Theory	3-1-0	4	MATH	Major
MA232A1	Elementary Number Theory	3-1-0	4	MATH	Major
MA231A8	Probability Theory	3-1-0	4	MATH	Minor
*****	Elective-IV	3-1-0	4	MATH	MLTD/ Minor
*****	Leadership and Behavior Management/ Emotional Intelligence/ Alternative English/ Nepali/ Sanskrit/ MOOC/ Elective-V	2-0-0	2	—	AEC
MA231A9	Summer Internship/ Vocational	0-0-2	2	—	SEC
Total Credits in Semester III			**20**		
Semester IV					
MA233A1	Algebra II: Ring Theory	3-1-0	4	MATH	Major
MA234A1	Multivariable Calculus	3-1-0	4	MATH	Major
MA235A1	Ordinary Differential Equations	3-1-0	4	MATH	Major
MA232A8	Statistical Methods	3-1-0	4	MATH	Minor
*****	Elective-VI/ MOOC	3-1-0	4	—	MLTD/ Minor
MA232A9	Community based participatory research(Field work)	0-0-2	2	MATH	AEC/ Summer Internship
Total Credits in Semester IV			**22**	EXIT-II(Diploma)	

Semester V					
CODE	TITLE	L-T-P	CREDIT	TEACHING DEPT	REMARKS
MA331A1	Complex Analysis	3-1-0	4	MATH	Major
MA332A1	Numerical Analysis	3-1-0	4	MATH	Major
MA331A8	Dynamics	3-1-0	4	MATH	Minor
MA332A8	Introduction to Machine Learning	3-1-0	4	MATH	Minor
******	Elective-VII/ MOOC	3-1-0/ 3-0-1	4	—	MLTD/ Minor
Total Credits in Semester V			**20**		
Semester VI					
MA333A1	Metric Spaces	3-1-0	4	MATH	Major
MA334A1	Classical Mechanics	3-1-0	4	MATH	Major
MA333A8	Theory of Computation	3-1-0	4	MATH	Minor
******	Elective-VIII/ MOOC	3-1-0/ 3-0-1	4	—	MLTD/ Minor
MA331A7	Seminar-I	0-0-3	3	MATH	SEC
Total Credits in Semester VI			**19**		
Total Credits after three years			**123**	EXIT-III(Degree)	
Semester VII(B.Sc.)/Semester-I(2 Years M.Sc. Program)(ENTRY-II)					
MA431A1/ MA541A1	Real Analysis	3-1-0	4	MATH	Major
MA432A1/ MA542A1	Abstract Algebra	3-1-0	4	MATH	Major
MA433A1/ MA543A1	Ordinary and Partial Differential Equations	3-1-0	4	MATH	Major
MA434A1/ MA544A1	Advanced Linear Algebra	3-1-0	4	MATH	Major
MA431A8/ MA541A8	Basics of Financial Mathematics	3-1-0	4	MATH	Minor
MA431A4/ MA541A4	Computational Laboratory	0-0-2	2	MATH	SEC
Total Credits in Semester VII			**22**		
Semester VIII(B.Sc.)/Semester-II(2 Years M.Sc. Program)					
MA435A1/ MA545A1	Measure and Integration	3-1-0	4	MATH	Major
MA436A1/ MA546A1	Graph Theory	3-1-0	4	MATH	Major
MA437A1/ MA547A1	Topology (in lieu of Project)	3-1-0	4	MATH	Major
MA438A1/ MA548A1	Advance Complex Analysis(in lieu of Project)	3-1-0	4	MATH	Major
MA4**A3/ MA5**A3	Elective-IX/MOOC(in lieu of Project)	3-1-0/ 3-0-1	4	MATH	Minor
MA431A6	Project/Dissertation	—-	12	MATH	Project
Total Credits in Semester VIII			**20**		
Total Credits after 4 years			**165**	EXIT-IV(B.Sc. Mathematics (Honors)/ B.Sc. Mathematics (Honors with Research))	

Semester IX(Integrated M.Sc.)/ Semester-III(2 Years M.Sc. Program)/ Semester-I(1 Year M.Sc. Program)(ENTRY-III)					
MA641A1	Stochastic Processes	3-1-0	4	MATH	Major
MA642A2	Functional Analysis-I	3-1-0	4	MATH	Major
MA643A1	Integral Equations and Transforms	3-1-0	4	MATH	Major
MA641A8	Number Theory and Cryptography	3-1-0	4	MATH	Minor
MA6***A3	Elective-X/ MOOC	3-1-0/ 3-0-1	4	—	MLTD/ Minor
Total Credits in Semester IX			**20**		
Semester X(Integrated M.Sc.)/ Semester-IV(2 Years M.Sc. Program)/ Semester-II(1 Year M.Sc. Program)(ENTRY-III)					
MA644A1	Variational Calculus	3-1-0	4	MATH	Major
MA645A1	Functional Analysis-II	3-1-0	4	MATH	Major
MA6**A3	Elective-XI (in lieu of Project)	3-1-0	4	MATH	Major
MA6**A3	Elective-XII (in lieu of Project)	3-1-0	4	MATH	Major
MA6**A3	Elective-XIII (in lieu of Project)/MOOC	3-1-0/ 3-0-1	4	—	MLTD/ Minor
MA641A6	MAJOR PROJECT	—-	12	MATH	Project
Total Credits in Semester X			**20**		
Total Credits of Integrated M.Sc. Degree			**205**	EXIT-V(Integrated M.Sc. Degree)	
Total Credits of 2 Years M.Sc. Degree			**82**	2 Years M.Sc.Degree	
Total Credits of 1 Year M.Sc. Degree			**40**	1 Year M.Sc.Degree	

ELECTIVE COURSES

Elective I			Elective III		
1	CH10201A, CH10419A	Chemistry-I, Chemistry Lab-I	1	PH1XXA1, PH1XXA4	Physics-I, Physics Lab-I
2	BA10106A	Business Economics	2	MA132A3	Data Structures
3	MA131A3	Classical Algebra	3		
Elective IV			**Elective VI**		
1	MA231A3	Linear Programming & Game Theory	1	MA232A3	Object Oriented Programming
2	BA10116A	Accounting for Management	2	MA231A4	Object Oriented Programming-Lab
2			3	XXXXA1, XXXXA4	Python Programming, Python Programming Lab

Elective VII			Elective IX		
1	MA331A3	Artificial Intelligence	1	MA431A3/ MA541A3	Advance Numerical Analysis
2			2	MA432A3/ MA542A3	Artifical Neural Network
3			3	MA433A3/ MA543A3	Introduction to Data Science and Statistical Techniques
Elective X			**Elective XI-XII**		
1	MA641A3	Design and Analysis of Algorithms	1	MA644A3	Plasma Dynamics
2	MA642A3	Fluid Mechanics	2	MA645A3	Algebraic Topology
3	MA643A3	Field and Galois Theory	3	MA646A3	Dynamical Systems
4	MA653A3	Advanced Data Science Techniques and Python Programming	4	MA647A3	Wavelet Analysis and Signal Processing
Elective XIII			5	MA648A3	Representation Theory
1	MA650A3	Queuing Theory and Modeling	6	MA649A3	Algebraic Graph Theory
2	MA651A3	Optimization Techniques	6		
3	MA652A3	Mathematical Finance	7		

Major Courses

MA131A1 Foundation Course in Mathematics CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: Enhance the skill of logical thinking and mathematical writing.

Pre-requisites: NIL

Course Objectives: On completion of the course successfully a students will be able to

CO1: Understand and get comfortable with basic language and terminologies of mathematics.

CO2: Understand basic logical operators and start writing precise mathematical statements.

CO3: Understand the idea of real numbers and its properties along with the geometric visualization.

CO4: Understand GLB and LUB of a set and Archimedian property.

CO5: Understand the principle of mathematical induction and its applications.

Module	Topic	Hrs			
Module: 1	Sets, set operations, principle of inclusion and exclusions, statements, negations, quantifiers.	9			
Module: 2	Implications, converse and contra positive statements, relations and functions, equivalence classes, inverse images.	8			
Module: 3	Real number system, the field axioms, the order axioms, integers, rational numbers, irrational numbers, geometrical interpretation of real numbers as points on a line.	7			
Module: 4	Upper bound of a set, maximum element, least upper bound, lower bound of a set, minimal element, greatest lower bound, Archimedian property.	7			
Module: 5	Representation of real numbers by decimals, mathematical induction, well ordering principle and its proof, absolute values and triangle inequality, law of trichotomy.	9			

Texts:

- A. Kumar, S. Kumaresan, B. K. Sarma, Foundation course in Mathematics, Alpha Science International Ltd, Oxford, UK.
- T. M. Apostol, Calculus, Volume-2, Wiley India, 2003.

References:

- A Kumar, S. Kumaresan, A basic Course in Real Analysis, CRC Press.
- G. B. Thomas, Jr. and R. L. Finney, Calculus and Analytic Geometry, Pearson India, 9th Edition, 2006.

- R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Wiley India, 4th Edition, 2014.
- S. R. Ghorpade and B. V. Limaye, An Introduction to Calculus and Real Analysis, Springer India, 2006.
- J. E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer India, 2002.

MA132A1 **Single Variable Calculus** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The goal of this course is to acquaint the students about basis analysis of mathematics such as set theory, natural number system, differentiation, integration etc.

Pre-requisites: Basic idea of real line and set theory.

Module	Topic	Hrs			
Module: 1	Convergence of sequences of real numbers, Cauchy Sequences, Monotone sequences, Sandwich lemma, Sequences diverging to ∞, subsequences.	8			
Module: 2	Convergence of series of real numbers, Tests of convergence, absolute, conditional convergence.	6			
Module: 3	Continuity of functions, $\epsilon - \delta$ definition and the sequence definition, Intermediate Value Theorem, Extreme Value theorem, Limits, Uniform continuity.	8			
Module: 4	Differentiability, Rolle's theorem, mean value theorems, L'Hospital's rule, Taylor's theorem. Power series.	8			
Module: 5	Riemann integration, Fundamental Theorem of Calculus, improper integrals, Application to length, area, volume and surface area of revolution.	10			

Texts:

- G. B. Thomas, Jr. and R. L. Finney, Calculus and Analytic Geometry, Pearson India, 9th Edition, 2006.

References:

- A Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press.
- R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Wiley India, 4th Edition, 2014.
- S. R. Ghorpade and B. V. Limaye, An Introduction to Calculus and Real Analysis, Springer India, 2006.
- T. M. Apostol, Calculus, Volume-2, Wiley India, 2003.
- J. E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer India, 2002.

MA133A1 Solid Geometry & Vector Calculus CREDIT:4 [L:3,T:1,P:0]

Course Objectives: Students should get fundamental knowledge about straight lines and Euclidean distance, concepts of conic sections and parametric curves. Understand vector algebra and vector valued functions.

Pre-requisites: MA133A1

Module	Topic	Hrs			
Module: 1	Two dimensional coordinate geometry, straight line, euclidean distance,	7			
Module: 2	conic section*s, parametrized curves, polar coordinates, vectors in plane, vectors in space,	8			
Module: 3	dot product, cross product, cylinders, cylindrical and spherical coordinate systems,	9			
Module: 4	vector valued functions and space curves, modeling projectile motion,	8			
Module: 5	arc length, unit tangent vector, curvature, torsion, planetary motion and satellites.	8			

Texts:

- G. B. Thomas, Jr. and R. L. Finney, Calculus and Analytic Geometry, Pearson India, 9th Edition, 2006.

References:

- James Stewart, Multivariable Calculus, CENGAGE Learning.
- T. M. Apostol, Calculus, Volume-2, Wiley India, 2003.
- J. E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer India, 2002.

MA134A1 Discrete Mathematics CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: Introduce concepts of mathematical logic for analyzing propositions and proving theorems. Use sets for solving applied problems, and use the properties of set operations algebraically. Introduce basic concepts of graphs, digraphs and trees.

Pre-requisites: MA131A1

Module	Topic	Hrs			
Module: 1	Partially ordered sets, countability, lattices and Boolean algebras.	8			
Module: 2	Logic: Well-formed formula, interpretations, propositional logic, predicate logic, theory of inference for propositional logic and predicate logic. Graph Theory:	8			
Module: 3	Combinatorics: Permutations, combinations, recurrences, generating functions, partitions, special numbers like Fibonacci, Stirling and Catalan numbers.	10			
Module: 4	Graphs and digraphs, special types of graphs, isomorphism, connectedness,	7			
Module: 5	trees, Euler and Hamilton paths, planar graphs, graph colouring, matching.	7			

Text Books:

- J. P. Tremblay and R. Manohar, Discrete Mathematics with Applications to Computer Science, Tata McGraw-Hill, 1997.
- Frank Harary, Graph Theory, Narosa Publishers, New Delhi (1989).

Reference Books:

- K. H. Rosen, Discrete Mathematics & its Applications, 6th Ed., Tata McGraw-Hill, 2007.
- A. Kumar, S. Kumaresan and B. K. Sarma, A Foundation Course in Mathematics, Narosa, 2018.
- Narasing Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice Hall, India (1995).
- R. Balakrishnan and K. Ranganathan, A Text Book of Graph Theory, Springer, 2000.

MA135A1 Linear Algebra CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: This is one of the fundamental subjects in mathematics. Linear algebra is also prerequisite for the subjects like functional analysis, spectral graph theory, optimization techniques, differential equations etc.

Pre-requisites: MA132A1

Course Outcomes:

CO1: Analyze whether a system is consistent or inconsistent and its solution is unique or infinite.

CO2: Perform row operations on matrices and find bases and dimension of vector spaces.

CO3: Linearly transform the system from one dimension to another and represent the pertinent linear transformation in matrix form.

CO4: Compute orthogonal and orthonormal vectors required to analyze image and signal processing problems.

CO5: Apply decomposition techniques for problems arising in various fields of applications.

Module	Topic	Hrs			
Module: 1	Vector spaces (over the field of real and complex numbers), sub-spaces, spanning set, linear independence.	8			
Module: 2	Basis and dimension. Linear transformations, rank-nullity theorem.	8			
Module: 3	Matrix of a linear transformation, Column space, null space, rank of a matrix, Eigenvalues and eigenvectors,	7			
Module: 4	Inner-product & orthogonality, orthogonal basis, Gram–Schmidt process, LU decomposition, LDU decomposition, Cholesky decomposition, Rank factorization, QR factorization	10			
Module: 5	Decompositions based on eigenvalues and related concepts, Eigendecomposition, Jordan decomposition, Schur decomposition	7			

Text Books:

- K Hoffman and R Kunze; Linear Algebra; Prentice-Hall of India, Pvt Ltd.
- Gilbert Strange, Linear Algebra and Its Applications, Thomson Learning.

Reference Books:

- S. Kumaresan, Algebra a Geometric Approach, PHI.
- A R Rao and P Bhimashankaram; Linear Algebra and Applications; TMH Edn.

- Theory and problems of matrices, Schaums outline series , McGraw Hill.
- Linear Algebra ; C Y Hsiung , G Y Mao
- Linear Algebra and its Applications ; David C. Lay

MA231A1 Algebra I: Group Theory CREDIT: 5 [L:4,T:1,P:0]

Course Objectives: The objective of teaching this paper is to give a generalized view of abstract spaces along with some binary operations and their inter play.

Pre-requisites: MA131A1, MA132A1

Module	Topic	Hrs			
Module: 1	Definitions and examples of groups, Elementary properties of groups, subgroups.	6			
Module: 2	Order of an element, order of a group, cyclic groups, classification of subgroups of a cyclic group.	8			
Module: 3	Permutation groups, homomorphisms, isomorphisms and automorphisms. Examples along with explicit computation of homomorphisms and automorphisms.	8			
Module: 4	Cosets, Lagrange's Theorem and related problems, Normal subgroup, Quotient groups, Cayley's theorem.	10			
Module: 5	Isomorphism theorems, Direct Products, Fundamental theorem of Finite Abelian groups.	8			

Text Books:

- J. A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1998.

Reference Books:

- I. N. Herstein, Topics in Algebra, Wiley, 2004.
- J. B. Fraleigh, A First Course in Abstract Algebra, Addison Wesley, 2002.

MA232A1 **Elementary Number Theory** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The core objective of this course is to provide an introduction to basic number theory and its applications.

Pre-requisites: MA131A1, MA132A1

Module	Topic	Hrs			
Module: 1	Well ordering principle, principle of mathematical induction, Divisibility, Division algorithm, GCD and LCM, Euclidean algorithm.	8			
Module: 2	Primes, the fundamental theorem of arithmetic, Congruences, Properties of congruences.	8			
Module: 3	Linear congruences, Euler's theorem, Fermat's little theorem, Chinese Remainder Theorem, Primitive Roots,	8			
Module: 4	Quadratic reciprocity, Linear Diophantine equations, Pell's equation.	8			
Module: 5	Multiplicative functions, Arithmetic functions, Mobius inversion formula.	8			

Text Books:

- D. M. Burton, Elementary Number Theory, 7th Ed., McGraw Hill, 2017

Reference Books:

- I. Niven, S. Zuckerman and H. L. Montgomery, An Introduction to the Theory of Numbers, 5th Ed., Wiley-India, 1991.
- G. A. Jones and J. M. Jones, Elementary Number Theory, Springer, 1998
- K. H. Rosen, Elementary Number Theory and its Applications, Pearson, 2015

MA233A1 Algebra II: Ring Theory CREDIT: 4 [L:3,T:1,P:0]

Pre-requisites: MA231A1

Module	Topic	Hrs			
Module: 1	Definitions and examples of rings, basic properties of rings, subrings, integral domains, fields (definition and ring theoretic properties only), characteristic of a ring.	8			
Module: 2	Ideals, Prime ideals, Maximal ideals, homomorphisms, properties of homomorphisms, field of quotients, quotient rings.	8			
Module: 3	Isomorphisms, Isomorphism theorems, automorphisms, polynomial rings, division algorithm for polynomial rings.	8			
Module: 4	Irreducibility, Factorization in polynomials, Reducibility tests, UFD in $\mathbb{Z}[x]$.	8			
Module: 5	Unique Factorization domains, Euclidean domains and Basics of finite fields.	8			

Text Books:

- J. A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1998.

Reference Books:

- I. N. Herstein, Topics in Algebra, Wiley, 2004.
- J. B. Fraleigh, A First Course in Abstract Algebra, Addison Wesley, 2002.

MA234A1 Multi Variable Calculus CREDIT: 4 [L:3,T:1,P:0]

Pre-requisites: MA131A1,

Module	Topic	Hrs			
Module: 1	Functions of several variables, Limits and continuity.	8			
Module: 2	Partial derivatives, differentiability, The chain rule, Directional derivatives.	8			
Module: 3	Extreme value and saddle points, Lagrange's Multiplier, Taylor's Theorem.	8			
Module: 4	Multiple integrals with applications to volume, surface area, Change of variables.	8			
Module: 5	Line integrals, Green's theorem, Stoke's Theorem, Divergence Theorem.	8			

Texts:

- G. B. Thomas, Jr. and R. L. Finney, Calculus and Analytic Geometry, Pearson India, 9th Edition, 2006.

References:

- James Stewart, Multivariable Calculus, CENGAGE Learning.
- T. M. Apostol, Calculus, Volume-2, Wiley India, 2003.
- J. E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer India, 2002.

MA235A1 Ordinary Differential Equations CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The objective of this course is to make the student understand the theory of ordinary differential equations and their utility in solving real world problems arising in mathematical physics and engineering.

Pre-requisites: MA133A1

Module	Topic	Hrs			
Module: 1	Ordinary and partial differential equations, order and degree of Differential equations, Solutions:general, particular, singular. Equations of The First Order and of The First Degree: Exact differential equations, Integrating Factors	8			
Module: 2	linear equations, equations reducible to the linear form, Bernoulli equations, existence and uniqueness theorem, Application of first order differential equations: Orthogonal trajectories, Newton's law of cooling, Law of natural growth and decay, Initial Value Problems for a Single First-order Differential Equation.	8			
Module: 3	Differential Equations of first order but not of the first degree:Equations solvable for p; Equations solvable for y; Equations solvable for x; Equations that do not contain x (or y); Equations of the first degree in x and y – Clairaut's equations.	8			
Module: 4	Higher–order linear differential equations, solutions of homogeneous and non-homogeneous equations, complementary functions, particular integral, complete integral, auxiliary equation, the symbolic function 1/f(D), methods of finding the particular integral.	8			
Module: 5	Equations reducible to linear equations with constant coefficients, Cauchy's homogeneous linear equation, Legendre's linear equation, Method of variation of parameters, Simultaneous differential equations, Applications to Electrical Circuits and Simple harmonic motion.	8			

Text Books:

- S. L. Ross, Differential Equations, Wiley India, 3rd Edition, 2004.

Reference Books:

- E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
- T. M. Apostol, Calculus, Volume-2, Wiley India, 2003.
- W. E. Boyce and R. C. DiPrima, Elementary Differential Equations, Wiley India, 9th Edition, 2008.

- M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand

MA331A1 **Complex Analysis** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The course has been designed to introduce the fundamental ideas of complex numbers, the functions of complex variables and to develop a clear understanding of the basic concepts of Complex Analysis such as analytic functions, complex integrals, power series and a range of skills which will allow students to work effectively with the concepts.

Pre-requisites: MA131A1, MA133A1, MA134A1

Module	Topic	Hrs			
Module: 1	Complex numbers and elementary properties, Functions of a complex variable, limits, continuity and differentiation, Cauchy-Riemann equations.	8			
Module: 2	Analytic and harmonic functions, elementary analytic functions.	8			
Module: 3	Anti-derivatives and line (contour) integrals, Cauchy-Goursat theorem, Cauchy's integral formula, Morera's theorem, Liouville's theorem, Fundamental theorem of algebra and maximum modulus principle.	9			
Module: 4	Power series, Taylor series, zeros of analytic functions, singularities and Laurent series, Rouche's theorem and argument principle.	9			
Module: 5	Residues, Cauchy's Residue theorem and applications.	6			

Texts:

- J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.

References:

- J. H. Mathews and R. W. Howell, Complex Analysis for Mathematics and Engineering, 3rd Ed., Narosa,1998.

MA332A1 **Numerical Analysis** **CREDIT: 4 [L:3,T:0,P:1]**

Course Objectives: Numerical analysis plays a crucial role in building a good foundation on analysis of various physical and engineering problems based on different conditions. The course aims to create a good understanding and modeling and finally obtaining solutions and interpretation of problems as required by scientists and engineers.

Pre-requisites: MA131A1, MA135A1

Module	Topic	Hrs			
Module: 1	Approximation and Errors in computing: Introduction, Significant digits, Inherent error, Rounding error, Truncation error, Absolute and relative error, Error propagation. Roots of Non Linear Equations: Bisection method, False position Method, Newton-Raphson Method, fixed point methods, convergence of Bisection, Newton- Raphson's and False position methods.	8			
Module: 2	Solution of System of Equations: Gauss Elimination method by pivoting, Gauss - Jordan method, Gauss - Seidel method, Relaxation method, convergence of iteration methods.	8			
Module: 3	Interpolation and Approximation: Difference Operators & Interpolation: Forward and Backward difference operators and table, Interpolation with equidistant point, Lagrange Interpolation Polynomial, Newton Interpolating Polynomial using divided Difference Table.	8			
Module: 4	Numerical Differentiation and Integration: Differentiating continuous functions, differentiating tabulated functions, Higher order derivatives, Richardson's Extrapolation, Newton - cotes integration formula, Trapezoidal rule, Simpson's rules	9			
Module: 5	Solution of ordinary Differential Equations: Initial Value problems, Taylor's Series method, Euler Method, Runge Kutta Method.	7			

Text Books:

- E. Balagurusamy, "Numerical Method", Tata McGraw Hill Publication.
- S.S. Sastry, "Introductory Methods of Numerical Analysis", PHI learning Pvt. Ltd.
- S. D. Conte and C. de Boor, Elementary Numerical Analysis; An Algorithmic Approach, McGraw Hill, 1981.

Reference Books:

- D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Ed., AMS, 2002.
- K. E. Atkinson, An Introduction to Numerical Analysis, Wiley, 1989.
- Richard L. Burden and J. Douglas Faires, Numerical analysis, Brooks/Cole, 2001.

MA333A1 **Metric Spaces** **CREDIT: 4 [L:3,T:1,P:0]**

Pre-requisites: MA131A1

Module	Topic	Hrs			
Module: 1	Open balls and Open sets, convergent sequences, limit and cluster points, Cauchy's sequence and completeness, bounded sets, dense sets.	8			
Module: 2	Basis, continuity, uniform continuity, limit of a function, open and closed maps.	10			
Module: 3	The Bolzano-Wierstrass theorem for $\mathbb{R}$ only, the Hiene-Borel covering theorem, compactness.	8			
Module: 4	Characterization of compact Metric spaces, Arzela-Ascoli Theorem, connected spaces, path-connected spaces.	8			
Module: 5	Examples of Complete metric spaces, Completion of a metric space, Baire Category theorem, Banach's contraction principle.	6			

Text Books:

- S. Kumresan, Topology of Metric spaces, Alpha Science.

Reference Books:

- G. F. Simmons, Introduction to Topology and Mordern Analysis, McGraw Hill.
- James R. Munkres, Topology, Pearson.

MA334A1 **Classical Mechanics** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: To introduce students with different types of motions, their equations and understand difference physical systems.

Pre-requisites: Calculus, Differential Equations

Module	Topic	Hrs			
Module: 1	Laws of Motion: Moving axes. Foucault's Pendulum. Coriolis Force. Virial Theorem. Generalised Co-ordinates. Unilateral and Bilateral Constraints. Principle of Virtual Work. D'Alembert's Principle. Holonomic and Non-holonomic Systems. Scleronomic and Rheonomic Systems.	8			
Module: 2	Lagrange's Equation of Motion. Applications. Energy Equation for Conservative Fields. Cyclic or Ignorable Co-ordinates. Routh's Equations. Dynamical Systems of Liouville's Type Hamilton's Equations of Motion.	8			
Module: 3	Hamilton's Principle. Lagrange's Equations of Motion form Hamilton's Principle. Principle of Least Action. Constants of Motion. Noether's Theorem. Conservation Laws. Infinitesimal transformations. Motion of a Rigid Body about a Fixed Point in it. Euler's Dynamical Equations. Eulerian angles.	8			
Module: 4	Gyroscope and non-holonomic Problems. Motion of a Symmetrical Spinning Top on a perfectly Rough Floor. Stability of Steady Precession. Canonical Transformations. Generating Functions. Poisson's Bracket. Jacobi's Identity. Poisson's Theorem. Jacobi-Poisson Theorem.	8			
Module: 5	Hamilton-Jacobi Equation. Jacobi's Theorem. Hamilton's Principal Function. Hamilton's Characteristic Function. Action-Angle Variables. Adiabatic Invariance. Theory of Small Oscillations (Conservative System). Normal Co-ordinates. Oscillations under Constraints. Stationary Character of Normal Modes. Elements of Non-linear Oscillations.	8			

Text books:

1. H. Goldstein, Classical Mechanics. Narosa Publishing House, New Delhi, (1980).

2. F. Gantmacher, Lectures in Analytical Mechanics, MIR Publishers, Moscow (1975)

3. J. L. Synge and B.A. Griffith, Principles of Mechanics, McGraw-Hill, N.Y. (1970)

Reference book:

1. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill Pub. Company Ltd., New Delhi (1998)

2. N. H. Louis and Janet D. Finch, Analytical Mechanics, C.U.P. (1998)

MASTERS MAJOR COURSES

MA431A1/ MA541A1 **Real Analysis** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The goal of the course is to impart students with the topic of real analysis which forms the base of higher mathematics.

Pre-requisites: Calculus of single variable

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Understand the basics of single variable calculus.

CO2: Understand uniform convergence and its interactions with differentiation.

CO3: Understand Stone-Weierstrass theorem and some special functions.

CO4: Understand functions of several variables and important results.

CO5: Understand the method of Lagrange multipliers and its applications.

Module	Topic	Hrs			
1	Overview of Calculus of single variable without proofs. Recall important definitions and theorems from continuity, differentiability. (No proofs)	6			
2	Sequence and series of functions. Pointwise convergence, Uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation.	10			
3	Uniform convergence and integration, Equicontinuous families of functions, Stone-Weierstrass Theorem. Some special functions, Power series, Log and exponential functions, trigonometric functions.	8			
4	Functions of several variables, Linear transformations, Contraction principle, Inverse and Implicit function theorems, derivatives of higher order, Differentiation of integrals.	8			
5	The method of Lagrange Multipliers with applications.	8			

Text books:

1. Functions of single variables, Kumaresan.
2. Principles of Mathematics Analysis- Walter Rudin, McGraw-Hill.
3. Introduction to real analysis, William Trench.

Reference book:

1. Calculus Vol 1 and Vol 2- Tom Apostle, Wiley.

MA432A1/ MA542A1 **Abstract Algebra** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The objective of teaching this paper is to give a generalized view of abstract spaces along with some binary operations and their inter play.

Pre-requisites: Algebra

Module	Topic	Hrs			
Module: 1	Groups, Subgroup, Normal Subgroups, Quotient group. Homomorphism, Isomorphism,	8			
Module: 2	Conjugacy relation, Class equation, Cauchy theorem and p-groups Group action	8			
Module: 3	Syllow's theorems, direct products, semi-direct product	8			
Module: 4	Rings, Homomorphism, Ideals and quotient rings, Euclidean Domain, Unique Factorization Domain.	8			
Module: 5	Polynomial rings, Fields, Finite fields	8			

Text books:

1. I . Herstein; Topics in Algebra; Wiley Eastern Ltd
2. N Jacobson; Basic Algebra; Hindustan Publishing Corporation

Reference book:

1. D. S Malik, John N. Mordeson, M.K Sen: Fundamentals of Abstract Algebra; Mc Graw Hill International Editions.
2. PM Cohn; Basic Algebra; Springer International Edn.

MA433A1/ MA543A1 **Ordinary and Partial Differential Equations**

CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: To have capability of solving analytically partial differential equations involved in any physical problem.

Pre-requisites: MA235A1

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Identify and apply the concepts of Linear PDEs to solve various scientific problems.

CO2: Associate and apply the concept of nonlinear PDEs in various real life problems.

CO3: Formulate and apply the concept of PDEs in various physical problems.

CO4: Idetify and solve initial value problems.

CO5: Apply the concepts of Laplace Transform to solve ODE and PDE problems.

Module	Topic	Hrs			
Module: 1	Linear ordinary differential equations with variable coefficients, Power series method, singular points, existence and uniqueness of solution.	8			
Module: 2	First order partial differential equations, solutions of linear and quasilinear first order PDEs, method of characteristics;	8			
Module: 3	Classification of second-order PDEs, canonical form; Initial and boundary value problems involving wave equation and heat conduction equation, boundary value problems involving Laplace equation and solutions by method of separation of variables;	8			
Module: 4	Initial-boundary value problems in non-rectangular coordinates. Laplace and inverse Laplace transforms, properties, convolutions;	8			
Module: 5	Solution of ODEs and PDEs by Laplace transform; Solution of PDEs by Fourier transform.	8			

Text books:

1. Ian Sneddon, Elements of Partial Differential Equation, Dover Publication

2. K Sankara Rao, Elements of Partial Differential Equations, PHI.

Reference book:

1. K Zackman & S DuChaetu: Partial Differential Equations, Schuam's Outline Series

MA434A1/ MA544A1 Advanced Linear Algebra CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: Continue the theoretical development of linear algebra, focusing on canonical forms of matrices and spectral theory, vector and matrix norms. Students will become more adept at solving abstract problems and writing proofs.

Pre-requisites: A basic course in Linear Algebra

Course Outcomes (CO): On completion of the course successfully a students will be able to

1. Understand vector spaces and the important notions of linear combination, basis, dimension.
2. Obtain a deeper understanding of eigenvalues/eigenvectors as well as understand the Jordan Canonical form
3. Understand different canonical forms and apply them to solve problems.
4. Understand inner product spaces, matrix norms, and their algebraic and analytic properties.
5. Become proficient in reading and writing rigorous mathematics.

Module	Topic	Hrs			
Module: 1	Revision of vector space, ,basis, dimension, linear transformations, rank and nullity, The eigenvalue-eigenvector equation, the characteristic polynomial and algebraic multiplicity,	10			
Module: 2	similarity, left and right eigenvectors and geometric multiplicity, Unitary matrices and QR factorization, unitary similarity, normal matrices	8			
Module: 3	The Jordan canonical form, the minimal polynomial and the companion matrix, triangular factorization and canonical forms(LU, LDU, PLU and LPU factorizations), triangularly equivalent matrices	10			
Module: 4	Norms of vectors and Matrices, definition and examples, algebraic and analytic properties of norms, duality and geometric properties of norms, matrix norms, singular value decomposition	8			
Module: 5	Positive Definite and Semidefinite Matrices, Characterization and Properties, The polar and singular value decompositions, The Schur product theorem	8			

Text books:

1. Matrix Analysis, Roger H. Horn and Charles R. Johnson, Cambridge University Press

Reference book:

1. Linear Algebra and its Applications, Gilbert Strange, Thomson Learning.

2. Linear Algebra and its Applications ; David C. Lay

MA435A1/ MA545A1 Measure and Integration CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The goal of the course is to introduce the students to Lebesgue measure and Lebesgue integration which is a generalization of the Riemann Integration that they have seen before.

Pre-requisites: MA131A1, MA132A1

Course Outcomes (CO): On completion of the course successfully a students will be able to

1. Understand basics of σ-algebras and examples.
2. Understand the idea the Lebesgue measure on $\mathbb{R}$ with examples and non-examples.
3. Understand Lebesgue measurable functions and their properties.
4. Understand the development of Lebesgue integral and it's basic properties.
5. Understand the interaction between the derivative and integral of a measurable function.

Module	Topic	Hrs			
1	Recall Riemann integration, important properties (without proofs), operations on sets, LUB and GLB (definitions), σ-algebras, F_σ, G_δ sets.	6			
2	Lebesgue outer measure, measurable sets, σ-algebra of measurable sets in $\mathbb{R}$, Countable additivity, Borel-Cantelli Theorem, Example of a non-measurable set, Cantor set and its measure theoretic properties.	10			
3	Lebesgue measurable functions, sums, products and compositions, pointwise limit of a sequence of measurable function, Littlewood's three principles.	7			
4	Development of the Lebesgue integral, Bounded convergence theorem, Fatou's lemma, Monotone convergence theorem, Dominated convergence theorem, Countable additivity and continuity of integral.	10			
5	Differentiation and integration: Lebesgue's theorem, functions of bounded variation, Jordan's theorem, interaction between integrals and derivatives.	7			

Texts:

- Real Analysis, 4th Edition, H.L. Royden, P.M. Fitzpatrick, China Machine press.

References:

- Real and Complex Analysis, Walter Rudin.

MA436A1/ MA546A1 **Graph Theory** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The basic objective of this course is to introduce basic concepts of graph theory and the counting principles. Graph theory is one of the important branch of modern applied Mathematics. It has applications in Chemistry, Optimizations techniques and computer science and many more. Graph theory is also used as a tool to model many physical and applied problems.

Pre-requisites: MA131A1, MA231A1

Module	Topic	Hrs			
Module: 1 Graphs, Subgraphs and Trees:	Graphs and simple graphs, Graph Isomorphism, Subgraphs, Spanning Sub-graps, Induced Subgraphs, Operations on Graphs, Connectedness, Cut Edges, Cut Vertices, Blocks.Trees, Connectivity and Traversability: Characterization of Trees, Centers of Trees, Spanning Trees, Rooted and Binary Trees, Fundamental Cycles	10			
Module: 2 Connectivity, Planarity and Coloring	Point and Line Connectivity, Euler Graphs, Hamiltonian Graphs, The Traveling Salesman Problem. Planarity and Coloring: Plane and Planar Graphs, Dual Graphs, Euler's Formula, The Chromatic Number, The Five-Color Theorem, The Four Color Theorem, Kuratowski's Theorem, Matching.	8			
Module: 3 Directed Graphs and Tournaments:	Directed Graphs, In-degree, Out- degree, Complete Digraphs, Balanced Digraphs, Euler Digraphs, Teleprinters Problem, Trees with Directed Edges, Polish Notation, Paired Comparisons and Tournaments.	10			
Module: 4 Matrices:	Positive Definite Matrices, Generalized Inverses. Incidence Matrix: Incidence Matrix of a Graph, Rank of The Incidence Matrix, Minors, Path Matrix, 0-1 Incidence Matrix.	8			
Module: 5 Adjacency & and Laplacian Matrix	Adjacency Matrix: Adjacency Matrix of a Graph, Eigenvalues of The Adjacency Matrices of different graphs, Determinant of Adjacency Matrix, Bounds for Eigenvalues. Laplacian Matrix: Laplacian Matrix of Graph, Basic Properties, Laplacian Eigenvalues, Matrix Tree Theorem.	8			

Text books:

1. Frank Harary, Graph Theory, Narosa Publishers, New Delhi (1989).

2. R B Bapat, Graphs and Matrices, Hindustan Book Agency.

Reference book:

1. Narasing Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice Hall, India (1995).

2. Douglas B. West, Introduction to Graph Theory Prentice- Hall, New Delhi (1999)

3. John Clarke and D.A. Holton, A First Look at Graph Theory, Allied Publisher (1991)

MA437A1/ MA547A1 **Topology** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The objective of teaching this paper is to give a generalized /extended analysis of general spaces, showing real analysis is a particular case of such general space.

Pre-requisites: Real Analysis

Module	Topic	Hrs			
Module: 1	Topological Spaces, Examples of topological spaces, Bases and sub Bases, neighbourhood, interior, boundary, Open and closed sets , closure, interior. Subspace topology,	8			
Module: 2	Continuous functions, open and closed functions, Homeomorphisms. Sum and product of topological spaces, Product topology, Quotient topology, Metric topology.	8			
Module: 3	Separation axioms, Hausdorff spaces, Regular space, Normal space, Fully normal space,Uryshon's function and lemma, Tietze's extension theorem, Completely Regular space, Tychonoff space.	8			
Module: 4	Connectedness, path connected and locally connected spaces. Count ability axioms, first countable space, second countable space, separable space, Lindelof space.	8			
Module: 5	Compactness, finite intersection property, limit point compactness, locally compact spaces and one point compactification, Para compactness. Convergence, nets and filters.	8			

Text books:

1. J.R. Munkres, Topology: A first course. Prentice-Hall, Inc. 1975.

Reference book:

1. J. Dugundji, Topology. Allyn and Bacon Series in Advanced Mathematics. Allyn and Bacon, Inc., 1978.

2. K. D. Joshi : Introduction to General Topology (Wiley Eastern Limited).

3. J. L. Kelley : General Topology (Springer Verlag, New York 1991.)

MA438A1/ MA548A1 Advance Complex Analysis CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The objective of this course is to introduce the students with some advanced topics of complex analysis which will be beneficial for them in teaching post graduate students and pursuing research works in the field of complex analysis or any related areas.

Pre-requisites: MA332A1 or a basic Complex Analysis course.

Course Outcomes (CO):

CO1: Use the concepts of Hadamard's three circle theorem and Phragman-Lindelof theorem in related problems and theorems.

CO2: Understand the compactness and convergence in the space of Analytic Function.

CO3: Understand the factorization of sine function and its consequences in related concepts.

CO4: Understand Mittag-Leffler's theorem and its use in related theorem.

CO5: Evaluate order of analytic function, factorize analytic function, and understand the concept of Picard theorems.

Module	Topic	Hrs			
Module: 1	Hadamard's three circles theorem, Phragmen-Lindelof theorem.	6			
Module: 2	The space of continuous functions $C(G,\Omega)$, spaces of analytic functions, spaces of meromorphic functions. Riemann mapping theorem, Weiersirass' factorization theorem,	10			
Module: 3	Factorization of the sine function. Runge's theorem, simply connected regions	6			
Module: 4	Mittag-Leffler's theorem, Analytic Continuation, Schwarz Reflection Principle, Monodromy Theorem,	8			
Module: 5	Entire functions. Jensen's formula, The Genus and Order, Hadamard Factorization Theorem, Bloch's theorem, Picard theorems.	10			

Text books:

1. J B Conway, Functions of one complex variables, 2nd ed, Narosa Publishing House, New Delhi, 2002.

Reference book:

1. L.V. Ahlfors, Complex Analysis, Mc. Graw Hill Co., New York, 1988.
2. L. Hahn, B. Epstein, Classical Complex Analysis, Jones and Bartlett, India, New Delhi, 2011.
3. W. Rudin, Real and Complex Analysis, McGraw-Hill, 1987

MA641A1 **Stochastic Processes** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The objective of the course is train students on stochastic processes which these days has enormous application on computer science, communication engineering and mathematical aspects of finance. On successful completion of the course, this will enable the students to broaden their job horizon as well as opening new and exciting research topics.

Pre-requisites: Calculus, Linear Algebra, Probability Theory

Course Outcomes (CO): On completion of the course successfully a students will be able to

1. identify different types random (or stochastic) processes.
2. understand Poisson process and apply.
3. determine different Markov processes and use them for solution of various problems that arise.
4. model and apply continuous time processes in different situations.
5. analyze special types of stochastic processes and apply them effectively in different branches.

Module	Topic	Hrs			
Module1	Classification of Stochastic Processes, Stationary and weak sense, strong sense processes, Auto-correlation, auto-covariance, cross correlation and cross covariance functions	6			
Module2	The Poisson process- Fundamental Results, Compound and Conditional Processes, Inter arrival times and Waiting time distributions. Renewal theory-Fundamental Theorem.	8			
Module3	Markov Chains: discrete parameter Markov chains, Chapman Kolmogorov equations, classification of states and chains with fundamental theorems. Gambling problems.	9			
Module4	Continuous Time Markov Chains- Basic results, Birth and Death processes. Deduction of Kolmogorov differential equations. Kolmogorov Forward and backward equations and their applications. Queuing Theory: M/M/1, M/M/c, M/G/k queues - Pollazack Kinchin equation. .	9			
Module5	Martingales, Brownian Motion and Geometric Brownian motion, Brownian motion with drifts. Basic ideas of Random Walk problems. Branching Processes. .	8			

Texts:

- S. M. Ross, Stochastic Processes. John Wiley & Sons, Inc., 1996.
- J Medhi; Stochastic Processes, New Age International.

References:

- R. N. Bhattacharya and E. C. Waymire, Stochastic processes with applications. A Wiley-Interscience Publication. John Wiley & Sons, Inc., 1990..
- J. Medhi: Stochastic models in queuing theory, Elsevier, 2007

MA642A2 Functional Analysis-I CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: This course is intended to familiarize the graduate students of mathematics and physics with the basic concepts, principles and methods of this subject and its applications.

Pre-requisites: MA133A1, MA231A1or a basic course in Linear Algebra and Calculus

Course Outcomes (CO): On successful completion of this course, students will be able to:

CO1: Identify the different spaces and their norms.

CO2: Derive the completeness of norm spaces and dual spaces.

CO3: Identify category of a space and open map.

CO4: Understand the inner product space and its completeness.

CO5: Understand and apply the operators.

Module	Topic	Hrs			
Module: 1	Metric spaces, Normed linear spaces, Banach spaces.	8			
Module: 2	Bounded linear operators. Dual of a normed linear space. Fixed point.	8			
Module: 3	Bair's category, Hahn-Banach theorem, uniform boundedness principle, open mapping theorem, closed graph theorem, Banach-Steinhaus theorem. Computing the dual of well-known Banach spaces.	8			
Module: 4	Hilbert spaces, direct sum, Bessel's inequality, Orthogonal Projection, Gram-Schmidt process	8			
Module: 5	Operator theory: adjoint operators, self-adjoint and normal operators	8			

Text books:

1. Functional Analysis , E. Kreyszig, Wiley India.
2. Foundation of Functional Analysis, S. Ponnusamy, Narosa

Reference book:

1. W. Rudin, Functional analysis. McGraw-Hill, Inc., 1991.
2. J. B. Conway, A course in functional analysis. Graduate Texts in Mathematics, 96. Springer-Verlag, 1990.
3. B.V. Limayae, Functional Analysis
4. B. K. Lahiri, Functional Analysis.

MA643A1 Integral Equations and Transforms **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: To familiarize with different kinds of integral equations and transforms, and their application in solving ODE and PDE.

Pre-requisites: Calculus, Differential Equations

Module	Topic	Hrs			
Module: 1	Integral Transforms: Laplace transform. Convergence. Continuity requirements. Exponential order. Existence and Uniqueness. Heaviside's unit step function. Convolution theorem. Complex inversion formula. Inverse Laplace transform.	8			
Module: 2	Fourier transform. Derivation of Fourier transform from Fourier series. Convolution theorem. Inverse Fourier transform. Properties of inverse Fourier transform. Parseval's Identity. Applications of Laplace and Fourier transforms.	8			
Module: 3	Integral Equations. Conversion of ordinary differential equations into integral equations. Conversion of integral equations into ordinary differential equations. Linear integral equations of Volterra type. Solution of Volterra integral equations by successive substitutions, successive approximations.	8			
Module: 4	Series solution, Adomian decomposition, modified Adomian decomposition and Laplace transform methods. Resolvent kernel. Linear integral equations of Fredholm type. Solution of Fredholm integral equations by successive substitutions, successive approximations, series solution, Adomian decomposition and modified Adomian decomposition methods.	8			
Module: 5	Resolvent kernel. Neumann series. Solution of integral equations with separable kernels. Fredholm Alternative theorem. Hilbert-Schmidt theory of integral equations for symmetric kernels. Singular integral equations. Solution of singular integral equations by Laplace transform method. Existence and uniqueness of integral equations. Applications.	8			

Text books:

1. F.G. Tricomi - Integral Equations (Inter - Science)

2. A. M. Wazwaz -Linear and Nonlinear Integral Equations. (Springer)

3. P.P.G. Dyke- An introduction to Laplace Transforms and Fourier Series. (Springer)

4. M.G. Spiegel- Laplace Transforms (Schaum's OuTlines series)

Reference book:

1. J. L. Schiff - The Laplace Transform (Springer)
2. S. L. Ross- Ordinary Differential Equations. (Wiley)
3. R.L. Bracewell-The Fourier Transforms and Its Applications (McGraw-Hill)
4. R. P. Kanwal -Linear Integral Equations (Academic Press)

MA644A1 **Variational Calculus** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: To familiarize with the concept of variational calculus which are widely used in many different areas science and engineering.

Pre-requisites: Real Analysis, Linear Algebra

Module	Topic	Hrs			
Module: 1	Elements of the theory-Functionals, Function spaces, the variational of a functional, a necessary condition for an extremum, the simplest variational problem-Euler equation.	8			
Module: 2	The Fixed End problem for n unknown Functions, variational problems in parametric form.	8			
Module: 3	Functional depending on higher order derivatives.	8			
Module: 4	The general Variation of a Functional-Derivation of the basic formula, End points lying on two given curves.	8			
Module: 5	Canonical Form of Euler equation, canonical Transformations, Hamilton Jacobi equation.	8			

Text books:

1. I.M. Gelfand and S.V. Fomin: Calculus of variations, Prentice Hall Inc.

2. A.S. Gupta: Calculus of variations, PHI.

Reference book:

1. Mukesh Kumar: Calculus of Variations, PHI.

2. C Fox: Calculus of Variations: Dover INC.

MA645A1 Functional Analysis-II CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: This course is intended to familiarize the graduate students of mathematics and physics with the basic concepts, principles and methods of this subject and its applications.

Pre-requisites: MA133A1, MA231A1or a basic course in Linear Algebra and Calculus

Course Outcomes (CO): On successful completion of this course, students will be able to:

CO1: Identify the fixed point.

CO2: Apply fixed point and contraction mapping.

CO3: Use Inner product space in series and polynomial.

CO4: Understand and apply the operators and their spectrums.

CO5: Identify the week and weak* topology.

Pre-requisites: XX

Module	Topic	Hrs			
Module: 1	Fixed point theorem , contraction mapping principle , applications.				
Module: 2	Series related to Orthonormal sequences, Legendre, Hermite polynomials.				
Module: 3	Spectral theory of Linear operators in Normed space. Spectral Mapping theorem and spectral representations.				
Module: 4	Weak and weak* topologies, Banach-Alaoglu Theorem.				
Module: 5	The double dual, Goldstein's Theorem, reflexivity.				

Text books:

1. Functional Analysis , E. Kreyszig, Wiley India.
2. Foundation of Functional Analysis, S. Ponnusamy, Narosa

Reference book:

1. W. Rudin, Functional analysis. McGraw-Hill, Inc., 1991.
2. J. B. Conway, A course in functional analysis. Graduate Texts in Mathematics, 96. Springer-Verlag, 1990.
3. K. Yosida, Functional analysis. Grundlehren der Mathematischen Wissenschaften, 123. Springer-Verlag, 1980.

Minor Courses

MA231A8 **Probability Theory** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The objective of the course is to introduce the students with the basics of probability theory and its applications in computer science, communication engineering and mathematical aspects of finance. On successful completion of the course, this will enable the students to broaden their job horizon as well as opening new and exciting research topics.

Pre-requisites: MA131A1, MA132A1, MA133A1, MA135A1

Module	Topic	Hrs			
Module: 1	Probability spaces, independence, conditional probability, and basic formulae;	8			
Module: 2	Random variables, distribution functions, probability mass/density functions, functions of random variables;	8			
Module: 3	Standard univariate discrete and continuous distributions and their properties;	8			
Module: 4	Mathematical expectations, moments, moment generating functions;	8			
Module: 5	Random vectors, multivariate distributions, marginal and conditional distributions, conditional expectations;	8			

Text Books:

- P. L. Meyer, Introductory Probability and Statistical Applications Meyer.

Reference Books:

- P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2000.
- S. M. Ross, Introduction to Probability Models, 11th Ed., Academic Press, 2014.
- W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.
- K. S. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, 2nd Ed., Wiley, 2001.

MA232A8 Statistical Methods CREDIT: 4 [L:3,T:0,P:1]

Course Objectives: The course has been designed so that the students get exposed to basic ideas of sampling, statistical inference. The knowledge of statistical methods will empower the students to analyze critically the data and classify them. Organizations require people with good background as large volume of data analysis and classifications are necessary. This course aims to provide students with necessary theoretical skill to be successful in their area of work.

Pre-requisites: Probability Theory, Linear Algebra.

Course Outcomes (CO): On successful completion of this course, students will be able to:

CO1: Analyse data and sample them according to various characteristics.

CO2: Determine various estimates based on sample.

CO3: Conclude and justify the inferences on the basis hypothesis.

CO4: Model the data based on different classification.

CO5: Identify and execute different types of tests that appear in variety of problems.

Module	Topic	Hrs			
Module1	Sample Moments and Their Distributions: Random Sampling, Sample Characteristics and their distributions, Chi-squared, t- and F distributions, exact sampling distributions.	8			
Module2	Theory of Point estimates: The problem of point estimates, properties of estimates, Unbiased estimates, Method of Moments, Maximum Likelihood estimates.	8			
Module3	Testing of Hypothesis: Fundamental definitions and Notations; Neyman-Pearson Theory, Likelihood ratio tests.	8			
Module4	Inferences on Normal Models: Quadratic Forms, Analysis of Variance (One way), Multiple correlations, regression problems.	8			
Module5	Non-parametric Tests: The Sign Test, The Runs Tests, Spearman Rank Correlation .	8			

Text Books

1. Introduction .to Mathematical Statistics, R Hogg, J. Mckean, A. Craig, Pearson, VII Ed.2017
2. Fundamentals of Mathematical Statistics, Gupta, S.C, Kapoor, V.K, S Chand
3. Statistics Using R.: Sudha Purohit, G., Sharad Gore, D., & Shailaja Deshmukh, R. (2008)., Narosa Publishing House

Reference Books:

- Probability and Statistics for Engineers and Scientists, R Walpole, R Myers, S Myres, K E Ye, IX Ed 2014.
- Introduction to Probability and Statistics for Engineers and Scientists. S Ross; 6/e, Paperback, 2021

MA331A8 **Dynamics** **CREDIT: 4 [L:3,T:1,P:0]**

Pre-requisites: MA132A1

Module	Topic	Hrs			
Module: 1	Rectangular motion: Laws of motion, motion in a straight line, motion in a resisting medium, damped and forced oscillation, motion under gravity,	8			
Module: 2	impulse, impulsive force, work, power, and energy, principle of conservation of energy and momentum, collision of elastic bodies, loss of kinetic energies in collisions.	8			
Module: 3	Motion in a plane: Expressions of velocity and acceleration in Cartesian and polar coordinates, tangent and normal accelerations, equations of motions in Cartesian and polar coordinates,	8			
Module: 4	equation of motion of a particle moving in a plane with respect to a set of rotating axes, central force and central orbits, stability of nearly circular bodies, motion under inverse square law, planetary motion, slightly disturbed orbits, constrained motion of a particle,	8			
Module: 5	simple and cycloidal pendulum, motion on rough orbits (circles, ellipse, parabolas and cycloids), motion of a particle under resistance, motion of a particle under varying mass, motion on the rotating earth, motion of falling body.	8			

Text books:

1. N. Dutta and R. N. Jana, Dynamics of a Particle, Shreedhar Prakashani
2. F. Chorltan, Textbook of Dynamics, John Wiley & Sons
3. J. G. Chakraborty and P. R. Ghosh, Advanced Analytical Dynamics, U. N. Dhur & Sons Pvt. Ltd.

Reference book:

1. S. L., Loney, The Elements of Statistics & Dynamics Part-II, Arihant Publications

MA332A8 Introduction to Machine Learning **CREDIT: 3 [L:2,T:0,P:1]**

Course Objectives: Machine Learning is an important area in which mathematicians, statisticians and computer scientists work together improve progressively an assigned task. This course is designed so that students get an idea of area with programming applications such as R.

Pre-requisites: MA231A1, MA234A1

Module	Topic	Hrs			
Module: 1	Learning Associations, Classification, Scaling, Dimensionality, Principle Component Analysis, Maximum likelihood estimate,	8			
Module: 2	Parametric classification, regression, Multivariate methods, K- nearest neighbour classification, Hierarchical clustering, Naive Bayes classifier	8			
Module: 3	Linear discrimination, Gradient descent, Logistic discrimination, Single layer Perceptron, Training a perceptron, Multilayer perceptron, Decision trees.	8			
Module: 4	Support vector machines, Decision tress.	8			
Module: 5	Neural Networks, Reinforcement learning	8			

Text Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", (2e), MIT Press. 2010.

Reference Books:

1. Peter Harrington, "Machine Learning in Action", Manning Publications, 2012.

2. Christopher M. Bishop," Pattern Recognition and Machine Learning", Springer, 2007.

3. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification",(2e), Wiley, 2001.

MA333A8 **Theory of Computation** **CREDIT: 4 [L:3,T:1,P:0]**

Pre-requisites: MA131A1, MA135A1

Module	Topic	Hrs			
Module: 1	Alphabets, languages, grammars; Finite automata,	8			
Module: 2	regular languages, regular expressions, regular grammers, properties of regular languages;	8			
Module: 3	Context-free languages, parsing and ambiguity,	8			
Module: 4	Context-free grammers and normal forms, Chomsky Normal forms	8			
Module: 5	pushdown automata, non-deterministic and deterministic pushdown automata, Turing Machine	8			

Text Books:

- P. Linz, An Introduction to Formal Languages and Automata, Narosa, 2007.

Reference Books:

- M. Sipser, Introduction to the Theory of Computation, Thomson, 2004.
- J. E. Hopcroft and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, Narosa, 1995.
- H. R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation, Pearson Education, 1998.
- D. C. Kozen, Automata and Computability, Springer, 1997.

MA431A8/ MA541A8 Basics of Financial Mathematics CREDIT: 4 [L:3,T:1,P:0]

Pre-requisites: MA131A1, MA234A1

Module	Topic	Hrs			
Module: 1	Overview of financial engineering, financial markets and financial instruments; Interest rates, present and future values of cash flow streams;	8			
Module: 2	Risk free assets, bonds and bond pricing, yield, duration and convexity, term structure of interest rates, spot and forward rates;	8			
Module: 3	Risky assets, risk-reward analysis, Markowitz's mean-variance portfolio optimization model and efficient frontier, CAPM;	8			
Module: 4	No-arbitrage principle; Derivative securities, forward and futures contracts and their pricing, hedging strategies using futures, interest rate and index futures,	8			
Module: 5	General properties of options, trading strategies involving options; Discrete time financial market model, Cox-Ross-Rubinstein binomial asset pricing model, pricing of European derivative securities by replication;	8			

Text Books:

- D. G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013.
- S. Shreve, Stochastic Calculus for Finance, Vol. I, Springer, 2004.

Reference Books:

- M. Capinski and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Ed., Springer, 2010.
- J. C. Hull, Options, Futures and Other Derivatives, 10th Ed., Pearson, 2018.
- J. Cvitanic and F. Zapatero, Introduction to the Economics and Mathematics of Financial Markets, Prentice-Hall of India, 2007.
- S. Roman, Introduction to the Mathematics of Finance: From Risk Management to Options Pricing, Springer, 2004.
- N. J. Cutland and A. Roux, Derivative Pricing in Discrete Time, Springer, 2012.

MA641A8 Number Theory and Cryptography CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: To covers fundamental of design and analysis of algorithms for integer arithmetic, greatest common divisor calculation, modular arithmetic, primality testing and integer factorization. To understand fundamental of elliptic curves and its application in cryptography.

Pre-requisites: Elementary Number Theory

Module	Topic	Hrs			
Module: 1	Finite Fields and Quadratic Residues, Arithmetic functions Primality Testing and factorization algorithms, Pseudo-primes, Fermat's pseudo-primes,	9			
Module: 2	Pollard's rho method for factorization,Continued fractions, Continued fraction method Hash Functions,	7			
Module: 3	Public Key cryptography, Diffie-Hellmann key exchange, Discrete logarithm-based cryptosystems,	7			
Module: 4	RSA crypto-system, Signature Schemes, Digital signature standard, RSA Signature schemes, Knapsack problem.	8			
Module: 5	Introduction to elliptic curves, Group structure, Rational points on elliptic curves, Elliptic Curve Cryptography. Applications in cryptography and factorization, Known attacks.	9			

Text Books:

- N. Koblitz, A Course in Number Theory and Cryptography, Springer 2006.
- L. C. Washington, Elliptic curves: number theory and cryptography, Chapman & Hall/CRC, 2003.

Reference Books:

- I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to theory of numbers, Wiley, 2006.
- J. Silverman and J. Tate, Rational Points on Elliptic Curves, Springer-Verlag, 2005.
- D. Hankerson, A. Menezes and S. Vanstone, Guide to elliptic curve cryptography, Springer-Verlag, 2004.
- J. Pipher, J. Hoffstein and J. H. Silverman , An Introduction to Mathematical Cryptography, Springer-Verlag, 2008.
- G.A. Jones and J.M. Jones, Elementary Number Theory, Springer-Verlag, 1998.
- R.A. Mollin, An Introduction to Cryptography, Chapman & Hall, 2001.

Elective Courses

MA131A3 **Classical Algebra** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: To introduce the students with the concept of complex number system and its interaction with polynomial equations, solution of system of linear equations and convergence of series.

Pre-requisites: NIL

Module	Topic	Hrs			
Module: 1	Complex numbers, De Moivre's theorem and its applications, Exponential, Sine, Cosine and logarithm of a complex number, Inverse circular and hyperbolic functions.	7			
Module: 2	Polynomials, Fundamental Theorem of classical algebra (statements only), polynomials with real coefficients, n^{th} degree polynomial with exactly n roots, nature of roots of an equation.	8			
Module: 3	Statements of Descarte's rule of signs and its applications, relation between roots and coefficients, symmetric functions of roots, transformation of equations, Cardan's method of solution of a polynomial equations.	8			
Module: 4	System of linear equations, matrices, symmetric and skew symmetric, Hermitian and skew Hermitian matrices, idempotent, nilpotent, orthogonal, unitary matrices and their properties.	9			
Module: 5	Summation of series, inequalities (Cauchy's and Schwartz inequality, Theorem on means, Theorem on weighted means, Weierstrass's Inequality, Holder's Inequality, Jensen's Inequality, Jensen's Theorem, Minkowski's Inequality)	8			

Text Books:

1. Higher Algebra: Classical, S K Mapa, Sarat Book House.

Reference Books:

1. Higher Algebra,George Egbert Fisher, Isaac Joachim Schwatt, Macmillan.

2. Higher Algebra, Ghosh and Maity, New Central Book Agency (P) Limited.

MA132A3 Data Structures CREDIT: 4 [L:3,T:0,P:1]

Course Objectives: To provide the knowledge of basic data structures and their implementations, develop skills to apply data structures efficient programming.

Pre-requisites: MA135A1

Module	Topic	Hrs			
Module: 1	Asymptotic notation, space and time complexity;	8			
Module: 2	Abstract data types, arrays, stacks, queues, linked lists, matrices, binary trees, tree traversals, heaps;	8			
Module: 3	Sorting - mergesort, quicksort, heapsort; Graph representations, breadth first search, depth first search;	9			
Module: 4	Hashing; Searching - linear search, binary search,	7			
Module: 5	binary search trees, AVL trees, red-black trees, B-trees.	8			

Text Books:

- T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, Prentice-Hall of India, 2009.
- E. Horowitz, S. Sahani and D. Mehta, Fundamentals of Data Structures in C++, University Press, 2008.

Reference Books:

- A. V. Aho, J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pearson Education, 2006.
- A. M. Tannenbaum, Y. Langsam and M. J. Augenstein, Data Structures Using C++, Prentice-Hall of India, 1996.
- M. A. Weiss, Data Structures and Problem Solving Using Java, Addison-Wesley, 1997.

MA231A3 Linear Programming & Game Theory CREDIT: 4 [L:3,T:0,P:1]

Course Objectives:

Pre-requisites: NIL

Course Objectives: On completion of the course successfully a students will be able to

CO1: Formulate a linear programming problem.

CO2: Apply simplex method to solve LPP.

CO3: Distinguish different variations of simplex methods and apply them appropriately.

CO4: Formulate and solve industrial problems involving transformation and assignments.

CO5: Differentiate and solve different types of games

Module	Topic	Hrs			
Module: 1	Classification and general theory of optimization; Linear programming (LP) - formulation and geometric ideas,	7	1		
Module: 2	Development of simplex method, related theorems and problems	9	2		
Module: 3	Artificial Variable techniques: Big-M method, Two-Phase Simplex Method, Duality	8	3		
Module: 4	transportation and assignment problems	8	4		
Module: 5	Game Theory: Two Person- Zero Sum Games, The Maxmin-Minimax Principle, Saddle Point, Games Without Saddle Points-Mixed strategies, 2×2 Rectangular Games, Dominance Property, The Linear Programming Method.	8	5		

Text Books:

- Kanti Swaroop, P.K. Gupta, Man Mohan, (1985), Operation Research, Sultan Chand & Sons.

Reference Books:

- J.K.Sharma (2001).Operations Research Theory and Applications. McMillan New Delhi.
- Hadley, G. (1964). Linear Programming, Oxford & IBH Publishing Company, New Delhi.
- Hamdy A Thaha Operations Research, An Introduction, 8th Edition, Pearson Prentice Hall.

MA232A3 Object Oriented Programming CREDIT: 3 [L:3,T:0,P:0]

Course Objectives: This course will enable the students to apply the concepts of Object-oriented programming in real life problems in designing efficient applications in different areas of science, engineering and finance.

Pre-requisites:

Course Objectives: On completion of the course successfully a students will be able to

CO1: Realize the need for Object Oriented programming.

CO2: Identify and declare variables statements, array, pointers.

CO3: Apply the concepts of functions and structures, pre-processor directives.

CO4: Use data abstraction through Classes, user defined data type, and operator overloading for various real-life application.

CO5: Determine areas of application using object oriented design with C++.

Module	Topic	Hrs			
Module1	The need for Object Oriented programming, the basics of OOP, OO Languages, OOP terminologies: Class, Object, Abstraction and Encapsulation, Polymorphism, Inheritance.	8			
Module2	Declarations, Expressions, Statements, Arrays, Pointers.	8			
Module3	Design Programs based on above. Functions, Pre-processor directives, use of standard Header and C library functions.	8			
Module4	Data Abstraction through classes, user defined data types; Operator Overloading, Class relationship; Use of Templates, Exception handling .	10			
Module5	Data Structures and applications in C++; Object oriented design concepts.	6			

Text Books:

- The C++ Programming Language, Bjarne Stroustrup, 11 Ed, 2013.
- Thinking in C++, Vol I and Vol II; Bruce Eckel

Reference Books:

- C++ programming: From problem analysis to program design: D Malik , Paperback 204
- C++ and Object Oriented Programming and paradigm:, D Jana, PHI, 2nd Ed, 2005

MA331A3 **Artificial Intelligence** **CREDIT: 3 [L:2,T:1,P:0]**

Pre-requisites: MA131A1, MA135A1

Module	Topic	Hrs			
Module: 1	Logic and reasoning; Predicate logic - terms, formulae and clauses, clausal form of formulae,	10			
Module: 2	types of clauses, Horn clauses, substitution, unification algorithm, resolution, SLD-refutation;	8			
Module: 3	Introduction to Prolog, structure of logic programs, syntax and meaning, controlling backtracking, negation in logic programs and implementation issues,	7			
Module: 4	lists, operators, arithmetic, input and output, built-in predicates,	7			
Module: 5	operations on data structures, meta-programming; Constraint logic programming.	8			

Text/Refernce Books:

- I. Bratko, Prolog: Programming for Artificial Intelligence, 3rd Edn., Pearson, 2001.
- M. Ben-Ari, Mathematical Logic for Computer Science, 2nd Edn., Springer, 2003.
- J. W. Lloyd, Foundations of Logic Programming, Springer Verlag, 1987.
- T. Fruhwirth, H. Wiesenthal, and S. Abdennadher, Essentials of Constraint Programming, 1st Edn.,Springer, 2003.
- K. R. Apt, and M. Wallace, Constraint Logic Programming Using Eclipse, Cambridge University Press, 2007.

MA641A3 Design and Analysis of Algorithms CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: To introduce the various process of designing and analysing algorithms.

Pre-requisites: Discrete Mathematics, Linear Algebra, Probability Theory

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Apply the concept of sorting to solve various sorting problems.

CO2: Design algorithms efficiently.

CO3: Apply different methods of disign to improve algorithms.

Module	Topic	Hrs			
Module: 1	Sorting and order statistics - linear time sorting, randomize quicksort, lower bounds for sorting,	8			
Module: 2	median and order statistics, randomized selection; Design and analysis techniques - greedy method, divide-and-conquer,	8			
Module: 3	dynamic programming, amortized analysis; Graph algorithms - properties of BFS and DFS, connected components,	8			
Module: 4	topological sort, minimum spanning trees, shortest paths,	8			
Module: 5	maximum flow; NP-completeness; Approximation algorithms.	8			

Text books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, Prentice-Hall of India, 2009.

2. E. Horowitz, S. Sahani and D. Mehta, Fundamentals of Data Structures in C++, University Press, 2008.

Reference book:

1. A. V. Aho, J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pearson Education, 2006.

2. A. M. Tannenbaum, Y. Langsam and M. J. Augenstein, Data Structures Using C++, Prentice-Hall of India, 1996.

3. M. A. Weiss, Data Structures and Problem Solving Using Java, Addison-Wesley, 1997.

MA642A3 Fluid Mechanics CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: Introduce the basic terminology of fluid mechanics. Understand the principles of continuity, Momentum and energy as applied to fluid motions. To solve basic flow problems and evaluate the flow potential of given systems. To familiarize the student with the Navies-Stokes equation and its solution for different flow problems. To acquire the basic knowledge about the boundary layer approximation.

Pre-requisites: Numerical Analysis, Calculus and Differential equations.

Module	Topic	Hrs			
Module: 1	Introduction: Basic concept of fluid, Unit of Measurement, solid, Liquids and Gases, Continuum Hypothesis, Transport Phenomena, surface Tension, Inviscid Incompressible fluid: Lagrangian and Eulerian specifications, Streamline, Path line and Streak line.	8			
Module: 2	Vorticity and circulation. Stream function.Conservation of Mass, Euler Equation of motion along Streamline. Bernoulli's equations and its applications.Two-dimensional motion. Stream function, complex potential and velocity, sources, sinks.	8			
Module: 3	Doublets and their images. Circle theorem, Blasius's theorem, Vortex motion, vortex lines and filaments, strength of a vortices, systems of vortices, rectilinear vortices, vortex pair and doublets. A single infinite row of vortices, Karman's vortex sheet.	8			
Module: 4	Viscous incompressible fluid: Basic equation of conservation of mass, momentum and energy. Law of similarity, Reynolds numbers. Exact solutions of the Navier-Strokes equations: Flow through parallel walls, flow through circular pipe,	8			
Module: 5	Stroke's first and second problems. Prandtl's concept of boundary layer. Boundary layer approximation. Derivation of boundary-layer equations for two-dimensional flow, different measures of boundary layer on a flat plate Blasius solution.	8			

Text books:

1. H. Schlichting: Boundary-Layer theory, McGraw-Hill,Inc.

2. S.W Yuan: Foundation of fluid Mechanics, Prentice Hall

Reference book:

1. L.M Milne-Thomson: Theoretical hydrodynamics. The Macmilan Co. 1960.

2. L.D Landau and E.M Lifshitz: Fluid mechanics. Course of Theoretical Physics, Vol.6 Pergamon Press, 1959.

3. H. Lamb: Hydrodynamics. Cambridge Mathematical Library. Cambridge University Press, 1993

4. W.H. Besant and A.S. Ramsey: A treatise of Hydro-mechanics, Part II, ELBS

MA643A3 Field and Galois Theory CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The goal of the course is to impart the knowledge of Field Theory and Galois Theory which forms an important part of higher mathematics. This subject also has applications in coding theory, algebraic geometry, algebraic number theory and such topics.

Pre-requisites: MA131A1, MA135A1, MA231A1

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Understand basics of fields and extensions and its application to constructions.

CO2: Understand the ideas of algebraic closures, cyclotomic extensions.

CO3: Understand the Fundamental theorem of Galois theory.

CO4: Understand finite fields (relevant to coding theory), cyclotomic extensions and relation with cyclotomic polynomials.

CO5: Understand application of field and Galois theory to solvability of polynomials.

Module	Topic	Hrs			
1	Basic theory of field extensions, Algebraic extensions, Classical Straightedge and compass constructions,	9			
2	Splitting fields and Algebraic closures, Separable and Inseparable extensions. Cyclotomic polynomials and extensions.	8			
3	Basic definitions, The Fundamental Theorem of Galois Theory.	7			
4	Finite fields, Composite and Simple extensions, Cyclotomic and abelian extensions over $\mathbb{Q}$.	7			
5	Galois groups of polynomials, Insolvability of a 5 degree polynomial, Computations of Galois groups over $\mathbb{Q}$.	9			

Text books:

1. Abstract Algebra, David S. Dummit and Richard M. Foote, Wiley.
2. Basic Abstract Algebra, P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul, Cambridge university press.

Reference book:

1. Fields and Galois Theory, J.S. Milne, Springer.
2. Field and Galois Theory, Patrick Morandi, GTM-Springer.

MA644A3 Plasma Dynamics CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: To study and understand different plasma systems using various mathematical techniques.

Pre-requisites: Fluid Dynamics, Partial Differential Equations.

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Identify and understand the concepts of plasmas in some space environments.

CO2: Associate and apply the concept of nonlinear waves in various plasmas.

CO3: Formulate and apply the concept of some special kind of waves in various plasmas.

CO4: Analysis the concepts of kinetic theory and linear analysis to various plasma systems.

CO5: Apply the concepts of nonlinear evolution equations in various plasma systems.

Module	Topic	Hrs			
Module: 1	Laws of Electrodynamics, Maxwell's equations. Dynamics of a Charge Particle. Basic Plasma Concept: Definition of plasma, Classification of plasmas, Debye shielding, Space charge, Fluids of positive and negative charges.	8			
Module: 2	Waves in un-magnetized plasma, Longitudinal Waves, Waves in magnetized plasma, Transverse waves, Langmuir waves, Ion-acoustic Waves.	8			
Module: 3	Electron-acoustic Waves, Ion Cyclotron waves, Magnetic-acoustic waves, Alfven Waves.	8			
Module: 4	Kinetic theory: Introduction, Distribution function, Vlasov equation, Fluid equations, Dispersion relations for different plasma waves. Waves, Solitary waves and Solitons.	8			
Module: 5	The Burgers equation, the KdV equation, the KdV-Burgers equation, the MKdV equation and the KP equation, Reductive Perturbation Technique and Sagdeev's Pseudopotential method and their applications.	8			

Text books:

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion (Plenum)

2. R. J. Goldston and P. H. Rutherford, Introduction to Plasma Physics (IOP)

Reference book:

1. D. R. Nicholson, Introduction to Plasma Theory (Wiley)

2. Basudev Ghosh, Basic Plasma Physics (Narosa)

MA645A3 Algebraic Topology CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The goal of the course is to impart students with the knowledge of Algebraic Topology which is a very important topic in Pure Mathematics. The students will learn techniques in Algebraic topology which is widely used in research and will give them a glimpse into higher mathematics.

Pre-requisites: Group Theory, Topology

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Understand the idea of homotopy of functions in particular homotopy of paths.

CO2: Understand the ideas of a fundamental group and the idea of converting a topological problem into a algebraic problem.

CO3: Understand covering spaces and basic properties.

CO4: Understand an application of covering spaces.

CO5: Understand how problems in algebra can be addressed by the theory learned till now and classification of covering spaces.

Module	Topic	Hrs			
1	Topology, continuous functions, homeomorphisms, Quotient spaces, universal property of quotient spaces. Definition of paths, homotopy of paths, Homotopy as an equivalence relation, Homotopy of functions, Homotopy type. Contractible spaces. Examples.	9			
2	Definition of $\pi_1(X, x_0)$. Examples. Basic properties of $\pi_1(X, x_0)$: concatenation defines a multiplication on $\pi_1(X, x_0)$. $\pi_1(X, x_0)$ forms a group. Other properties like path connected implies independence of the base point, induced homomorphism on π_1's. $\pi_1(X \times Y)$. Simply-connected spaces. Examples.	10			
3	Evenly covered neighbourhoods. Definition and examples. Covering spaces definitions and examples. Basic properties: Product of covering spaces is covering, restrictions.	8			
4	Lifting correspondence and basic properties. Lifting theorem in general.* $\mathbb{R} \to S^1$ is a covering map. Application: $\pi_1(S^1) \cong \mathbb{Z}$.	7			
5	Fundamental Theorem of Algebra.(optional) Universal covering and classification of covering spaces.	6			

Text books:

1. Topology, James R. Munkres, Pearson Education, Inc,
ISBN-978-81-203-2046-8

Reference book:

1. Alan Hatcher, Algebraic Topology- First Edition.

2. Topology and Geometry,Glen E. Bredon, GTM, Springer,
   ISBN-978-81-8128-266-8

MA646A3 **Dynamical Systems** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: To familiarize with different dynamical systems and its application in various fields

Pre-requisites: Fluid Dynamics, ODE and PDE.

Module	Topic	Hrs			
Module: 1	Equilibrium Solutions: Linearised Stability Liapunov Stability, Asymptotic Stability, Liapunov Functions, Invariant	8			
Module: 2	Manifolds: Linear and Non-Linear Systems(Local, Stable, Unstable and Center Manifolds of Fixed Points), Application to unforced Duffing oscillator, Periodic Solutions, Bendixson's Criterion, Integrable vector fields on two manifolds, Examples: Unforced Duffing Oscillator, Pendulum.	8			
Module: 3	Index theory, Poincre-Bendixson Theorem, Poincre Maps: Theory and Examples. Method for Symplifying Dynamical Systems: Center Manifolds, Center Manifolds for Vector Fields, Center Manifolds Depending on Parameters, Center Manifolds for Maps,	8			
Module: 4	Normal forms: Vector Fields, Vector Fields with Parameters. Hartman-Grobman Theorem. Local Bifurcations, Bifurcation of Fixed Points of Vector Fields, a zero Eigen Value.	8			
Module: 5	Saddle-Nod Bifurcation. Transcritical Bifurcation , Pitchfork Bifurcation, Poincre-Andronov-Hopf Bifurcation.	8			

Text books:

1. S S. Wiggins; Introduction to Applied Nonlinear Dynamical system systems and chaos, Springer Verlag

2. S. H. Strogatz; Nonlinear Dynamical Systems and Chaos, Perseus Books, Reading, Massachusetts

3. P. Manneville; Instabilities, Chaos and Turbulence: An Introduction to Nonlinear Dynamics and Complex Systems, Imperial College Press, London

MA647A3 Wavelet Analysis and Signal Processing CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The goal of this course is to acquaint the students about time and frequency analysis of a signal and its properties.

Pre-requisites: Functional Analysis-I, Functional Analysis-II

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1:

Module	Topic	Hrs			
Module: 1	Fourier transform on $L_1(\mathbb{R})$ and $L_2(\mathbb{R})$, basic properties and examples, Windowed Fourier Transform : Motivation and definition of Windowed Fourier Transform and examples, Time frequency localization, the reconstruction formula Continuous Wavelet Transform.	8			
Module: 2	Continuous-time wavelets, Definition of the CWT, the VWT as a Correlation, Constant-Factor Filtering Interpretation and Time-Frequency Resolution, the VWT as an Operator, Inverse CWT, Problems.	8			
Module: 3	Introduction to Discrete Wavelet Transform And Orthogonal Wavelet Decomposition: Introduction, Approximation of Vectors in Nested Linear Vector Subspaces.	8			
Module: 4	Multiresolution Analysis : Definition of MRA and examples, Properties of scaling functions and orthonormal wavelets basis, Construction of orthonormal wavelets, Interpreting Orthonormal MRAs for Discrete-Time signals, Scaling Functions and wavelets from Filter Coefficient, Problems.	8			
Module: 5	Wavelet Transform And Data Compression: Introduction, Transform Coding, DTWT for Image Compression, Audio Compression, Video Coding Using Multi-resolution Techniques.	8			

Text books:

1. L. Debnath, Wavelet Transformation and Their Applications, Birkhauser Pub.
2. E. Mallat, A wavelet Tour of Signal Processing, Elsevier.
3. Yves Mayer, Wavelets and Operators, Cambridge University Press.

Reference book:

1. G. Kaiser: A Friendly Guide to Wavelets, Birkhauser Pub.
2. G. Bachman, L. Narici & E. Beckensterin: Fourier and Wavelet Analysis, Springer Verlag, 2009.

3. C. K. Chui, An Introduction to Wavelets, Academic Press, 1992.

4. C. K. Chui, An Introduction to Wavelets, Academic Press, 1992.

5. Archit Yajnik, Wavelet Analysis - An Introduction, Narosa press.

MA648A3 **Representation Theory** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: The goal of the course is to impart students with the knowledge of Representation theory. The students will learn basics of Representation theory which is a very important part of recent research in Mathematics.

Pre-requisites: Group Theory, Linear Algebra

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: Get comfortable with the idea of group actions.

CO2: Understand the basics of representation theory, examples and one of the most important results in Representation theory- Complete reducibility theorem.

CO3: Understand characters of a representation and how one can use characters to understand representations.

CO4: Understand induced representations which is a fundamental construction in representation theory.

CO5: Understand representations of the group $GL(2, \mathbb{F}_q)$ which is the starting point of many research problems in Representation theory.

Module	Topic	Hrs			
1	Recall Group theory and important ideas in finite groups. Group actions. Discuss groups S_n, A_n, D_{2n} along with structure of finite abelian groups. General Linear groups over a finite field.	6			
2	Basics of Representation theory, Definitions, examples, Complete reducibility theorem, Unitary representations, direct sum and duals of representations.	10			
3	Character Theory, Schur's lemma, Schur's orthogonality relations and its consequences, Character table.	8			
4	Induced representations, Frobenius reciprocity, Mackey theory.	8			
5	Representation theory of $GL(2, \mathbb{F}_q)$	8			

Text books:

1. Abstract Algebra, David S. Dummit and Richard M. Foote, Wiley.

2. Groups and representations- J. L. Alperin and Rowen B. Bell- Graduate Texts in Mathematics, Springer.

3. Linear Representations of Finite groups, J. P. Serre- Graduate text in Mathematics, Springer-Verlag.

Reference book:

1. Representation Theory- A first course, William Fulton, Joe Harris, Springer Verlag.

MA649A3 **Algebraic Graph Theory** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: Algebraic graph theory is a branch of Mathematics that studies graphs by using algebraic properties. In this course we focus on the spectral graph theory that studies the relation between graph properties and the spectrum of the adjacency matrix and the Laplacian matrix.

Pre-requisites: Group Theory, Graph Theory, Linear Algebra

Module	Topic	Hrs			
1	Incidence Matrix, Adjacency matrix of a graph and its eigenvalues, Spectral radius of graphs	6			
2	Regular graphs and Line graphs, Strongly regular graphs, Cycles and Cuts,	10			
3	Laplacian matrix of a graph, Algebraic connectivity, Laplacian spectral radius of graphs,	8			
4	Distance matrix of a graph, General properties of graph automorphisms, Transitive and Arc-transitive graphs, Symmetric graphs.	8			
5	Groups and Graphs, Permutation Groups, Counting, Asymmetric Graphs	8			

Reference book:

- N. Biggs, "Algebraic Graph Theory", Cambridge University Press, 1993.
- C. Godsil, G. Royle, "Algebraic Graph Theory", Graduate Texts in Mathematics 207, Springer-Verlag, 2001.
- R. B. Bapat, "Graphs and Matrices", Universitext, Springer, Hindustan Book Agency, New Delhi, 2010.

MA650A3 Queuing Theory and Modeling CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The course focusses on modeling and finding solution of different queuing models that appear many branches of engineering sciences. The course equips the students with sophisticated mathematical tools to analyze and model various problems in this area.

Pre-requisites: Linear Algebra, Probability, Stochastic Processes, Numerical Analysis.

Course Outcomes (CO): On completion of the course successfully a students will be able to

CO1: analyze different discrete and continuous time models.

CO2: identify different distributions to queueing theory

CO3: solve different generalized models.

CO4: understand different networks , model them in queuing notation.

CO5: tackle error, obtain bounds by numerical techniques and compare with analytical solutions.

Module	Topic	Hrs			
Module: 1	Introduction to Queues and Queuing Theory, Stochastic Processes, Markov Processes and Markov Chains, Birth-Death Process Basic Queueing Theory ((M/M/-/- Type Queues), M/M/1 Model: Steady state solution, M/M/1/N Queuing system, Queues with Bulk Arrivals.	8			
Module: 2	Queue with parallel Channels (M/M/c), Erlang Formula Steady state formula, Derivation and problems. M/M/c/K Queue.	8			
Module: 3	Equilibrium Analysis of the M/G/1 Queue, Analyzing the M/G/1 Queue using the Method of Supplementary Variables, M/G/1 with Vacations, M/[x]/G/1 Queue, Priority Operation of the M/G/1 Queue.	8			
Module: 4	Classification and Basic Concepts: Open Jackson Networks and closed Jackson Networks Type Queues, Jackson's Theorem, Analysis of closed Queuing Networks using Convolution and Mean Value Algorithms, Norton's Theorem for Closed Queuing Networks.	8			
Module: 5	Numerical Techniques, Bounds, Approximations, Discrete event Simulation.	8			

Text books:

1. Donald Gross, James M. Thompson, John F. Shortle and Carl W. Harris, Fundamentals of Queueing Theory, Wiley 2008.

2. Medhi, Stochastic Models in Queuing Theory, Elsevier 2/e, 2003.

Reference book:

1. Sanjay K. Bose, An Introduction to Queuing Systems, Springer 2002.

2. U N Bhat, An Introduction to Queuing Theory, modeling and analysis, 2nd Ed, Birkhauser, 2015

MA651A3 **Optimization Techniques** **CREDIT: 4 [L:3,T:1,P:0]**

Course Objectives: To familiarize with the basics of linear and non-linear optimization problems which naturally occurs in many areas of science and engineering.

Pre-requisites: MA231A1

Module	Topic	Hrs			
Module: 1	Mathematical Preliminaries, Characteristics of an Optimal Solution, Development of Simplex Method and Simplex Algorithm	10			
Module: 2	Duality, Dual Simplex Algorithm, Sensitivity Analysis- Changes in the objective function, Variations in requirement Vector, changes in the coefficient matrix, Addition of a variable, Addition of a constraint.	8			
Module: 3	Integer Linear programming- Cutting Plane method, Branch and Bound method.	6			
Module: 4	Non Linear programming- Introduction, unconstrained optimization, Constrained Optimization, Lagrange Method of Multipliers, Kuhn Tucker Optimality conditions,	8			
Module: 5	Quadratic Programming- Wolfe's Method, Dantzig's Method, Beale's Method. Separable Programming, Kelly's Cutting Plane problem, Wolfe's Reduced Gradient Method.	8			

Text books:

1. G Hadley: Linear Programming; Narosa.
2. H. Taha: Oerations Research, An Introduction; Pearson.
3. Kanti Swarup, P K Gupta & Man Mohan: Operations Research, S Chand.

Reference book:

1. S. M. Sinha: Mathematical programming; Elsevier
2. F. S. Hillier & G. J. Leiberman: Introduction to Operations Research, Tata McGraw Hill.

MA652A3 Mathematical Finance CREDIT: 4 [L:3,T:1,P:0]

Course Objectives: The objective of the course is to make students aware of the applications of Mathematics in financial Markets. With a basic level understanding student will be able to apply concepts of pricing in various assets classes. Concepts of derivatives will enable students to test and apply the theories in determining the theoretical prices of options, futures and forwards.

Pre-requisites: Calculus, Linear Algebra, Probability Theory.

Course Outcomes (CO): On successful completion of this course, students will be able to:

CO1: Understand the basics of Financial market and interest rates.

CO2: Apply the concepts of interest rate in pricing bonds and other asset classes

CO3: Analyse fundamental theorems in Portfolio optimizations and apply.

CO4: Identify and determine prices using No arbitrage conditions.

CO5: Model the pricing of different derivatives products.

Module	Topic	Hrs			
Module1	Overview of financial engineering, financial markets and financial instruments; Interest rates, present and future values of cash flow streams;	8			
Module2	Risk free assets, bonds and bond pricing, yield, duration and convexity, term structure of interest rates, spot and forward rates.	8			
Module3	Risky assets, risk-reward analysis, Markowitz's mean-variance portfolio optimization model and efficient frontier, CAPM.	8			
Module4	No-arbitrage principle; Derivative securities, forward and futures contracts and their pricing, hedging strategies using futures, inter- est rate and index futures..	8			
Module5	General properties of options, trading strategies involving options; Discrete time financial market model, Cox-Ross-Rubinstein binomial asset pricing model, pricing of European derivative securities by replication..	8			

Texts:

1. D. G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013..
2. S. M. Ross , An elementary introduction to Mathematical Finance III Ed , 2013, Cambridge University Press
3. J. C. Hull, Options, Futures and Other Derivatives, 10th Ed., Pearson, 2018.

References:

- S. Shreve, Stochastic Calculus for Finance, Vol. I, Springer, 2004
- Amber Habib, The Calculus of Finance: Ist Ed, 2011

Electives from Other Departments

CH10201A **Chemistry-I** **CREDIT: 4 [L:3,T:0,P:1]**

Course Objectives: This course aims at giving students theoretical understanding about the electronic structure and reactivity of elements. Periodic classification of elements in the periodic table and changes in properties along the periods and groups to be studied in detail. To derive the expressions for determining the physical properties of solids. To study the concept of ionization in aqueous solution, pH, buffers and various applications of ionization.

Pre-requisites: NIL

Course Objectives: On completion of the course successfully a students will be able to

CO1: Demonstrate understanding related to atomic and molecular structure, chemical bonding, periodic properties and redox behaviour of chemical species.

CO2: Derive mathematical expressions for different properties of solids and understand their physical significance.

CO3: Explain the crystal structure and calculate related properties of cubic systems.

CO4: Explain the concept of ionization of electrolytes with emphasis on weak acid and base and hydrolysis of salt.

CO5: Apply the concepts of gas equations, pH and electrolytes while studying other chemistry courses and everyday life.

Module	Topic	Hrs			
Module: 1 Atomic Structure	Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ϕ and ϕ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.	12			

Module	Topic	Hrs			
Module: 2 Periodicity of Elements	s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block. a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. b. Atomic radii (van der Waals) c. Ionic and crystal radii. d. Covalent radii (octahedral and tetrahedral) e. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. f. Electron gain enthalpy, trends of electron gain enthalpy.	12			
Module: 3	Molecular and Crystal Symmetry: Elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices.	6			
Module: 4	Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Liquid crystals (Introductory idea).	10			
Module: 5	Ionic equilibria: Strong, moderate, and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity,buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.	20			

Reference book:

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed.,Wiley, 2007.
3. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH,2007.
4. Atkins, P.W. & Paula, J. Physical Chemistry, 11th Ed., Oxford University Press, 2018.
5. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
6. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
7. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 1) McGraw Hill Education; Sixth edition (2019)

CH10419A **Chemistry Lab-I** **CREDIT: 2 [L:0,T:0,P:1]**

(A) Titrimetric Analysis

(i) Calibration and use of common laboratory apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants.

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents.

(C) Surface tension measurements.

(a) Determine the surface tension by (i) drop number (ii) drop weight method.

(b) Study the variation of surface tension of detergent solutions with concentration.

(D) Viscosity measurement using Ostwald's viscometer.

(a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

(b) Study the variation of viscosity of sucrose solution with the concentration of solute.

Reference book:

1. Mendham, J. et al.: Vogel's Text Book of Quantitative Chemical Analysis; 6th Ed. Pearson Education, 2009.

2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003). 12

4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Ability Enhancement Core Courses(AECC)

BA10101A **English** **CREDIT: 2 [L:2,T:0,P:0]**

Course Objectives:

- The course is intended to familiarize students with effective communication strategies by improving their verbal and non-verbal communication style.
- The course enhances interpersonal skills of students by focusing on the four macro communication skills LSRW (Listening, Speaking, Reading, and Writing), which makes them job and industry ready.

Pre-requisites: NIL

Course Outcomes:

CO1: To comprehend and apply a variety of communications (verbal/Non – verbal, formal/informal) techniques in the Professional Environment and to overcome the barriers of communication.

CO2: To develop and expand writing skills through controlled and guided activities on vocabulary and comprehension.

CO3: To write and draft different kinds of effective business correspondences such as reports, letters, memos, email and resume with clarity and aptness.

CO4: To demonstrate the ability to write error free while making an optimum use of correct Business Vocabulary and Grammar.

CO5: To develop coherence, cohesion and competence in oral discourse through appropriate pronunciation.

Module	Topic	Hrs			
Module: 1 Introduction to Communication Skills	Fundamentals of Communication Skills Process of Communication Types of Communication Flows of Communication Barriers to Communication Types of Listening 7 C's of Communication Verbal Communication- 3 V's of Communication Non Verbal Communication- Types of Body Language	4			
Module: 2 Vocabulary and Comprehension Skills	Precise Writing Expansion of ideas Comprehension Skills Vocabulary: One Word substitution, Foreign Words Commonly used in English, Synonyms, Antonyms, Idioms.	4			

Module	Topic	Hrs			
Module: 3 Writing Skills	Paragraph Writing, Summarizing, Paraphrasing and Note making Reported Speech. Report Writing: Performance Appraisal Report, Disciplinary Report, Inspection Report, Site Survey Report, Market Survey report, Event Management Report Business Correspondence: Kinds of Business Letters, Enquiries and Replies, Letters to Newspapers, Circulars and Memorandum Floating Tenders, Inviting Quotations, Submission of Quotation, Placing an Order, Notice, Agenda and Minutes of Meeting, Job application (including Resume / Bio data) E-mail Writing.	4			
Module: 4 Grammar	Parts of Speech Time, Tense and Aspect Correct Usage of Adjectives, Adverbs, Nouns, and Prepositions.	4			
Module: 5 Phonetics	Study of Speech sounds- Pure vowels, Diphthongs, Consonants Description of Consonant Sounds Place of Articulation Manner of Articulation. Syllable, Stress, Problem Sound for Indian Speakers. Intonation.	4			

Text books:

1. Sen, Leena. Communication Skills. (Prentice Hall)
2. Raman, Menashi & Sharma, Sangeeta. Technical Communication - Principles and Practice (Oxford)
3. Wren, R.C. & Martin, H. English Grammar and Composition (S Chand & Co Ltd)

Reference book:

1. Mehra, Payal, Business Communication for Managers. (Pearson)
2. Miglani, Seema & Goyal, Shikha. English for Professional. (VEI)

Skill Development Courses

MA133A1 Programming with C **CREDIT: 3[L:3,T:0,P:0]**

Course Objectives: : The goal of this course is to make the students capable of developing logic and write their own code using suitable programing language. Students can implement various numerical and statistical techniques using matlab, maple, mathematics or C.

Pre-requisites: MA131A1, Algebra I: Group Theory,

Module	Topic	Hrs			
Module: 1	Introduction to computing, Importance of Problem solving using computers, Algorithms and Flow charts, Simple C programs, Syntax and Logical Errors in compilation, Object and executable code,	9			
Module: 2	Variable names and declaration, Data types, Sizes and Constants, Various operators, Type conversion and expressions, Precedence and order of evaluation, Statements and blocks,	9			
Module: 3	Control flow, Break and continue, 1-D and 2-D Arrays and Strings, Searching and Sorting,	8			
Module: 4	Multidimensional Arrays and Matrices, Modular programming and Recursive functions, Structure and Pointers	7			
Module: 5	Defining Structures and Array of Structures, Pointer arithmetic, Pointer to Structures, File Management and Cyber Security.	7			

Text Books:

- Balagurusamy, E, Computing fundamentals and C programming (1e), McGraw-Hill, 2008.
- Brian W. Kernighan and Dennis M. Ritchie, The C Programming language (2e), Pearson Education, 1988.

Reference Books:

- Dromey. R. G, How to solve it by computers, Pearson, 1982.
- Deital. P. J and Deitel. H. M, C: How to program (7e), Pearson Education, 2010.

MA131A4 **Programming with C-Lab** **CREDIT: 1 [L:0,T:0,P:1]**

Course Objectives:

Pre-requisites: NIL

Course Objectives: On completion of the course succesfully a students will be able to

CO1: To make the student learn a programming language.

CO2: To learn problem solving techniques.

CO3: To teach the student to write programs in C.

CO4: To learn implementing algorithms thhrough C programing.

CO5: To solve the real world problems.

Reference book:

1. Problem Solving and Program Design in C, 4th edition, by jeri R. Hanly and Elli B.Koffman.
2. E. Balaguruswamy, Programming in ANSI C 5th Edition McGraw-Hill
3. Brain W.Kernighan & Dennis Ritchie, C Programming Language, 2nd edition, PHI
4. A first book of ANSI C by Gray J.Brosin 3rd edition Cengagedelmer Learning India P.Ltd

PE108A4 Fitness and Yoga CREDIT: 2 [L:1,T:0,P:2]

Course Objectives:

Pre-requisites: NIL

Course Objectives: On successful completion of this course, students will be able to

CO1: Explores the relationship between yoga and mental/physical health.

CO2: Execute effective warm-up, general exercise, cooling down, and diet plans, and assess the impact of physical activity on overall health and wellness.

CO3: Define, practice, and honor Asana to create a healthy physical and mental lifestyle.

CO4: Explain difference between pranayama and deep breathing, and practice different pranayama techniques.

CO5: Explain and implement the principles and practices of bandhas, mudras, meditation, and Shuddhi kriyas, and apply them to their own yoga practice.

Module	Topic	Hrs			
Module: 1 Introduction to Yoga	Historical aspect of yoga. Yoga: Mean and Definition, Types of yoga Scopes & Importance of yoga.	6			
Module: 2 Basic Preparation	Warm-up, General exercise and cooling down. Demonstration: Aerobics, Circuit Training and Calisthenics. Diet chart & measurement of BMI	6			
Module: 3 Asanas	Asana, differences between asana and physical exercise. Suraya-Namaskar, 02 Standing Asanas, 02 – Sleeping (Supine Position) Asanas, 02 – Sitting Asanas	6			
Module: 4 Pranayama	Pranayama Practices Difference between pranayama and deep breathing.	4			
Module: 5 Techniques	Bandhas, Mudras, Meditation, and Shuddhi Kriyas.	4			