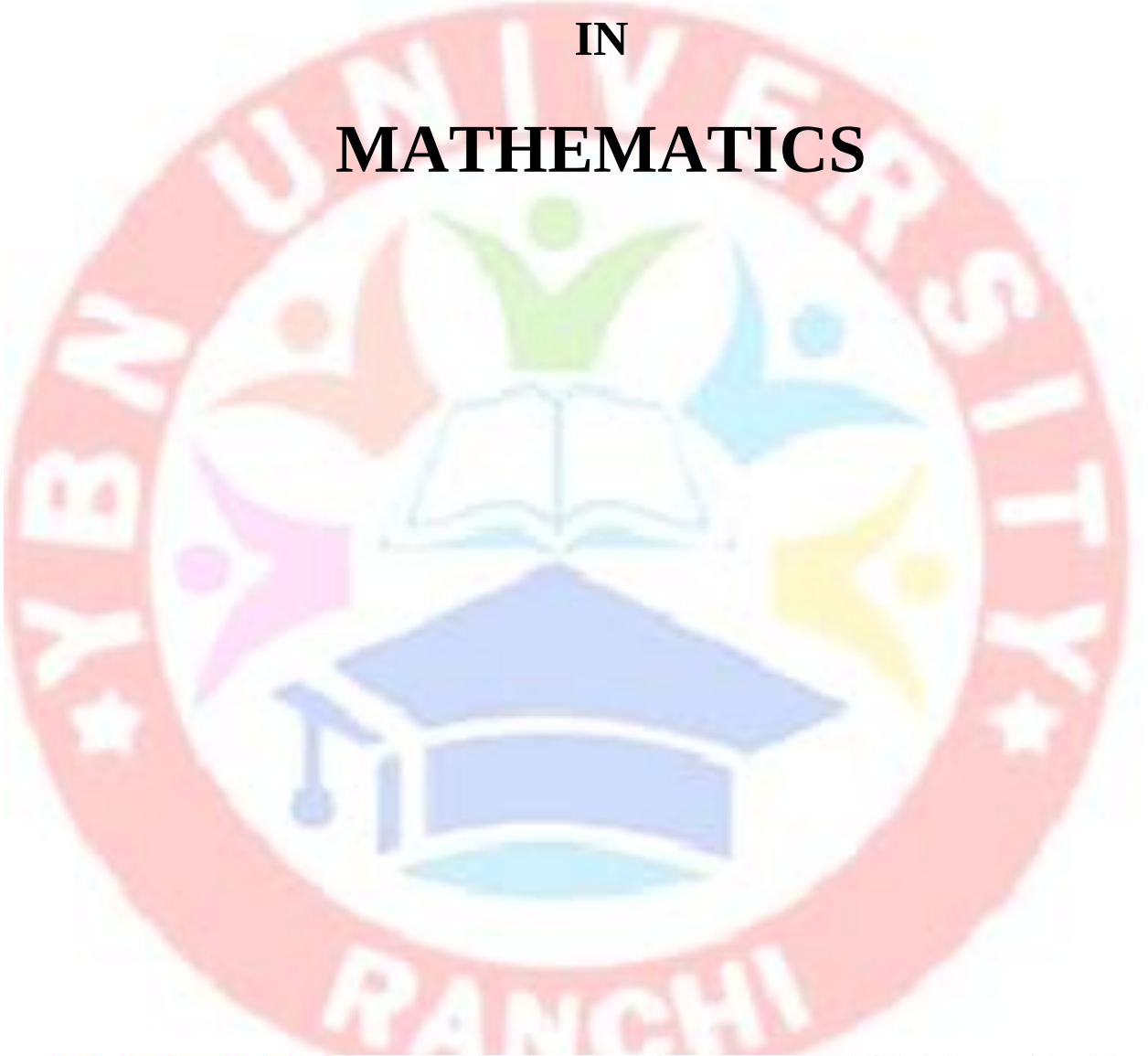
DEPARTMENT OF MATHEMATICS

Syllabus for Three Years Bachelor Degree Course
(Implemented from the Academic Year 2020 onwards)

CHOICE BASED CREDIT SYSTEM (CBCS)
SYLLABUS FOR BACHELOR IN SCIENCE
IN

MATHEMATICS



YBNUNIVERSITY

Established by the Act of Government of Jharkhand Act 15, 2017
Gazette Notification No. 505, Dated 17th July 2017
As per Section 2(f) of UGC Act. 1956

Scheme for Choice Based Credit System in B.Sc. (Hons.) Mathematics

Semester	Core Course (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
1	Calculus Algebra	AECC1			GE1
2.	Real Analysis Differential Equations	AECC2			GE2
3.	Theory of Real Functions Group Theory I PDE and Systems of ODE		SEC1		GE3
4.	Numerical Methods Riemann Integration and Series of Functions Ring Theory		SEC2		GE4
5.	Multivariate Calculus Group Theory II			DSE-1 DSE-2	
6.	Metric Spaces and Complex Analysis Linear Algebra			DSE-3 DSE-4	

Details of courses under B.Sc. (Hons.) Mathematics Course *Credits

	Theory + Practical	Theory + Tutorial
I. Core Course (14 Papers)	14×4 = 56	14×5 = 70
Core Course Practical / Tutorial* (14 Papers)	14×2 = 28	14×1 = 14
II. Elective Course (8 Papers)		
A.1. Discipline Specific Elective **(4 Papers)**	4×4 = 16	4×5 = 20
A.2. Discipline Specific Elective Practical/ Tutorial* **(4 Papers)**	4×2 = 8	4×1 = 4
B.1. Generic Elective/ Interdisciplinary **(4 Papers)**	4×4 = 16	4×5 = 20
B.2. Generic Elective Practical/ Tutorial* **(4 Papers)**	4×2 = 8	4×1 = 4

• Optional Dissertation or project work in place of one Discipline Specific Elective Paper (6 credits) in 6th Semester

III. Ability Enhancement Courses

1. **Ability Enhancement Compulsory Courses (AECC)** (2 Papers of 2 credit each) Environmental Science English/MIL Communication	2×2 = 4	2×2 = 4
2. Skill Enhancement Courses (SEC) (Minimum 2) (2 Papers of 4 credits each)	2×4 = 8	2×4 = 8
Total credit	144	144

Institute should evolve a system/ policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own.

*** wherever there is a practical there will be no tutorial and vice-versa**

Programme Objectives: Students, who choose B.Sc(Hons.) Mathematics, develop the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life. Pursuing a degree in mathematics will introduce the students to a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector, business sector and industry.

The programme covers the full range of mathematics, from classical Calculus tocomputer graphics. The course lays a structured foundation of Calculus, Real & Complex analysis, Abstract Algebra, Differential equations (including Mathematical modeling), Number theory, Graph theory, and C++ programming exclusively for mathematics.

An exceptionally broad range of topics covering Pure & Applied Mathematics: Linear Algebra, Metric spaces, Statistics, Linear Programming, Numerical Analysis, Mathematical Finance, Coding theory, Mechanics and Bio-Mathematics cater to varied interests and ambitions. Also hand on sessions in Computer lab using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima, R to have a deep conceptual understanding of the above tools are carried out to widen the horizon of students' self-experience

To broaden the interest for interconnectedness between formerly separate disciplines one can choose from the list of Generic.Skill enhancement Courses enable the student acquire the skill relevant to the main subject. Choices from Discipline Specific Electives provide the student with liberty of exploring his interests within the main subject.
Of key importance is the theme of integrating mathematical and professional skills. The well-structured programme empowers the student with the skills and knowledge leading to enhanced career opportunities in industry, commerce, education, finance and research.

Programme Learning Outcomes: The completion of the B.Sc(Hons.) Mathematics, Programme will enable a student to:

i) Communicate mathematics effectively by written, computational and graphic means
ii) Create mathematical ideas from basic axioms
iii) Gauge the hypothesis, theories, techniques and proofs provisionally
iv) Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis
v) Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research

Programme Structure: The B.Sc(Hons.) Mathematics, programme is a three-year, six-semester course. A student is required to complete 144 credits for completion of the course and award of degree

		Semester	Semester
Part-I	First Year	Semester I: 20	Semester II: 20
Part-II	Second Year	Semester III: 28	Semester IV: 28
Part-III	Third Year	Semester V: 24	Semester VI: 24

Semester wise Details of **B.Sc. (Hons.) Mathematics** Course & Credit Scheme

Semester	Core Course(14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)	Total Credits
I	1Y3MAT101: Calculus 1Y3MAT102: Algebra	1Y3MAT103: English Communication/MIL			1Y3MAT104: GE-1	
L+T/P	5+ 1 = 6 5 + 1 = 6	2			5+1 = 6	20
II	1Y3MAT 201: Real Analysis 1Y3MAT202: Differential Equations	1Y3MAT203: Environmental Science			1Y3MAT204: GE-2	
L+T/P	5+ 1 = 6 5 + 1 = 6	2			5+1 = 6	**20**
III	1Y3MAT301: Theory of Real Functions 1Y3MAT302: Group Theory-I 1Y3MAT303: PDE and Systems of ODE		1Y3MAT304: **(SEC -1)** Logic and Sets/ Computer Graphics		1Y3MAT305: (GE-3)	
L+T/P	5 + 1 = 6 5 + 1 = 6 5 + 1 = 6		**4**		5+1 = 6	**28**
IV	1Y3MAT401: Numerical Methods 1Y3MAT402: Riemann Integration and Series of Functions 1Y3MAT403: Ring Theory		1Y3MAT404: **(SEC- 2)** Graph Theory/ Operating System: Linux		1Y3MAT405: (GE-4)	
L+T/P	5 + 1 = 6 5 + 1 = 6 5 + 1 = 6		**4**		5+1 = 6	**28**
V	1Y3MAT501: Multivariate Calculus 1Y3MAT502: Group Theory-II			1Y3MAT503: **(DSE-1)** 1Y3MAT504: **(DSE-2)**		
L+T/P	5 + 1 = 6 5 + 1 = 6			5 + 1 = 6 5 + 1 = 6		**24**
VI	1Y3MAT601: Matric Space and Complex Analysis 1Y3MAT602: Linear Algebra-II			1Y3MAT603: **(DSE-3)** 1Y3MAT604 **(DSE-4)**		
L+T/P	5 + 1 = 6 5 + 1 = 6			5 + 1 = 6 5 + 1 = 6		**24**

Total Credits = 144

Legend: L: Lecture Class; T: Tutorial Class; P: Practical Class

Note: One-hour lecture per week equals 1 Credit, 2 Hours practical class per week equals 1 credit

List of Discipline Specific Electives (DSE) courses

DSE-1 (choose one)

1. Linear Programming
2. Number Theory
3. Analytical Geometry

DSE - 2 (choose one)

1. Cryptography and Network Security
2. Probability and Statistics
3. Discrete Mathematics

DSE - 3 (choose one)

1. Mathematical Finance
2. Introduction to Information Theory and Coding
3. Biomathematics

DSE - 4 (choose one)

1. Mechanics
2. C + + Programing for Mathematics
3. Finite element methods

List of Skill Enhancement Course (SEC)

SEC 1 (choose one)

1. Logic and Sets
2. Computer Graphics

SEC 2 (choose one)

1. Graph Theory
2. Computer Algebra and System related Software

Generic Electives (GE): All Four Papers of Any One Subject to be opted

Choices for GE 1

1. Mechanics +Lab
2. Atomic Structure, Bonding, General Org Chem & Aliphatic Hydrocarbons +Lab

Choices for GE 2

1. Electricity and Magnetism +Lab
2. Chemical Energetics, Equilibria & Functional Gp Org Chemistry-I +Lab

Choices for GE 3

1. Thermal & Statistical Physics +Lab
2. Chem. of s- and p-block elements, States of matter and Chem. Kinetics +Lab

Choices for GE 4

1. Waves and Optics +Lab
2. Chem. of d-block elements, Molecules of Life +Lab

Teaching:

The faculty of the Department is primarily responsible for organizing lecture work for BMH. The instructions related to tutorials are provided by the respective registering units under the overall guidance of the Department. Faculty from some other Departments and constituent colleges are also associated with lecture and tutorial work in the Department. There shall be 90 instructional days excluding examination in a semester.

Teaching Pedagogy:

Teaching pedagogy involving class room interactions, discussion, presentation etc. to be detailed out. The description should not be more than 300 words and could be both in general for all the courses and even for some particular papers requiring specific pedagogy like project work, group activities, or live projects. This section (for each paper) could include the class-wise/week-wise flow of the course.

Eligibility for Admissions:

Senior Secondary School Certificate Examination (Class XII) of the Central Board of Secondary Education or an examination recognized as equivalent thereto. 50% marks in Mathematics and an aggregate of 45% marks in the qualifying examination. (Relaxation will be given to the candidates belongin SC, ST and OBC category as per the University rules).

Specific Requirements:

The merit shall be determined on the basis of aggregate of marks obtained in Mathematics, one language paper and two best elective subjects under academic stream.

Assessment Tasks:

Comprising MCQs, Project work and presentations, design and production of course related objects, written assignments, open or closed book exams specifically designed to assess the Learning Outcomes. (Evidence of achieving the Outcomes).

Assessment of Students' Performance and Scheme of Examinations:

i) English shall be the medium of instruction and examination.

ii) ii) Assessment of students' performance shall consist of: (Point wise details of internal assessment and end semester examination, their weightage and scheme to be given)

Pass Percentage & Promotion Criteria: As per University Examination rule.

Part to Part Progression: As per University Examination rule

Conversion of Marks into Grades: As per University Examination rule

Grade Points: Grade point table as per University Examination rule

CGPA Calculation: As per University Examination rule.
SGPA Calculation: As per University Examination rule

Grand SGPA Calculation: As per University Examination rule

Conversion of Grand CGPA into Marks: As per University Examination rule

Division of Degree into Classes: As per University Examination rule

Attendance Requirement: As per University Examination rule

Guidelines for the Award of Internal Assessment Marks BMH Programme (Semester Wise)

Mention the components of Internal Assessment and the scheme for awarding marks for students' attendance)

1. That 10% (of the maximum marks) weightage be assigned to House Examination / class test in each paper (two best out of three)
2. That 20% (of the maximum marks) weightage be assigned to mid-term examination.
3. That 5% (of the maximum marks) weightage be given for regularity in attending lectures and tutorials. That the credit for regularity in each paper, based on attendance shall be as follows:

The percentage of attendance in a paper

I. More than 67% but less than 70% - 1 mark
II. II. 70 or more but less than 75% - 2 marks
III. III. 75 or more but less than 80% - 3 marks
IV. IV. 80 or more but less than 85% - 4 marks
V. V. 85 and above - 5 marks

SEMESTER-I

1Y3MAT101: Calculus

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion, design of telescope and to the real-world problems. Also, to carry out the hand on sessions in computer lab to have a deep conceptual understanding of the above tools to widen the horizon of students' self-experience.

Course Learning Outcomes: This course will enable the students to:

i) Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.

ii) Apply derivatives in Optimization, Social sciences, Physics and Life sciences etc.

iii) Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

Course Contents:

UNIT - I

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type eax+bsinx, eax+bcosx, (ax+b)nsinx, (ax+b)ncosx, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule. (2 questions)

UNIT - II

Reduction formulae, derivations and illustrations of reduction formulae of the type
∫sinnx dx, ∫cosnx dx, ∫tannx dx, ∫sinnx cosmx dx, ∫sin mx cos nx dx, ∫ (log x)n dx, parametric equations,parameterizing a curve, arc length, arc length of parametric curves, volume and area of surface of revolution. (2 questions)

UNIT - III

Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

(1 questions)

UNIT - IV

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration. (2 questions)

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), SpringerVerlag, New York, Inc., 1989.

1Y3MAT102: Algebra

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems. Perform matrix algebra with applications to Computer Graphics.

Course Learning Outcomes: This course will enable the students to:

i) Employ De Moivre's theorem in a number of applications to solve numerical problems.
ii) Apply Euclid's algorithm and backwards substitution to find greatest common divisor.
iii) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
iv) Find eigenvalues and corresponding eigenvectors for a square matrix.

Course Contents:

UNIT - I

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications, logarithmic of complex numbers. (2 questions)

UNIT - II

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.

(2 questions)

UNIT - III

Rank of a matrix, row and column rank of a matrix, vector space and subspace, theorem of subspaces, Rn space and its subspaces, basis and dimension of subspaces of Rn, system of linear equations Ax=B, Consistency of the system Ax=B, Set of Solutions of Ax=0, invertible matrices and Characterizations of invertible matrices, Characteristic polynomial of a matrix, Eigen values and Eigen vectors of a matrix, Linear transformations and their matrix representation, transition matrices.

(3 questions)

Books Recommended

1. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to Z*, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

SEMESTER-II

1Y3MAT201: Real Analysis

Course Objectives: The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts has vide range of applications in real life scenario.

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line and learn to define sequence in terms of functions from to a subset of.

ii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

iii) Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Contents:

UNIT - I

Review of Algebraic and Order Properties of R, δ -neighborhood of a point in R, Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R, The Archimedean Property, Density of Rational (and Irrational) numbers in R, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

(1 questions)

UNIT - II

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. 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. (2 questions)

UNIT - III

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Raabe,s test, DeMorgan's and Bertrand's test, Alternating series, Leibniz test, Absolute and Conditional convergence, Kummer's test, logarithmic ratio test.

(4 questions)

Books Recommended

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis*, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, *Elementary Real Analysis*, Prentice Hall, 2001.
4. S.K. Berberian, *A First Course in Real Analysis*, Springer Verlag, New York, 1994.

1Y3MAT202: Differential Equation

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of Differential Equations, Mathematical Modeling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Formulate Differential Equations for various Mathematical models.
ii) Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.
iii) Apply these techniques to solve and analyze various mathematical models.

Course Contents:

UNIT - I

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order and higher degree equations solvable for x, y, p. Clairaut's form, singular solutions, general solution. Second order linear differential equation with constant coefficient.

(2 questions)

UNIT - II

General solution of second order linear homogeneous and non-homogeneous equations, linear homogeneous and non-homogeneous equations of higher order with constant coefficients, The Cauchy-Euler equation. Second order linear differential equations with variable coefficients.

(2 questions)

UNIT -III

Power series solution of a differential equation about an ordinary point, solution about a regular Singular point, Bessel's equation and Legendre's equation, recurrence formulae, orthogonal properties, generating function. (2 questions)

UNIT IV

Laplace transform and inverse transform, properties, application to initial value problem up to second order ODE. (1 questions)

Books Recommended

1. Ordinary and partial differential equation, M.D. Raisinghania, S.Chand and Company limited, 2006.
2. Integral transform, A.R.Vashistha, krishna Publication.
3. C.H. Edwards and D.E. Penny, *Differential Equations and Boundary Value problems Computing and Modeling*, Pearson Education India, 2005.
4. S.L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, India, 2004.
5. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004

SEMESTER-III

1Y3MAT301: Theory of Real Functions

Course Objectives: It is a basic course on the study of real valued functions that would develop an analytical ability to have a more matured perspective of the key concepts of calculus, namely, limits, continuity, differentiability and their applications.

Course Learning Outcomes: This course will enable the students to learn:

i) To have a rigorous understanding of the concept of limit of a function.

ii) The geometrical properties of continuous functions on closed and bounded intervals.

iii) The applications of mean value theorem and Taylor's theorem.

Course Contents:

UNIT - I

Limits of functions sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity, Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem. Uniform continuity, non- uniform continuity criteria, uniform continuity theorem. (3 questions)

UNIT - II

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, Taylor's theorem to inequalities.

(2 questions)

UNIT - III

Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1 + x)$, $1/ax+b$ and $(1 +x)n$. (2 questions)

Books Recommended:

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, John Wiley and Sons, 2003.
2. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004.
3. A. Mattuck, *Introduction to Analysis*, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis*, Springer, 2006.

1Y3MAT302: Group Theory- I

Course Objectives: The objective of the course is to introduce the fundamental theory of groups and their homomorphisms. Symmetric groups and group of symmetries are also studied in detail. Fermat's Little theorem as a consequence of the Lagrange's theorem on finite groups.

Course Learning Outcomes: The course will enable the students to:

i) Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.;
ii) Link the fundamental concepts of Groups and symmetrical figures.
iii) Analyze the subgroups of cyclic groups.
iv) iv) Explain the significance of the notion of cosets, normal subgroups, and factor groups

Course Contents:

UNIT - I

Symmetries of a square, Dihedral groups, definition and examples of groups, abelian groups, permutation groups, Cycle notation for permutations, even and odd permutations, quaternion group and its matrix representation, elementary properties of groups. (1 questions)

Order of a group element and order of a group, Subgroups and examples and theorems on subgroups, normal subgroups and their properties, centralizer (normalizer) of a group element, centre of a group. (2 questions)

UNIT - II

Properties of cyclic groups, classification of subgroups of cyclic groups. Cosets and their properties, Lagrange's theorem and consequences including Fermat's Little theorem. Group homomorphism, kennel of homomorphism, properties of homomorphism. (2 questions)

UNIT - III

factor groups (quotient groups), Cauchy's theorem for finite abelian groups; Group isomorphism, properties of isomorphisms, First, Second and Third isomorphism theorems, Cayley theorem. External direct product of a finite number of groups. (2 questions)

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, *An Introduction to the Theory of Groups*, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.

1Y3MAT303: Systems of ODE and ODE

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

Course Learning Outcomes: The course will enable the students to:

i) Formulate, classify and transform partial differential equations into canonical form.

ii) ii) Solve linear and non-linear partial differential equations using various methods; and apply these methods in solving some physical problems.

Course Contents:

UNIT - I

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. (1 questions)

UNIT - II

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, Lagrange's equation, Method of Separation of Variables for solving first order partial differential equations (3 questions)

UNIT - III

Classification of second order linear equations as hyperbolic, parabolic and elliptic. Reduction of second order Linear Equations to canonical forms. (1 questions)

UNIT - IV

Nonlinear partial differential equation, standard forms I, II,III and IV, Charpit's method, Monge's method to solve equation of the form $Rr + Ss + Tt = V$ (2 questions)

Books Recommended:

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers,* 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, *Differential equations,* 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA,* 3rd Ed., Elsevier Academic Press, 2004.

1Y3MAT304A: Logic and Sets

Course Objectives :This course is designed to expand an understanding in the fundamental concepts of logic and set theory. After completing this course, the student will have a better understanding of logic and should be able to apply the knowledge to everyday matters.

Course Learning Outcomes: Upon completion of this course, the student should be able to:

(i) Properly use the vocabulary and symbolic notation of higher mathematics in definitions, theorems, and problems

(ii) Analyze the logical structure of statements symbolically, including the proper use of logical connectives, predicates, and quantifiers.

(iii) Construct truth tables, prove or disprove a hypothesis, and evaluate the truth of a statement using the principles of logic.

UNIT – I

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. (2 questions)

UNIT - II

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. countability of a set. (3 questions)

UNIT - II

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,equivalence relations, Partial ordering relations, n-ary relations, lattices. (2 questions)

Books Recommended:

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
2. P.R. Halmos, Naive Set Theory, Springer, 1974. 3. E. Kamke, Theory of Sets, Dover Publishers, 1950.

1Y3MAT304B: Computer Graphics

Course Objectives : This course is designed to Understand the need of developing graphics application.

Course Learning Outcomes: Upon completion of this course, the student should be able to:

(i) Understand the basics of computer graphics, different graphics systems and applications of computer graphics

(ii) Use of geometric transformations on graphics objects and their application in composite form.

UNIT - I

Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices.

(3 questions)

UNIT - II

Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. (2 questions)

UNIT III

Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

(2 questions)

Books Recommended:

1. D. Hearn and M.P. Baker, Computer Graphics, 2nd Ed., Prentice–Hall of India, 2004.
2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, Computer Graphics: Principals and Practices, 2nd Ed., Addison-Wesley, MA, 1990.
3. D.F. Rogers, Procedural Elements in Computer Graphics, 2nd Ed., McGraw Hill Book Company, 2001.
4. D.F. Rogers and A.J. Admas, Mathematical Elements in Computer Graphics, 2nd Ed., McGraw Hill Book Company, 1990.

SEMESTER IV

1Y3MAT401: Numerical Methods

Course Objectives: To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations, to find the approximate solutions of system of linear equations and ordinary differential equations. Also, the use of Computer Algebra System (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem solving skills.

Course Learning Outcomes: The course will enable the students to learn the following:

i) Some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.

ii) Interpolation techniques to compute the values for a tabulated function at points not in the table.

iii) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

Course Contents:

UNIT - I

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton-Raphson method, Secant method and their rate of convergence. (1 questions)

UNIT - II

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method. (1 question)

Interpolation: Calculus of finite difference operators, Newton's Gregory forward and backward difference interpolation. Lagrange and Newton interpolation formula for unequal intervals.

(2 questions)

UNIT - III

Numerical differentiation, Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Boole's Rule, Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

(2 questions)

Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.

(1 question)

Books Recommended:

1. Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.
2. 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.
3. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008.
4. Uri M. Ascher and Chen Greif, *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited, 2013.
5. John H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited, 2012.

1Y3MAT402: Riemann Integration and Series of Functions

Course Objectives: To understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration. The sequence and series of real valued functions, and an important class of series of functions (i.e., power series).

Course Learning Outcomes: The course will enable the students to learn about:

i) Some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.

ii) Beta and Gamma functions and their properties.

iii) The valid situations for the inter-changeability of differentiability and integrability with infinite sum, and approximation of transcendental functions in terms of power series.

Course Contents

UNIT - I

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. (1 question)

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 theorems of Calculus.

(3 questions)

UNIT - II

Improper integrals and their convergence, μ −test, Dirichlets and abel's tests, Convergence of Beta and Gamma functions. (2 questions)

UNIT - III

Limit superior and Limit inferior. Power series, radius of convergence. (1 question)

Books Recommended:

1. K.A. Ross, *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

1Y3MAT403: Ring Theory

Course Objectives: The objective of this course is to introduce the fundamental theory of - rings and their corresponding homomorphisms.

Course Learning Outcomes: The course will enable the students to learn about:
i). The fundamental concept of Rings, Fields, subrings the corresponding morphisms.

Course Contents

UNIT - I

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring, Ideals, ideal generated by a subset of a ring, factor rings, prime and maximal ideals, principal ideal domain. (3 questions)

UNIT - II

Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems, field of quotients. (2 questions)

UNIT - III

Polynomial rings over commutative rings, division algorithm and consequences, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion,unique factorization in Z[x]. Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains (2 questions)

Books Recommended

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

1Y3MAT404A: Graph Theory

Course Objectives: The main objective of this course is to teach students how to model physical problems using differential equations and solve them. Also, the use of Computer Algebr Systems (CAS) by which the listed problems can be solved both numerically and analytically.

Course Learning Outcomes: The course will enable the students to learn the following

i.) The use of mathematics software to observe the implementations of the above mentioned methods efficiently, and to enhance the problem solving skills.

ii.) To solve physical problems using differential equations.

UNIT - I

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs. (2 questions)

UNIT - II

Eulerian circuits, Eulerial graph, semi-Eulerian graph, theorems, Hamiltonian cycles,theorems (2 questions)

Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph, (1question)

UNIT – III

Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm (2 questions)

Books Recommended:

1. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

1Y3MAT404B: Computer Algebra Systems and Related Software

Course Objectives: This course aims at familiarizing students with the usage of computer algebra systems (/Mathematica/MATLAB/Maxima/Maple) and the statistical software **R**. The basic emphasis is on plotting and working with matrices using CAS. Data entry and summary commands will be studied in **R**. Graphical representation of data shall also be explored.

Course Learning Outcomes: This course will enable the students to:

i) Use CAS as a calculator, for plotting functions, animations and various applications of matrices.

ii) Understand the use of the software **R** for entry, summary calculation, pictorial representation of data and exploring relationship between data.

iii) Analyze, test, and interpret technical arguments on the basis of geometry.

UNIT - I

Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and ContourPlot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

UNIT - II

Simple programming in a CAS, Working with matrices, Performing Gauss elimination,operations (transpose, determinant, inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue,eigenvector and diagonalization.

UNIT-III

R as a calculator, Explore data and relationships in R. Reading and getting data into R:Combine and scan commands, Types and structure of data items with their properties.Manipulating vectors, Data frames, Matrices and lists. Viewing objects within objects.Constructing data objects and conversions.

UNIT-IV

Summary commands: Summary statistics for vectors, Data frames, Matrices and lists. Summary tables. Stem and leaf plot, Histograms. Plotting in R: Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and bar charts. Copy and save graphics to other applications.

Books Recommended:

1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice,*
2. Torrence, Bruce F., & Torrence, Eve A. (2009). *The Student's Introduction to Mathematica®: A Handbook for Precalculus, Calculus, and Linear Algebra* (2nd ed.). Cambridge University Press.

SEMESTER V

1Y3MAT501: Multivariate Calculus

Course Objectives: To understand the extension of the studies of single variable differential and integral

calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.

Course Learning Outcomes: This course will enable the students to learn:

i) The conceptual variations when advancing in calculus from one variable to multivariable discussions.
ii) Inter-relationship amongst the line integral, double and triple integral formulations.
iii) Applications of multi variable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

UNIT - I

Functions of several variables, limit and continuity of functions of two variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Extrema of functions of two variables, method of Lagrange multipliers,

(2 questions)

UNIT - II

Double and triple integrals, change of order of integration, surface area by double integral and Volume by triple integrals. (2 questions)

UNIT - III

The gradient, divergence and curl. Line integrals, surface integral, Green's theorem,. Stoke's theorem and Gauss theorem (3 questions)

Books Recommended:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus*, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE), Indian reprint, 2005.
4. James Stewart, *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

1Y3MAT502: Group Theory II

Course Objectives: The course will develop an in-depth understanding of one of the most important branch of the abstract algebra with applications to practical real-world problems.Classification of all finite Abelian groups (up to isomorphism) can be done.

Course Learning Outcomes: The course shall enable students to learn about:

i) Automorphisms for constructing new groups from the given group.
ii) External direct product 22ZZ applies to data security and electric circuits.
iii) Group actions, Sylow theorems and their applications to check nonsimplicity.

UNIT - I

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. (3 questions)

UNIT - II

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.

(2 questions)

UNIT - III

Class equation and consequences, conjugacy in Sn, p-groups, Sylow's 1st , 2nd and 3rd theorems.

(2 questions)

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.
4. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, *Modern Algebra*, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

1Y3MAT503A: Linear Programming Problems

1. **Course Objectives:** This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear

Programming with applications to Transportation, Assignment and Game Problem. Such problems arise in manufacturing resource planning and financial sectors.

Course Learning Outcomes: This course will enable the students to learn:

i) Analyze and solve linear programming models of real life situations.

ii) The graphical solution of LPP with only two variables, and illustrate the concept of convex set and extreme points. The theory of the simplex method is developed.

iii) The relationships between the primal and dual problems and their solutions with applications to transportation, assignment and two-person zero-sum game problem.

UNIT - I

Introduction to linear programming problem, convex sets and their properties, Graphical method, Theory of simplex method, optimality and unboundedness, the simplex method, introduction to artificial variables, two-phase method, Big-M method. (3 questions)

UNIT - II

Duality, formulation of the dual problem, primal-dual relationships. (1 question)

Transportation problem and its mathematical formulation, northwest-corner method, lowest cost entry method and Vogel's approximation method for determination of starting basic solution, optimality test, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

(2 questions)

UNIT - III

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure. (2 questions)

Books Recommended

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

1Y3MAT503B: Number Theory

Course Objectives: In number theory there are challenging open problems which are comprehensible at undergraduate level, this course is intended to build a micro aptitude of understanding aesthetic aspect of mathematical instructions and gear young minds to ponder upon such problems. Also, another objective is to make the students familiar with simple number theoretic techniques, to be used in data security.

Course Learning Outcomes: This course will enable the students to learn:

i) Some of the open problems related to prime numbers, viz., Goldbach conjecture etc.
ii) About number theoretic functions and modular arithmetic.
iii) Public crypto systems, in particular, RSA.

UNIT - I

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem. (3 questions)

UNIT - II

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function. (2 questions)

UNIT - III

Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli . (2 questions)

Books Recommended

1. David M. Burton, *Elementary Number Theory,* 6th Ed., Tata McGraw-Hill, Indian reprint, 2007.
2. Neville Robinns, *Beginning Number Theory,* 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

1Y3MAT503C: Analytical Geometry

Course Objectives: The aim of this course is to introduce the geometry of lines and conics in the Euclidean plane. Students can develop geometry with a degree of confidence and will gain fluency in the basics of Euclidean geometry. In this course, foundational mathematical training is also pursued.

Course Learning Outcomes: This course will enable the students to learn:

i) how to parametrize curves.

ii) to evaluate the distance and angle
iii) to identify conic section
iv) to determine congruent conics

UNIT - I

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola. Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.

(4 questions)

UNIT - II

Spheres, cone, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid. (3 questions)

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd. 2002.
3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.
4. R.J.T. Bill, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

1Y3MAT504A: Cryptography and Network Security

Course Objectives: This course helps the students to develop skills and knowledge of standard concepts in cryptography and demonstrates how cryptography plays an important role in the present digital world by knowing encryption and decryption techniques and secure data in transit across data networks.

Course Learning Outcomes: After the course, the student will be able to:

i) Understand the fundamentals of Cryptography and Network Security, including dataand advanced encryption standard (DES & AES), RSA and elliptic curve cryptography.

ii) Encrypt and decrypt messages using block ciphers, sign and verify messages using well known signature generation and verification algorithms.

iii) Acquire knowledge of standard algorithms that can be used to provide confidentiality, integrity and authentication of data.

UNIT - I

Overview of Cryptography, Computer security concepts, Security attacks, Symmetric cipher model, Cryptanalysis and brute-force attack, Substitution techniques, Caesar cipher,Monoalphabetic ciphers, Playfair cipher, Hill cipher, Polyalphabetic ciphers, One-time pad,Transposition techniques, Binary and ASCII, Pseudo-random bit generation, Stream cipher sand Block ciphers, The Feistal cipher, The data encryption standard (DES), DES example.

(2 questions)

UNIT – II

Review of basic concepts in Number theory and Finite Fields**:** Divisibility, Polynomial and modular arithmetic, Fermat's and Euler's theorems, The Chinese remainder theorem, Discrete logarithm., Finite fields of the form GF(*p*) and GF(2n). Advanced encryption standard (AES), AES transformation functions, AES key expansion, AES example.

Principles of public-key cryptosystems, The RSA algorithm and security of RSA, Elliptic curve arithmetic, Elliptic curve cryptography, Cryptographic Hash functions, Secure Hash algorithm.

(3 questions)

UNIT - III

Digital signatures, Elgamal and Schnorr digital signature schemes, Digital signature algorithm. Wireless network and mobile device security, Email architecture, formats, threats and security Secure/Multipurpose Internet Mail Extension (S/MIME) and Pretty Good Privacy (PGP).

(2questions)

Books Recommended

1. Stallings, William (2017). Cryptography and Network Security, Principles and Practice (7th ed.). Pearson Education Limited. England.Goodaire, Edgar G., & Parmenter, Michael M. (2011). Discrete Mathematics with graph theory (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.
2. Trappe, Wade & Washington, Lawrence C. (2006). Introduction to Cryptography with Coding Theory (2nd ed.). Pearson Education International.
3.

1Y3MAT503B: Probability and Statistics

Course Objectives: To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness. The course intends to render the students to several examples and exercises that blend their everyday experiences with their scientific interests.

Course Learning Outcomes: This course will enable the students to learn:

i) Distributions to study the joint behavior of two random variables.

ii) To establish a formulation helping to predict one variable in terms of theother,i.e.,correlation and linear regression.

iii) Central limit theorem, which helps to understand the remarkable fact that the empiricalfrequencies of so many natural populations, exhibit a bell shaped curve.

UNIT - I

Sample space, Probability set function, Real random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions, Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function. (3 questions)

UNIT - II

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric andPoisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution. (2 questions)

UNIT - III

The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers. (2 questions)

Books Recommended:

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

1Y3MAT503C: Discrete Mathematics

Course Objectives: This course aims at introducing the concepts of lattices, Boolean algebras, switching circuits and graph theory. The course discusses some important applications of Boolean algebra and graph theory in real life situations through switching circuits and shortest path algorithms.

Course Learning outcomes: After the course, the student will be able to understand the

concepts of:

i) Lattices and their types;
ii) Boolean algebra, switching circuits and their applications;
iii) Graphs, their types and its applications in study of shortest path algorithms.

UNIT - I

Definitions, Examples and basic properties of ordered sets, Order isomorphism, Hasse diagrams, Dual of an ordered set, Duality principle, Maximal and minimal elements, Building new ordered sets, Maps between ordered sets.

Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, Examples and properties of modular and distributive lattices,

(3 questions)

UNIT - II

The M3 – N5 Theorem with applications, Complemented lattice, Relatively complemented lattice, Sectionally complemented lattice.

Boolean Algebras, De Morgan's laws, Boolean homomorphism, Representation theorem;Boolean polynomials, Boolean polynomial functions, Disjunctive normal form and conjunctive normal form, Minimal forms of Boolean polynomial, Quinn-McCluskey method, Karnaugh diagrams, Switching circuits and applications of switching circuits. (2 questions)

UNIT - III

Introduction to graphs, Konigsberg Bridge problem, Instant insanity game; Definition, examples and basic properties of graphs, Subgraphs, Pseudographs, Complete graphs, Bipartite graphs,Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles,Adjacency matrix, Weighted graph, Travelling salesman problem, Shortest path, Dijkstra'salgorithm. (2 questions)

Books Recommended

1. Davey, B. A., & Priestley, H. A. (2002). Introduction to lattices and order (2nd ed.). Cambridge University press, Cambridge.
2. Goodaire, Edgar G., & Parmenter, Michael M. (2011). Discrete Mathematics with graph theory (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.
3. Rosen, Kenneth H. (2012). Discrete Mathematics and its applications, with combinatorics and graph theory. (7th ed.). McGraw Hill Education. Indian Reprint.

1Y3MAT601: Metric Spaces and Complex Analysis

Course Objectives: This course aims to demonstrate an understanding of metric spaces by proving unseen results using the methods of the course and explain their reasoning about rigorous Analysis clearly and precisely, using appropriate technical language. Also this course aims to introduce the basic ideas of

analysis for complex functions in complex variables with visualization through relevant practicals. Particularemphasis has been laid on Cauchy's theorems, series expansions and calculation of residues.

The completion of the course will enable the students to:

i) Understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.
ii) Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.
iii) Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities,

UNIT - I

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's intersection theorem. Subspaces.

(2 questions)

UNIT - II

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem.

(1 questions)

UNIT - III

Geometry of complex numbers, regions in the complex plane, Limits and continuity of functions of complex variable, Derivatives, Necessary and sufficient conditions for differentiability.

(1 questions)

UNIT - IV

Analytic functions, examples of analytic functions, Cauchy-Riemann equations, exponential function, Logarithmic function, trigonometric function, derivatives of functions, bilinear transformation, cross ratio, conformal mapping. (3 questions)

Books Recommended

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces*, Springer Verlag, London, 2006.
2. S. Kumaresan, *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications*, 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, *Complex Analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

1Y3MAT602: Linear Algebra

Course Objectives: The objective of this course is to introduce the fundamental theory of two objects, namely - rings and vector spaces, and their corresponding homomorphisms.

Course Learning Outcomes: The course will enable the students to learn about:

i) The concept of linear independence of vectors over a field, the idea of a finite dimensional vector space, basis of a vector space and the dimension of a vector space

ii) Basic concepts of linear transformations, the Rank-Nullity Theorem, matrix of a linear transformation, algebra of transformations and the change of basis.

UNIT - I

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces, theorems. Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations.

(3 questions)

UNIT – II

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. (2 questions)

UNIT - III

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, minimal solutions to systems of linear equations, Normal and self-adjoint operators (2questions)

Books Recommended

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

1Y3MAT603A: Mathematical Finance

Course Objectives: This course is an introduction to the application of mathematics in financial world, that enables the student to understand some computational and quantitative techniques required for working in the financial markets and actuarial mathematics.

Course Learning outcomes: In this course, the student will learn the basics of:

i) Financial markets and derivatives including options and futures.

ii) Pricing and hedging of options, interest rate swaps and no-Arbitrage pricing concept.

iii) Stochastic analysis (Ito formula and Ito integration) and the Black-Scholes model.

UNIT - I

Interest rates, Types of rates, Measuring interest rates, Zero rates, Bond pricing, Forward rate, Duration, Convexity, Exchange traded markets and OTC markets, Derivatives—Forward contracts, Futures contract, Options, Types of traders, Hedging, Speculation, Arbitrage.

(2 questions)

UNIT - II

No Arbitrage principle, Short selling, Forward price for an investment asset, Types of Options, Option positions, Underlying assets, Factors affecting option prices, Bounds on option prices, Put-call parity, Early exercise, Effect of dividends. (2 questions)

Binomial option pricing model, Risk neutral valuation (for European and American options on assets following binomial tree model), Lognormal property of stock prices, Distribution of rate of return, expected return, Volatility, estimating volatility from historical data, Extension of risk neutral valuation to assets following GBM, Black-Scholes formula for European options.

(1 questions)

UNIT - III

Hedging parameters (the Greeks: Delta, Gamma, Theta, Rho and Vega), Trading strategies involving options, Swaps, Mechanics of interest rate swaps, Comparative advantage argument,Valuation of interest rate swaps, Currency swaps, Valuation of currency swaps.

(2 questions)

Books Recommended

1. Hull, J. C., & Basu, S. (2010). Options, Futures and Other Derivatives (7th ed.). Pearson Education. New Delhi.

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1Y3MAT603B: Introduction to Information Theory and Coding

Course Objectives: This course aims to introduce the basic aspects of Information Theory and Coding to the students. Shannon's work form the underlying theme for the present course. Construction of finite fields and bounds on the parameters of a linear code discussed.

Course Learning Outcomes: This course will enable the students to learn:

i) The output of the channel, a received signal is observed.

ii) The detection &correction of errors while transmission.

iii) Representation of a linear code by matrices and its encoding and decoding.

UNIT - I

Communication processes, A model of communication system, A quantitative measure of information, Binary unit of information, A measure of uncertainty, H function as a measure of uncertainty, Sources and binary sources, Measure of information for two-dimensional discrete finite probability schemes. (2 questions)

UNIT – II

A sketch of communication network, Entropy, Basic relationship among different entropies,A measure of mutual information, Interpretation of Shannon's fundamental inequalities; Redundancy, Efficiency and channel capacity, Binary symmetric channel, Binary erasure channel, Uniqueness of the entropy function, Joint entropy and conditional entropy, Relative entropy and mutual information, Chain rules for entropy, Conditional relative entropy and conditional mutualinformation, Jensen's inequality and its characterizations, The log sum inequality and its applications. (2 questions)

UNIT – III

Block codes, Hamming distance, Maximum likelihood decoding, Levels of error handling, Error correction, Error detection, Erasure correction, Construction of finite fields, Linear codes, Matrix representation of linear codes. (2 questions)

Orthogonality relation, Encoding of linear codes, Decoding of linear codes, The singleton bound and maximum distance separable codes, The sphere-packing bound and perfect codes, The Gilbert-Varshamov bound, MacWilliams' identities. (1 questions)

Books Recommended:

1. B. D. Sharma and M. R. Hassan, "Hydrostatics", Kedar Nath Ram Nath, Meerut, 2018.
2. S.L.Loni, "An Introduction to Hydrostatics

1Y3MAT603C: Biomathematics

Course Objectives: The focus of the course is on scientific study of normal functions in living systems. The emphasis is on exposure to nonlinear differential equations with examples such as heartbeat, chemical reactions and nerve impulse transmission. The basic concepts of the probability to understand molecular evolution and genetics have also been applied.

Course Learning outcomes: Apropos conclusion of the course will empower the student to:

i) Learn the development, analysis and interpretation of bio mathematical models.

ii) Reinforce the skills in mathematical modeling.
iii) Appreciate the theory of bifurcation and chaos.
iv) Learn to apply the basic concepts of probability to molecular evolution and genetics.

UNIT – I

Population growth, Administration of drugs, Cell division, Systems of linear ordinary differential equations, Heartbeat, Nerve impulse transmission, Chemical reactions, Predatorprey models. (3 questions)

UNIT - II

Stability and oscillations**:** Epidemics, The phase plane and the Jacobian matrix, Local stability, Stability, Limit cycles, Forced oscillations; Mathematics of Heart Physiology**:** The local model, The Threshold effect, The phase plane analysis and the heartbeat model, A model of the cardiac pacemaker; Mathematics of Nerve Impulse Transmission**:** Excitability and repetitive firing, Travelling waves. (2 questions)

Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, The Poincaré plane.. (1 questions)

UNIT – III

Modelling Molecular Evolution: Matrix models of base substitutions for DNA sequences, The Jukes-Cantor model, The Kimura models, Phylogenetic distances; Constructing Phylogenetic Trees: Phylogenetic trees, Unweighted pair-group method with arithmetic means (UPGMA), Neighbor joining method; Genetics: Mendelian genetics, Probability distributions in genetics.

(2 questions)

Books Recommended

1. Allman, Elizabeth S., & Rhodes, John A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press.Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.
2. Jones, D. S., Plank, M. J., & Sleeman, B. D. (2009). *Differential Equations andMathematical Biology* (2nd ed.). CRC Press, Taylor & Francis Group, LLC.
3.

1Y3MAT604A: Mechanics

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques. It emphasizes knowledge building for applying mathematics in physical world.

Course Learning Outcomes: The course will enable the students to understand:

i) The significance of mathematics involved in physical quantities and their uses;
ii) To study and to learn the cause-effect related to these; and

iii) The applications in observing and relating real situations/structures.

UNIT - I

Analytical conditions of equilibrium of coplanar forces, virtual work, common catenary, forces in three dimension, Poinsot's central axis, wrenches. Null lines and planes, stable and unstable equilibrium. (4 questions)

UNIT - II

Velocities and acceleration along radial and transverse directions, along tangent and normal directions, simple harmonic motion, elastic string , Hook's law. Central orbit, kepler's laws of motion. (3 questions)

Books Recommended

1. I.H. Shames and G. Krishna Mohan Rao, *Engineering Mechanics: Statics and Dynamics,* (4th 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

1Y3MAT604B: C++ Programming for Mathematics

Course Objectives: This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.

Course Learning Outcomes: After completion of this paper, student will be able to:

i) Understand and apply the programming concepts of C++ which is important to mathematical investigation and problem solving.

ii) Use mathematical libraries for computational objectives.

iii) Represent the outputs of programs visually in terms of well formatted text and plots.

UNIT - I

Fundamentals of programming, Organization of logic flow in stored program model of computation, C++as a general purpose programming language, Structure of a C++ program, Common compilers and IDE's, Basic data-types, Variables and literals in C++, Operators, Expressions, Evaluation precedence, and Type compatibility. Outline of program development in C++, Debugging and testing. Applications: Greatest common divisor, and Random number generation. (2 questions)

UNIT - II

Structured data-types in C++, Arrays and manipulating data in arrays with applications in factorization of an integer and finding Euler's totient; Objects and classes**:** Information hiding Modularity, Constructors and Destructors, Methods and Polymorphism.

Applications**:** Cartesian geometry using points (2 & 3-dimensional), and Pythagorean triples.

(3 questions)

UNIT - III

Containers and Template Libraries**:** Sets, Iterators, Multisets, Vectors, Maps, Lists, Stacks and Queues. Applications**:** Basic set algebra, Modulo arithmetic, Permutations, and Polynomials. Arbitrary precision arithmetic using the GMP package; Linear algebra: Two-dimensional arrays in C++ with applications in finding Eigenvalues, Eigenvectors, Rank, Nullity, and Solving system of linear equations in matrices. Features of C++ for input/output and visualization: Strings, Streams, Formatting methods, processing files in a batch, Commandline arguments, Visualization packages and their use in plots.

(2 questions)

Books Recommended

1. Scheinerman, Edward (2006). C++ for Mathematicians: An Introduction for Students and Professionals. Chapman & Hall/CRC. Taylor & Francis Group, LLC.
2. Dale, Nell & Weems, Chip (2013). Programming and Problem Solving with C++ (6th ed.). Comprehensive Edition. Jones & Bartlett Learning.
3. Lippman, Stanley B. (2000). Essential C++. Addison-Wesley.
4. Stroustrup, Bjarne (2013). The C++ Programming Language (4th ed.). Addison-Wesley.

1Y3MAT604C: Finite Element Methods

Course Objectives: To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Course Learning Outcomes: After completion of this paper, student will be able to:

(i) Implement numerical methods to solve mechanics of solids problems.

(ii) Formulate and Solve axially loaded bar Problems.

(iii) Formulate and solve Axi-symmetric and heat transfer problems.

UNIT - I

Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares. (1 questions)

Applications to solving simple problems of ordinary differential equations. Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.

(2 questions)

UNIT – II

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries. (1 questions)

Interpolation functions, numerical integration**.** (2 questions)

UNIT - III

Solution of one dimensional heat and wave equation and solution of two dimensional Laplace equation under different Geometric conditions. (1 questions)

Books Recommended:

1. J.N. Reddy, *Introduction to the Finite Element Methods*, Tata McGraw-Hill, 2003.
2. K.J. Bathe, *Finite Element Procedures*, Prentice-Hall, 2001**.**
3. R.D. Cook, D.S. Malkus and M.E. Plesha, *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons, 2002.
4. Thomas J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publication, 2000.
5. George R. Buchanan, *Finite Element Analysis*, McGraw Hill, 1994.