

**PROPOSED UG SYLLABUS IN MATHEMATICS HONOURS PROGRAMME**  
**COURSE UNDER CBCS SYSTEM TO BE INTRODUCED IN 2018**

**Credit Distribution**

Course Type	Total Papers	Credits	Marks
1. Hard Core Courses (HCC)	14	$(13 \times 5) + (13 \times 1) = 78$ , $(1 \times 4) + (1 \times 2) = 6$ for HCC-XII	75 (60+10+5), 40+20+10+5 (for HCC-XII)
2. D.S. Elective (DSE)	4	$(4 \times 5) + (4 \times 1) = 24$	75 (60+10+5)
3. General Elective (GE)	4	$(4 \times 5) + (4 \times 1) = 24$	75 (60+10+5)
4. Skill Enhance (SE)	2	$2 \times 2 = 4$	75 (60+10+5)
5. Ability Enhance (AE)	2	$2 \times 2 = 4$	80+15+5=100 (AE-I), 35+10+5=50 (AE-II)
	26	140	1950

**SEMESTER-1**

Subject Course No.	Syllabus Code	Course	Credit
MATH 15 AE-I	AE-I	Eng com./Env.Sc.	2
MATH 11 HCC-I	HCC-I	Cal, Geo & D.E.	5 + 1
MATH 11 HCC-II	HCC-II	Algebra	5 + 1
MATH 13 GE-I	GE-I	Other Department	5 + 1

**SEMESTER-2**

Subject Course No.	Syllabus Code	Course	Credit
MATH 25 AE-II	AE-II	Eng Com/EVS	2
MATH 21 HCC-III	HCC-III	Real Analysis	5 + 1
MATH 21 HCC-IV	HCC-IV	D.E & Vector Calculus	5 + 1
MATH 23 GE-II	GE-II	Other Department	5 + 1

**SEMESTER-3**

Subject Course No.	Syllabus Code	Course	Credit
MATH 31 HCC-V	HCC-V	Theory Of Real Functions & Introduction of the metric space	5 + 1
MATH 31 HCC-VI	HCC-VI	Group Theory-I	5 + 1
MATH 31 HCC-VII	HCC-VII	Riemann Integration & Series of functions	5 + 1
MATH 33 GE-III	GE-III	Other Department	5 + 1
MATH 34 SE-I	SE-I	Logic & Sets/C++	2

**SEMESTER-4**

Subject Course No.	Syllabus Code	Course	Credit
MATH 41 HCC-VIII	HCC-VIII	Multivariate Calculus	5 + 1
MATH 41 HCC-IX	HCC-IX	Ring Theory & Linear Algebra I	5 + 1
MATH 41 HCC-X	HCC-X	Metric Space & Complex Theory	5 + 1
MATH 43 GE-IV	GE-IV	Other Department	5 + 1
MATH 44 SE-II	SE-II	Graph Theory/Operating System: Linux	2

**SEMESTER-5**

Subject Course No.	Syllabus Code	Course	Credit
MATH 51 HCC-XI	HCC-XI	Group TheoryII	5 + 1
MATH 51 HCC-XII	HCC-XII	Numerical Methods+Lab	4 + 2
MATH 52 DSE-I	DSE-I	Probability & Statistics/Linear Programming	5 + 1
MATH 52 DSE-II	DSE-II	Number Theory/Mechanics	5 + 1

**SEMESTER-6**

Subject Course No.	Syllabus Code	Course	Credit
MATH 61 HCC-XIII	HCC-XIII	Ring Theory & Linear Algebra-II	5 + 1
MATH 61 HCC-XIV	HCC-XIV	Partial Differential Equations & Applications	5 + 1
MATH 62 DSE-III	DSE-III	Point Set Topology/Boolean Algebra & Automata Theory	5 + 1
MATH 62 DSE-IV	DSE-IV	Differential Geometry/Theory Of Equation	5 + 1

## DETAILED SYLLABUS

### SEMESTER-1

Subject Course No.	Syllabus Code	Course	Credit
MATH 15 AE-I	AE-I	Eng com./Env.Sc.	2
MATH 11 HCC-I	HCC-I	Cal, Geo & D.E.	5 + 1
MATH 11 HCC-II	HCC-II	Algebra	5 + 1
MATH 13 GE-I	GE-I	Other Department	5 + 1

### **MATH11 HCC-I: Calculus, Geometry and Differential Equation**

6 Credits

#### **Unit 1**

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to the problems of the type  $e^{ax+b} \sin x$ ,  $e^{ax+b} \cos x$ ,  $(ax + b)^n \sin x$ ,  $(ax + b)^n \cos x$ , concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

#### **Unit 2**

Reduction formulae, derivations and illustrations of reduction formulae of the type  $\int \sin nx \, dx$ ,  $\int \cos nx \, dx$ ,  $\int \tan nx \, dx$ ,  $\int \sec nx \, dx$ ,  $\int (\log x)^n \, dx$ ,  $\int \sin^n x \cos^m x \, dx$ , parametric equations, parameterizing a curve arc length of a curve, arc length of parametric curves, area under a curve, area and volume of revolution, techniques of sketching conics.

#### **Unit 3**

Reflection properties of conics, rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid.

#### **Unit 4**

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

## Reference Books

- G. B. Thomas and R. L. Finney, Calculus, 9<sup>th</sup> Ed., Pearson education, Delhi, 2005.
- M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, 3<sup>rd</sup> Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
- H. Anton, I. Bivens and S. Davis, Calculus, 7<sup>th</sup> Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
- S. L. Ross, Differential Equations, 3<sup>rd</sup> Ed., John Wiley and Sons, India, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- G. F. Simmons, Differential Equations, Tata Mcgraw Hill.
- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and mathematical analysis.

## MATH11 HCC- II- ALGEBRA

6 Credits

### Unit 1

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.

Theory of equations : relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation. Graphical representation of a polynomial and maximum, minimum of polynomial.

Inequality: The inequality involving  $AM \geq GM \geq HM$ , Cauchy-Schwartz inequality.

### Unit 2

Equivalence relations. Functions, composition of functions, Invertible functions, one to one correspondence and cardinality of a set. Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of mathematical induction, statement of Fundamental Theorem of Arithmetic.

### Unit 3

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation  $Ax=b$ , solution sets of linear systems, applications of linear systems, linear independence.

### Unit 4

Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of  $R^n$ , dimension of subspaces of  $R^n$ , rank of matrix, Eigen values, Eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

## Reference Books

- Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3<sup>rd</sup> Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
- David C. Lay, Linear Algebra and its Applications, 3<sup>rd</sup> Ed., Pearson Education Asia, Indian Reprint, 2007.
- K. B. Dutta, Matrix and linear algebra.
- K. Hoffman, R. Kunze, Linear algebra.
- W. S. Burnstine and A. W. Panton, Theory of equations.

## SEMESTER-2

Subject Course No.	Syllabus Code	Course	Credit
MATH 25 AE-II	AE-II	Eng Com/EVS	2
MATH 21 HCC-III	HCC-III	Real Analysis	5 + 1
MATH 21 HCC-IV	HCC-IV	D.E & Vector Calculus	5 + 1
MATH 23 GE-II	GE-II	Other Department	5 + 1

## MATH21 HCC-III: REAL ANALYSIS

6 Credits

### Unit 1

Review of Algebraic and order properties of  $\mathbb{R}$ ,  $\varepsilon$ -neighborhood of a point in  $\mathbb{R}$ . Idea of countable sets, uncountable sets and uncountability of  $\mathbb{R}$ . Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima. Completeness property of  $\mathbb{R}$  and its equivalent properties. The Archimedean property, density of rational (and irrational) numbers in  $\mathbb{R}$ , intervals. Limit points of a set, isolated points, open set, closed set, derived set, illustrations of Bolzano-Weierstrass theorem for sets, compact sets in  $\mathbb{R}$ , Heine-Borel Theorem.

### Unit 2

Sequences, bounded sequence, convergent sequence, limit of a sequence,  $\liminf$ ,  $\limsup$ . Limit theorems. Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion.

### Unit 3

Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's  $n$ th root test, integral test. Alternating series, Leibniz test. Absolute and conditional convergence.

## Reference Books

- R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3<sup>rd</sup> Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
- Gerald G. Bilodeau, Paul R. Thie, G. E. Keough, An Introduction to Analysis, 2<sup>nd</sup> ed., Jones & Bartlett, 2010.
- Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
- S. K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.
- T. Apostol, Mathematical Analysis, Narosa Publishing House.
- Courant and John, Introduction to Calculus and Analysis, Vol I, Springer.
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
- Terence Tao, Analysis I, Hindustan Book Agency, 2006
- S. Goldberg, Calculus and mathematical analysis.

## MATH21 HCC – IV :

### DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS

6 Credits

#### Unit 1

Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian : its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

#### Unit 2

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients. Basic theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

#### Unit 3

Equilibrium points, Interpretation of the phase plane. Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

#### Unit 4

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

## Reference Books

- Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2<sup>nd</sup> Ed., Taylor and Francis group, London and New York, 2009.
- C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
- S. L. Ross, Differential Equations, 3<sup>rd</sup> Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3<sup>rd</sup> Ed., Elsevier Academic Press, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Diprima, Elementary Differential equations and boundary Value problems, Wiley.
- G. F. Simmons, Differential Equations, Tata McGraw Hill.
- Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
- Maity, K. C. and Ghosh, R. K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
- M. R. Spiegel, Schaum's outline of Vector Analysis.

### SEMESTER-3

Subject Course No.	Syllabus Code	Course	Credit
MATH 31 HCC-V	HCC-V	Theory Of Real Functions & Introduction of the metric space	5 + 1
MATH 31 HCC-VI	HCC-VI	Group Theory-I	5 + 1
MATH 31 HCC-VII	HCC-VII	Riemann Integration & Series of functions	5 + 1
MATH 33 GE-III	GE-III	Other Department	5 + 1
MATH 34 SE-I	SE-I	Logic & Sets/C++	2

## **MATH31 HCC-V: THEORY OF REAL FUNCTIONS AND INTRODUCTION TO METRIC SPACE**

6 Credits

### Unit 1

Limits of functions ( $\epsilon$ - $\delta$  approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

**Unit 2**

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions . Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem, intermediate value property of derivatives, darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials.

**Unit 3**

Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of reminder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions,  $\log(1+x)$ ,  $1/(ax+b)$  and  $(x + 1)^n$ . Application of Taylor's theorem to inequalities.

**Unit 4**

Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. Sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's theorem.

**Reference Books**

- R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
- K. A. Ross, Elementary Analysis : The Theory of Calculus, Springer, 2004.
- A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
- S. R. Ghorpade and B. V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
- T. Apostol, Mathematical Analysis, Narosa Publishing House.
- Courant and John, Introduction to Calculus and Analysis, Voll II, Springer.
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- Terence Tao, Analysis II, Hindustan Book Agency, 2006
- SatishShirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
- S. Kumareasan, Topology of Metric Spaces, 2<sup>nd</sup> Ed., Narosa Publishing House, 2011.
- G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

**MATH31 HCC VI : GROUP THEORY 1**

6 Credits

**Unit 1**

Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups.



**Unit 2**

Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

**Unit 3**

Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

**Unit 4**

External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

**Unit 5**

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

**Reference Books**

- John B. Fraleigh, A First Course in Abstract Algebra, 7<sup>th</sup> Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2<sup>nd</sup> Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4<sup>th</sup> Ed., Narosa Publishing House, New Delhi, 1999.
- Joseph J. Rotman, An Introduction to the Theory of Groups, 4<sup>th</sup> Ed., Springer Verlag, 1995.
- I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
- D. S. Malik, John M. Mordeson and M. K. Sen, Fundamentals of abstract algebra.

## **MATH31 HCC- VII : RIEMANN INTEGRATION AND SERIES OF FUNCTIONS**

6 Credits

**Unit 1**

Riemann integration: inequalities of upper and lower sums, Darboux integration, Darboux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two definitions. Riemann integrability of monotone and continuous functions, properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorem of Integral Calculus.

**Unit 2**

Improper integrals. Convergence of Beta and Gamma functions.

**Unit 3**

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions.

Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

**Unit 4**

Fourier series: Definitions of Fourier coefficients and series, Riemann Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series.

**Unit 5**

Power series, radius of convergence, Cauchy Hadamard theorem. Differentiation and integration of power series ; Abel's theorem ; Weierstrass approximation theorem.

**Reference Books**

- K. A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- R. G. Bartle D. R. Sherbert, Introduction to Real Analysis, 3<sup>rd</sup> Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
- Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
- S. Goldberg, Calculus and mathematical analysis.
- Santi Narayan, Integral calculus.
- T. Apostol, Calculus I, II.

**MATH34 SE-I: LOGIC AND SETS**

2 Credits

**Unit 1**

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, quantifiers, binding variables and negations.

**Unit 2**

Sets, subsets, set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. classes of sets. Power set of a set.

**Unit 3**

Difference and Symmetric difference of two sets. Set identities, generalized union and intersections. Relation: Product set. Composition of relations, types of relations, partitions, equivalence Relations with example of congruence modulo relation. Partial ordering relations, n- ary relations.

**Reference Books**

- R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
- P.R. Halmos, Naive Set Theory, Springer, 1974.
- E. Kamke, Theory of Sets, Dover Publishers, 1950.

**OR****MATH34 SE-I: C++**

2 Credits

**Unit 1**

Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.

**Unit 2**

Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

**Unit 3**

Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

**Reference Books**

- R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997.
- S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
- Bruce Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall.
- D. Parsons, Object Oriented Programming with C++, BPB Publication.
- Bjarne Stroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley.
- E. Balaguruswami, Object Oriented Programming In C++, Tata McGrawHill
- Herbert Schildt, C++, The Complete Reference, Tata McGrawHill.

**SEMESTER-4**

Subject Course No.	Syllabus Code	Course	Credit
MATH 41 HCC-VIII	HCC-VIII	Multivariate Calculus	5 + 1
MATH 41 HCC-IX	HCC-IX	Ring Theory & Linear Algebra I	5 + 1
MATH 41 HCC-X	HCC-X	Metric Space & Complex Theory	5 + 1
MATH 43 GE-IV	GE-IV	To be decided by concerned departments	5 + 1
MATH 44 SE-II	SE-II	Graph Theory/Operating System: Linux	2

**MATH41 HCC- VIII : MULTIVARIATE CALCULUS**

6 Credits

**Unit 1**

Functions of several variables, limit and continuity of functions of two or more variables

Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

**Unit 2**

Double integration over rectangular region, double integration over non-rectangular region, double integrals in polar co-ordinates, triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals.

**Unit 3**

Definition of vector field, divergence and curl.

Line integrals, applications of line integrals: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.

**Unit 4**

Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, the Divergence theorem.

**Reference Books**

- G. B. Thomas and R. L. Finney, Calculus, 9<sup>th</sup> Ed., Pearson Education, Delhi, 2005.
- M. J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3<sup>rd</sup> Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
- E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer(SIE), Indian reprint, 2005.

- James Stewart, Multivariable Calculus, Concepts and Contexts, 2<sup>nd</sup> Ed., Brooks/ Cole, Thomson Learning, USA, 2001.
- T. Apostol, Mathematical Analysis, Narosa Publishing House.
- Courant and John, Introduction to Calculus and Analysis, Vol II, Springer.
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
- Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
- Maity, K. C. and Ghosh, R. K. Vector Analysis, New Central Book Agency(P) Ltd. Kolkata (India).
- Terence Tao, Analysis II, Hindustan Book Agency, 2006.
- M. R. Spiegel, Schaum's outline of Vector Analysis.

## **MATH41 HCC-IX : RING THEORY AND LINEAR ALGEBRA 1**

6 Credits

### **Unit 1**

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristics of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

### **Unit 2**

Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients.

### **Unit 3**

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

### **Unit 4**

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

### **Reference Books**

- John B. Fraleigh, A First Course in Abstract Algebra, 7<sup>th</sup> Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2<sup>nd</sup> Ed., Pearson, 2011.
- Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4<sup>th</sup> Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4<sup>th</sup> Ed., Narosa Publishing House, New Delhi, 1999.
- S. Lang, Introduction to Linear Algebra, 2<sup>nd</sup> Ed., Springer, 2005.
- Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
- S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.

- Kenneth Hoffman, Ray Aiden Kunze, Linear Algebra, 2<sup>nd</sup> Ed., Prentice – Hall of India Pvt. Ltd., 1971.
- D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
- D. S. Malik, John M. Mordeson and M. K. Sen, Fundamentals of Abstract Algebra.

## **MATH41 HCC-X : METRIC SPACES AND COMPLEX ANALYSIS**

6 Credits

### **Unit 1**

Continuous mapping, sequential criterion and other characterizations of continuity. Uniform continuity. Connectedness, connected subsets of  $\mathbb{R}$ .

Compactness: Sequential compactness, Heine-Borel property, totally bounded spaces, finite intersection property and continuous functions on compact sets.

Homeomorphism. Contraction mappings. Banach fixed point theorem and its application to ordinary differential equation.

### **Unit 2**

Limits, limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings.

Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

### **Unit 3**

Analytic functions, examples of analytic functions, exponential function, logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula.

### **Unit 4**

Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

### **Unit 5**

Laurent series and its examples, absolute and uniform convergence of power series.

### **Reference Books**

- SatishShirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
- S. Kumaresan, Topology of Metric Spaces, 2<sup>nd</sup> Ed., Narosa Publishing House, 2011.
- G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

- James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8<sup>th</sup> Ed., McGraw – Hill International Edition, 2009.
- Joseph Bak and Donald J. Newman, Complex Analysis, 2<sup>nd</sup> Ed., Undergraduate texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
- S. Ponnusamy, Foundations of Complex analysis.
- E. M. Stein and R. Shakrachi, Complex Analysis, Princeton University Press.

## **MATH44 SE-II: GRAPH THEORY**

2 Credits

### **Unit 1**

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs, isomorphism of graphs. Trees and forests, paths and cycles.

### **Unit 2**

Eulerian circuits, Eulerian graph, semi-Eulerian graph, theorems, Hamiltonian cycles, theorems Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph.

### **Unit 3**

Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm. Connectivity, matching in bipartite graphs, matching in general graphs.

### **Reference Books**

- B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2<sup>nd</sup> Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
- Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2<sup>nd</sup> Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India Pvt. Ltd., New Delhi.
- Reinhard Diestel, Graph Theory, Springer-Verlag, 2000.

OR

## **MATH44 SE-II: OPERATING SYSTEM-LINUX**

2 Credits

### **Unit 1**

Linux – The operating system: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, overview of Linux architecture, installation, start up scripts, system processes (an overview), Linux security.

**Unit 2**

The Ext2 and Ext3 file systems: General characteristics of the Ext3 file system, file permissions. User management: types of users, the powers of root, managing users (adding and deleting): using the command line and GUI tools.

**Unit 3**

Resource management in Linux: file and directory management, system calls for files process Management, signals, IPC: Pipes, FIFOs, System V IPC, message queues, system calls for processes, memory management.

**Reference Books**

- Arnold Robbins, Linux Programming by Examples The Fundamentals, 2nd Ed., Pearson Education, 2008.
- Cox K, Red Hat Linux Administrator's Guide, PHI, 2009.
- R. Stevens, UNIX Network Programming, 3rd Ed., PHI, 2008.
- Sumitabha Das, UNIX Concepts and Applications, 4th Ed., TMH, 2009.
- Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, Linux in a Nutshell, 6th Ed., O'Reilly Media, 2009.
- Neil Matthew, Richard Stones, Alan Cox, Beginning Linux Programming, 3rd Ed., 2004.

**SEMESTER-5**

Subject Course No.	Syllabus Code	Course	Credit
MATH 51 HCC-XI	HCC-XI	Group TheoryII	5 + 1
MATH 51 HCC-XII	HCC-XII	Numerical Methods+Lab	4 + 2
MATH 52 DSE-I	DSE-I	Probability & Statistics/Linear Programming	5 + 1
MATH 52 DSE-II	DSE-II	Number Theory/Mechanics	5 + 1

**MATH51 HCC-XI: GROUP THEORY II**

6 Credits

**Unit 1**

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

**Unit 2**

Properties of external direct products, the group of units modulo  $n$  as an external direct product, internal direct products, Fundamental theorem of finite abelian groups.



**Unit 3**

Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem.

**Unit 4**

Groups acting on themselves by conjugation, class equation and consequences, conjugacy in  $S_n$ ,  $p$ -groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of  $A_n$  for  $n \geq 5$ , non-simplicity tests.

**Reference Books**

- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
- David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
- J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000.
- D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
- D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
- I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

**MATH51 HCC-XII – NUMERICAL METHODS**

4 Credits

**Unit 1**

Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

**Unit 2**

Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.

**Unit 3**

System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition.

**Unit 4**

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations, methods based on finite differences.

**Unit 5**

Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. midpoint rule, Composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula. The algebraic eigen value problem: Power method. Approximation: Least square polynomial approximation.

**Unit 6**

Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

**Reference Books**

- Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
- M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
- Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
- John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
- Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
- Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
- Yashavant Kanetkar, Let Us C , BPB Publications.

**NUMERICAL METHODS LAB (INTERNAL)**

2 Credits

List of practical (using any software)

1. Calculate the sum  $1/1 + 1/2 + 1/3 + 1/4 + \dots + 1/N$ .
2. Enter 100 integers into an array and sort them in an ascending order.
3. Solution of transcendental and algebraic equations by
  - i. Bisection method
  - ii. Newton Raphson method.
  - iii. Secant method.
  - iv. Regula Falsi method.

#### 4. Solution of system of linear equations

- i. LU decomposition method
- ii. Gaussian elimination method
- iii. Gauss-Jacobi method
- iv. Gauss-Seidel method

#### 5. Interpolation

- i. Lagrange Interpolation
- ii. Newton Interpolation

#### 6. Numerical Integration

- i. Trapezoidal Rule
- ii. Simpson's one third rule
- iii. Weddle's Rule
- iv. Gauss Quadrature

#### 7. Solution of ordinary differential equations

- i. Euler method
- ii. Modified Euler method
- iii. Runge Kutta method

## **MATH52 DSE-I: PROBABILITY & STATISTICS**

6 Credits

### **Unit 1**

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.

### **Unit 2**

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

### **Unit 3**

Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance, Markov chains, Chapman-Kolmogorov equations, classification of states.

**Unit 4**

Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis.

**Reference Books**

- Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
- Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7<sup>th</sup> Ed., Pearson Education, Asia, 2006.
- Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
- Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.
- A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers.

OR

**MATH52 DSE-I: LINEAR PROGRAMMING**

6 Credits

**Unit 1**

Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison.

**Unit 2**

Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

**Unit 3**

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

**Reference Books**

- Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
- F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
- Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
- G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

## **MATH52 DSE-II: NUMBER THEORY**

6 Credits

### **Unit 1**

Diophantine equation, Gaussian integers, Euclidean Algorithm for gcd, linear representation of gcd, primes and factorizations, consequences of unique prime factorization, linear Diophantine equation.

### **Unit 2**

Congruence arithmetic, inverse mod  $p$ , Fermat's little Theorem, congruence theorem of Wilson and Lagrange, inverse mod  $k$ , quadratic, Diophantine equations. Gaussian integers, Divisibility and primes in  $\mathbb{Z}[i]$  and  $\mathbb{Z}$ . Conjugates, division in  $\mathbb{Z}[i]$ , Fermat's two square theorem, Pythagorean triples.

### **Unit 3**

Linear congruence, Chinese remainder theorem, Euler's criterion, Legendre symbol, quadratic reciprocity.

### **Reference Books**

- Elements of Number Theory, John Stillwell, Springer, 2003.
- An introduction to theory of numbers, Niven and Zuckerman, Wiley 1991.
- David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
- Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

OR

## **MATH52 DSE-II: MECHANICS**

6 Credits

### **Unit 1**

Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work. Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium.

### **Unit 2**

Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium. Stability of nearly circular orbits. Motion under the inverse square law. Slightly disturbed orbits. Motion of artificial satellites. Motion of a particle in three dimensions. Motion on a smooth sphere, cone and on any surface of revolution.

### Unit 3

Degrees of freedom. Moments and products of inertia. Momental Ellipsoid. Principal axes. D'Alembert's principle. Motion about a fixed axis. Compound pendulum. Motion of a rigid body in two dimensions under finite and impulsive forces. Conservation of momentum and energy.

### Reference Books

1. I. H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4<sup>th</sup> Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
3. Chorlton, F., Textbook of Dynamics.
4. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.
5. Loney, S. L., Elements of Statics and Dynamics I and II.
6. Ghosh, M. C, Analytical Statics.
7. Verma, R. S., A Textbook on Statics, Pothishala, 1962.
8. Matiur Rahman, Md., Statics.
9. Ramsey, A. S., Dynamics (Part I).

### SEMESTER-6

Subject Course No.	Syllabus Code	Course	Credit
MATH 61 HCC-XIII	HCC-XIII	Ring Theory & Linear Algebra-II	5 + 1
MATH 61 HCC-XIV	HCC-XIV	Partial Differential Equations & Applications	5 + 1
MATH 62 DSE-III	DSE-III	Point Set Topology/Boolean Algebra & Automata Theory	5 + 1
MATH 62 DSE-IV	DSE-IV	Differential Geometry/Theory Of Equation	5 + 1

## **MATH61 HCC-XIII : RING THOERY & LINEAR ALGEBRA II**

6 Credits

### Unit 1

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in  $\mathbb{Z}[x]$ . Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains.

### Unit 2

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms.

### Unit 3

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator. Least squares approximation, minimal solutions to systems of linear equations. Normal and self-adjoint operators. Orthogonal projections and Spectral theorem.

#### Reference Books

- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
- Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
- S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
- Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
- S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
- Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
- S.H. Friedberg, A.L. Insel and L.E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., 2004.

## **MATH61 HCC-XIV: PARTIAL DIFFERENTIAL EQUATIONS & APPLICATIONS**

6 Credits

### Unit 1

Partial differential equations – Basic concepts and definitions. Mathematical problems. First-order equations: classification, construction and geometrical interpretation. Method of characteristics for obtaining general solution of quasi linear equations. Canonical forms of first-order linear equations. Method of separation of variables for solving first order partial differential equations.

### Unit 2

Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms.

### Unit 3

The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. Equations with non-homogeneous boundary conditions. Non-homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem

**Unit 4**

Central force. Constrained motion, varying mass, tangent and normal components of acceleration, modelling ballistics and planetary motion, Kepler's second law.

**Reference Books**

- Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
- S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
- Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill.
- Miller, F. H., Partial Differential Equations, John Wiley and Sons.
- Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.

**MATH62 DSE-III: POINT SET TOPOLOGY**

6 Credits

**Unit 1**

Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantor's Theorem. Cardinal numbers and cardinal arithmetic. Continuum Hypothesis, Zorns Lemma, Axiom of Choice. Well-ordered sets, Hausdorff's maximal principle. Ordinal numbers.

**Unit 2**

Topological spaces, basis and Sub basis for a topology, subspace topology, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of a set. Continuous functions, open maps, closed maps and homeomorphisms. Product topology, quotient topology, metric topology, Baire category theorem.

**Unit 3**

Connectedness. Distinguishing topological spaces via connectedness, intermediate value theorem, path connectedness, compact spaces, compact subspaces of the real line, limit point compactness.

**Reference Books**

- Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt.Ltd., New Delhi, 2000.
- Dugundji, J., Topology, Allyn and Bacon, 1966.
- Simmons, G.F., Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
- Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York, 1955.
- Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.



- Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970.
- Abhijit Dasgupta, Set Theory, Birkhäuser. I. H. Shames and G. Krishna Mohan Rao.
- Adams and Franzosa, Introduction to topology, Pearson 2008.

OR

## **MATH62 DSE-III: BOOLEAN ALGEBRA & AUTOMATA THEORY**

6 Credits

### **Unit 1**

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

### **Unit 2**

Definition, examples and properties of modular and distributive lattices, Boolean algebra, Boolean polynomials, minimal and maximal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Logic gates, switching circuits and applications of switching circuits.

### **Unit 3**

Introduction: Alphabets, strings and languages. Finite automata and regular languages: deterministic and non deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

### **Unit 4**

Context free grammars and pushdown automata: context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non deterministic PDA, properties of context free languages, normal forms, pumping lemma, closure properties, decision properties.

### **Unit 5**

Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

### **References Books**

- B. A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge 1990.
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2<sup>nd</sup> Ed.), Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.

- Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2<sup>nd</sup> Edition, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages and Computation, 2<sup>nd</sup> Ed., Addison-Wesley, 2001.
- H. R. Lewis, C. H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2<sup>nd</sup> Ed., Prentice-Hall, NJ, 1997.
- J. A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006.

## **MATH62 DSE-IV: DIFFERENTIAL GEOMETRY**

6 Credits

### **Unit 1**

Theory of space curves: Space curves. Planer curves, curvature, torsion and Serret-Frenet formula. Osculating circles, osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

### **Unit 2**

Theory of surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula. Conjugate and asymptotic lines.

### **Unit 3**

Developables: Developable associated with space curves and curves on surfaces. Minimal surfaces. Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

### **Reference Books**

- T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
- B. O'Neill, Elementary Differential Geometry, 2<sup>nd</sup> Ed., Academic Press, 2006.
- C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
- D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
- S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
- B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003

OR

## MATH62 DSE-IV: THEORY OF EQUATIONS

6 Credits

### Unit 1

General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.

### Unit 2

Symmetric functions. Applications of symmetric function of the roots. Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

### Unit 3

Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.

### Unit 4

Separation of the roots of equations, Strums theorem. Applications of Strum's theorem, conditions for reality of the roots of an equation. Solution of numerical equations.

### Reference Books

- W.S. Burnside and A.W. Panton, The Theory of Equations, Dublin University Press, 1954.
- C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.

**Prof. S. De Sarkar**  
**Chairman**  
**UG Board of Studies in Mathematics**  
**North Bengal University**

## ANEXURE

**For Generic Elective (GE) Course taken by students of Honours other than Mathematics Honours, any two of the following five (05) courses with credit (5+1) be chosen**

### **MATPGE1: Calculus, Geometry and DE**

6 Credits

#### **Unit 1**

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to the problems of the type  $e^{ax+b} \sin x$ ,  $e^{ax+b} \cos x$ ,  $(ax + b)^n \sin x$ ,  $(ax + b)^n \cos x$ , concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule.

#### **Unit 2**

Reduction formulae, derivations and illustrations of reduction formulae of the type  $\int \sin nx \, dx$ ,  $\int \cos nx \, dx$ ,  $\int \tan nx \, dx$ ,  $\int \sec nx \, dx$ ,  $\int (\log x)^n \, dx$ ,  $\int \sin^n x \cos^m x \, dx$ , parametric equations, parameterizing a curve arc length of a curve, arc length of parametric curves, area under a curve, area and volume of revolution.

#### **Unit 3**

Properties of conics, rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics.

#### **Unit 4**

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

## Reference Books

- G. B. Thomas and R. L. Finney, Calculus, 9<sup>th</sup> Ed., Pearson education, Delhi, 2005.
- M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, 3<sup>rd</sup> Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
- H. Anton, I. Bivens and S. Davis, Calculus, 7<sup>th</sup> Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
- S. L. Ross, Differential Equations, 3<sup>rd</sup> Ed., John Wiley and Sons, India, 2004.
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- G. F. Simmons, Differential Equations, Tata Mcgraw Hill.
- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and mathematical analysis.

## **MATPGE2: Algebra**

6 Credits

### Unit 1

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.

Theory of equations : relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation. Graphical representation of a polynomial and maximum, minimum of polynomial.

Inequality: The inequality involving  $AM \geq GM \geq HM$ , Cauchy-Schwartz inequality.

### Unit 2

Equivalence relations. Functions, composition of functions, Invertible functions, one to one correspondence and cardinality of a set. Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of mathematical induction, statement of Fundamental Theorem of Arithmetic.

### Unit 3

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation  $Ax=b$ , solution sets of linear systems, applications of linear systems, linear independence.

### Unit 4

Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of  $R^n$ , dimension of subspaces of  $R^n$ , rank of matrix, Eigen values, Eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

## Reference Books

- Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3<sup>rd</sup> Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
- David C. Lay, Linear Algebra and its Applications, 3<sup>rd</sup> Ed., Pearson Education Asia, Indian Reprint, 2007.
- K. B. Dutta, Matrix and linear algebra.
- K. Hoffman, R. Kunze, Linear algebra.
- W. S. Burnstine and A. W. Panton, Theory of equations.

## MATPGE3: DE and Vector Calculus

6 Credits

### Unit 1

Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian : its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

### Unit 2

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients,

Basic theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

### Unit 3

Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

### Unit 4

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

## Reference Books

- Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2<sup>nd</sup> Ed., Taylor and Francis group, London and New York, 2009.
- C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
- S. L. Ross, Differential Equations, 3<sup>rd</sup> Ed., John Wiley and Sons, India, 2004.
- Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3<sup>rd</sup> Ed., Elsevier Academic Press, 2004.

- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Diprima, Elementary Differential equations and boundary Value problems, Wiley.
- G. F. Simmons, Differential Equations, Tata McGraw Hill.
- Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
- Maity, K. C. and Ghosh, R. K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
- M. R. Spiegel, Schaum's outline of Vector Analysis.

### **MATPGE4: GROUP THEORY**

6 Credits

#### **Unit 1**

Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups.

#### **Unit 2**

Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

#### **Unit 3**

Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

#### **Unit 4**

External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

#### **Unit 5**

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems (Statement only).

#### **Reference Books**

- John B. Fraleigh, A First Course in Abstract Algebra, 7<sup>th</sup> Ed., Pearson, 2002.
- M. Artin, Abstract Algebra, 2<sup>nd</sup> Ed., Pearson, 2011.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4<sup>th</sup> Ed., Narosa Publishing House, New Delhi, 1999.
- Joseph J. Rotman, An Introduction to the Theory of Groups, 4<sup>th</sup> Ed., Springer Verlag, 1995.
- I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
- D. S. Malik, John M. Mordeson and M. K. Sen, Fundamentals of abstract algebra.

### **MATPGE5: Numerical Methods**

**Unit 1**

Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

**Unit 2**

Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.

**Unit 3**

System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.

**Unit 4**

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations, methods based on finite differences.

**Unit 5**

Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. midpoint rule, Composite trapezoidal rule, composite Simpson's 1/3rd rule.

**Unit 6**

Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two.

**Reference Books**

- Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
- M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
- C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
- Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.



- John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
- Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
- Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
- Yashavant Kanetkar, Let Us C , BPB Publications.

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