CBCS SYLLABUS

FOR

THREE YEARS

UNDER-GRADUATE COURSE

in

B.Sc. Mathematics (PROGRAMME)

(*w.e.f. A.Y. 2022-2023*)

BANKURA UNIVERSITY

BANKURA

WEST BENGAL

PIN 722155

STRUCTUREIN MATHEMATICS (PROGRAMME)

SEMESTER–I

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SP/MTH/101/C-1A	Calculus and Geometry	06	10	40	50	05	01	00
SP/102/C-2A	Discipline-2	06	10	40	50	05	01	00
SP/103/C-3A	Discipline-3	06	10	40	50	05	01	00
ACSHP/ 104/ AECC-1	Environmental Studies	04	10	40	50	03	01	00
Total in Semester-I		**22**	**40**	**160**	**200**	18	04	00

SEMESTER –II

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SP/MTH/201/C-1B	Algebra	06	10	40	50	05	01	00
SP/202/C-2B	Discipline-2	06	10	40	50	05	01	00
SP/203/C-3B	Discipline-3	06	10	40	50	05	01	00
ACSHP/204/AE CC-2	English/MIL	02	10	40	50	01	01	00
Total in Semester-II		**20**	**40**	**160**	**200**	**16**	**04**	**00**

SEMESTER–III

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SP/MTH/301/ C-1C	Real Analysis	06	10	40	50	05	01	00
SP/302/C-2C	Discipline-2	06	10	40	50	05	01	00
SP/303/C-3C	Discipline-3	06	10	40	50	05	01	00
SP/MTH/304/ SEC-1	Basic Numerical Methods	02	10	40	50	01	01	00
Total in Semester-III		**20**	**40**	**160**	**200**	**16**	**04**	**00**

SEMESTER–IV

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SP/MTH/401/ C-1D	Differential Equations and Vector Calculus	06	10	40	50	05	01	00
SP/402/C-2D	Discipline-2	06	10	40	50	05	01	00
SP/403/C-3D	Discipline-3	06	10	40	50	05	01	00
SP/MTH/404/ SEC-2	Graph Theory and Mathematical Logic	02	10	40	50	01	01	00
Total in Semester -IV		**20**	**40**	**160**	**200**	**16**	**04**	**00**

SEMESTER–V

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SP/MTH/501/DSE-1A	**Any one of the following:** • Linear Algebra and Linear Programming Problems • Statics and Dynamics	06	10	40	50	05	01	00
SP/502/DSE-2A	Discipline-2	06	10	40	50	05	01	00
SP/503/DSE-3A	Discipline-3	06	10	40	50	05	01	00
SP/MTH/504/SEC-3	Programming Using C	02	10	40	50	01	01	00
Total in Semester–V		**20**	**40**	**160**	**200**	**16**	**04**	**00**

SEMESTER–VI

Course Code	Course Title	Credit	Marks			No. of Hours		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SP/MTH /601/DSE-1B	**Any one of the following:** • Number Theory • Probability and Statistics	06	10	40	50	05	01	00
SP/602/DSE-2B	Discipline-2	06	10	40	50	05	01	00
SP/603/DSE-3B	Discipline-3	06	10	40	50	05	01	00
SP/MTH/ 604/SEC-4	Boolean Algebra	02	10	40	50	01	01	00
Total in Semester–VI		**20**	**40**	**160**	**200**	**16**	**04**	**00**

SP=Science programme/Pass, MTH=Mathematics, ACSHP=Arts Commerce Science Honours Pass, C=Core Course, MIL= Modern Indian Language, AECC = Ability Enhancement Compulsory Course, SEC= Skill Enhancement Course, DSE= Discipline Specific Elective, IA= Internal Assessment, ESE= End-Semester Examination, Lec.= Lecture, Tu.=Tutorial, and Pr.=Practical.

Undergraduate Syllabus of Mathematics (Programme)

w.e.f. A.Y. 2022-2023

Bankura University

Bankura
West Bengal
PIN 722155

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1. Introduction

The syllabus of Mathematics for B.A./B.Sc. with Mathematics as a subject using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weightage to both the core content and techniques used in Mathematics. Keeping in mind and in tune with the changing nature of the subject and the target group of pupil, adequate emphasis has been given on new techniques of mapping and understanding of the subject.

Mathematics is the study of quantity, structure, space and change. It has very broad scope in science, engineering and social sciences.

The syllabus has also been framed in such a way that the basic skills of subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

While the syllabus is incompliance with UGC model curriculum, some changes have been made to ensure all topics are covered and any of the subjects don't become difficult to be completed in one semester.

Similarly, Discipline Electives have been grouped where in student can choose 1 elective from a pool of courses. This has been done to help students learn a cross the semesters in their inter semesters.

Evaluation process of each course is carried out through Internal Assessment and End Semester Examination. 10 marks is allotted for Internal Assessment and 40 marks is allotted for End Semester Examination. Question paper of each course for End Semester Examination contains three units. 05 questions to be answered out of 08 questions carrying 02 marks of each in Unit –I. 04 questions to be answered out of 06 questions carrying 05 marks of each in Unit –II and similarly, 01 question to be answered out of 02 questions carrying 10 marks of each in Unit –III.

The Bachelor's Degree in B.A./B.Sc. with Mathematics as a subject, is awarded to the students on the basis of knowledge, understanding, skills, attitudes, values and academic achievements sought to be acquired by learners at the end of these programmes. Hence, the course objectives and course specific outcomes of mathematics for these courses are aimed at facilitating the learners to acquire these attributes, keeping in view of their preferences and aspirations for knowledge of mathematics.

These syllabi in Mathematics under CBCS are recommended keeping in view of the wide applications of Mathematics in science, engineering, social science, business and a host of other areas. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.

The textbooks mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help the learners to complete the study of concerned paper in certain periods and prepare them for examinations.

Hence, the programme has been chalked out in such manner that there is scope of flexibility and innovation in modifications of prescribed syllabi, teaching-learning methodology, assessment technique of students and knowledge levels, learning outcomes of courses, inclusion of new elective courses subject to availability of experts in across the country.

Programme Objectives (PO):

PO1: Mathematical Reasoning: Application of the mathematical knowledge to the solution of more complex problems in academic and in real life.

PO2: Analyzing Ability: Identification, formulation and solution of a problem which leads to conclusion using basic principles.

PO3: Developing Confidence: Analyzing more complicated problems and getting solutions helps to build up confidence.

PO4: Design/development of more accuracy: Design and development of methods/ procedures for solutions of problems which meet the specific queries in industry as well as real life.

PO5: Ability of investigations for more complex problems: Use research-based knowledge and research methods to handle more complex problems.

PO6: Applications of theory based knowledge: Ability to apply the theoretical knowledge including theory, experiment and computational data; analysis and interpretation of data, to get the valid conclusions.

PO7: Ability of Modern tool usage: Application of appropriate techniques, resources, updated software and modern mathematical tools to solve mathematical activities with a good understanding of their limitations.

PO8: Team work practice: Collective efforts for functioning effectively as a member or leader in diverse teams, and/or in multidisciplinary settings.

PO9: Communication skill: Effective Communication skill for scientific activities helps to establish a good researcher with popular face in the scientific community.

PO10: Ability of presentation: Writing the effective reports and design document to give and receive clear instructions/limitations/restrictions for good presentations.

PO11: Life-long learning process: Recognize the needs, proper learning and ability to engage in life-long learning in the broadest context of scientific & technological changes.

PO12: Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

Programme Specific Outcomes (PSO):

The Department of Mathematics offers exciting opportunities to talented students holding a Bachelor's degree for acquiring a rigorous and modern education in mathematics and for pursuing master's degree in both pure and applied mathematics as well as higher studies based on Mathematics. As a part of this Programme, the student has to complete 48 credits of courses.

Career Opportunities:

After completion of this programme, the students are well prepared for higher studies such as M. Sc., M. Tech., Integrated Ph.D. program, any professional degree. This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises. Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning which also helps more professional.

2. Scheme for CBCS Curriculum for B.A./B.Sc. with Mathematics as a subject

2.1 Credit Distribution

Course Type	Total Papers	Credits	
		Theory + Practical	Theory*
Core Courses	4	4*4=16 4*2=8	4*5=20 4*1=4
Discipline Specific Electives	2	2*4=8 2*2=4	2*5=10 2*1=2
Ability Enhancement Papers	2	2*2=4	2*2=4
Skill Enhancement Papers	2	2*4=8	2*4=8
Totals	10	48	48

*Tutorials of 1Credit will be conducted in case there is no practical component

2.2 Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course–I	Environmental Science	4
	Core course–I	Calculus and Geometry	6
	Core course–I Practical	-	-
II	Ability Enhancement Compulsory Course–II	English Communication	2
	Core course–II	Algebra	6
	Core course– II Practical	-	-
III	Core course–III	Real Analysis	6
	Skill Enhancement Course–1	Basic Numerical Methods	2
	Skill Enhancement Course–1 Practical	-	-
IV	Core course–IV	Differential Equations and Vector Calculus	6
	Core course–IV Practical	-	-
	Skill Enhancement Course-2	Graph Theory and Mathematical Logic	2
	Skill Enhancement Course-2 Practical	-	-
V	Discipline Specific Elective–1	TBD	6
	Discipline Specific Elective– 1 Practical	-	-
	Skill Enhancement Course-3	Programming Using C	2
	Skill Enhancement Course-3 Practical	-	-
VI	Discipline Specific Elective–1	TBD	6
	Discipline Specific Elective– 1 Practical	-	-
	Skill Enhancement Course-4	Boolean Algebra	2
	Skill Enhancement Course-4 Practical	-	-

TBD= To be decided (by the concerned department)

2.3 Choices for Discipline Specific Electives

(One course to be chosen from each of Discipline Specific Electives -1, 2)

Discipline Specific Elective–1	Discipline Specific Elective–2
Linear Algebra and Linear Programming Problems	Number Theory
Statics and Dynamics	Probability and Statistics

2.4 Choices for Skill Enhancement Courses

Skill Enhancement Course-1	Skill Enhancement Course-2	Skill Enhancement Course-3	Skill Enhancement Course-4
Basic Numerical Methods	Graph Theory and Mathematical Logic	Programming Using C	Boolean Algebra

Syllabus: B.A./B.Sc. with Mathematics as a subject

3. Core Subjects Syllabus: B.A./B.Sc. with Mathematics as a subject

3.1 Core T1A–Calculus and Geometry

Calculus and Geometry	
	6 Credits
Course Objectives: The course will enable the students to i) calculate the limit of indeterminate form and examine the concavity and convexity. ii) understand the application of calculus and its consequences indifferent coordinate systems. iii) understand the two and three dimensional problems and solutions.	
Course Specific Outcomes: The student acquires the knowledge of i) improper integrals, Beta and Gamma functions with its properties. ii) determination of surface area and volumes of revolution.	
Unit 1	
Higher order derivatives, Leibnitz's rule; Indeterminate forms, L'Hospital's rule; Cartesian and Polar subtangent and subnormal; Pedal equation of a curve; Curvature, Radius of Curvature, Centre of Curvature, Circle of Curvature; Concavity, Convexity and Points of inflexions; Envelopes: One and Two parameter family of curves; Rectilinear Asymptotes in Cartesian and Polar Coordinates; Curve tracing of standard curves in Cartesian and Polar Coordinates.	
Unit 2	
Reduction formulae; Parametric equations, Parameterizing a curve; Area under curves in Cartesian and Polar Coordinates; Rectification: Cartesian, Polar and Parametric curves, Intrinsic equations of curves; Volumes and Surfaces of revolution, Improper integrals, Convergency, Beta and Gamma functions and basic properties.	
Unit 3	

Reflection properties of Parabola, Ellipse and Hyperbola; Transformation of rectangular Cartesian coordinates – Translation, Rotation, Orthogonal transformation, General Orthogonal transformation, Invariants; General equation of second degree: Classification of Conics; Polar coordinates: Straight lines, Circles, Conics, Polar equations of tangent, normal and chord of contacts; Pair of Straight lines; Tangents, Normal, Chord of contacts, Pole, Polar.

Unit 4

Sphere: General equation, Circle; Cone: General homogeneous second degree equation, Enveloping Cone, Reciprocal Cone, Right circular cone; Cylinder, Right circular cylinder, Enveloping cylinder; Conicoid: Canonical equations of Ellipsoid, Hyperboloid, Paraboloid; Ruled surfaces, Generating lines and their properties, Transformation of coordinates: Invariants; Reduction of general equation of three variables, Concept of Cylindrical and Spherical Polar coordinates.

Reference Books

- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- M.J. Strauss, G. L. Bradley and K.J.Smith, Calculus, 3rd Ed., Dorling Kindersley(India)P.Ltd.(Pearson Education),Delhi,2007.
- H. Anton, I. Bivens and S. Davis, Calculus, 7th 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.
- G.F. Simmons, Differential Equations, Tata Mcgraw Hill, 2017.
- T.M. Apostol, Calculus, Volumes I and II. Wiley, 2007.
- T.G. Vyvyan, Elementary Analytic Geometry, Deighton, Bell and Company, 1867.
- E.H. Askwith, The Analytical Geometry of the Conic Sections, Adam and Charles Black, London, 1908.
- B.K. Kar, Advanced Analytic Geometry and Vector Analysis, Books & Allied Pvt. Ltd., Kolkata, 2000.
- S. Karmakar, S. Karmakar, Analytical Geometry: Two Dimensions, CRC Press (Taylor and Francis Group)/ Levant Books (India), London, 2022.
- K.C. Ghosh and R.K. Maity, An Introduction to Analysis: Differential Calculus (Part I), New Central Book Agency (P) Ltd., 2011.
- S. Narayan and M.D. Raisinghania, Elements of Real Analysis, S. Chand and Co. Ltd., 2003

3.2 Core T2B-Algebra

Algebra	
	6 Credits
Course Objectives: The main objective of this course is to give a deep insight of the roots of real and complex polynomials and learn various methods of obtaining roots. Employ De Moivre's theorem in a number of applications and able to knowledge to solve the system of linear equations.	
Course Specific Outcomes: After completion of this course a student would recognize the idea of inequalities. Also, they are able to find out the order of a Group and/or order of an element of a Group. It helps to acquire deep learning of the roots of quadratic and bi quadratic equations.	
Unit 1	
Complex numbers: Polar and exponential form, *n*-th roots of unity, De Moivre's theorem for rational indices and its applications, Exponential, Trigonometrical, Logarithmic, Inverse circular and Hyperbolic functions of a complex variable and their properties. Inequalities: AM ≥ GM ≥ HM, Cauchy-Schwartz inequality, Well-ordering property of positive integers, Division algorithm, GCD and LCM, Divisibility and Euclidean algorithm, Prime numbers, Congruence relation between integers, Fermat's little theorem, Euler's ϕ-function, Statement of Fundamental theorem of Arithmetic.	
Unit 2	
Theory of Equations: Polynomials, Remainder Theorem, Statement of Fundamental theorem of Algebra, Relation between roots and coefficients, Symmetric functions of roots, Transformation of equations, Removal of terms from an equation, Standard cubic, Cardon's method for solving cubic equations, Biquadratic equations: Descartes's and Ferrari's method, Nature of the roots of equation, Descartes rule of sign, Multiple roots, Roll's theorem.	
Unit 3	
Binary composition, Algebraic structure, Definition of Groups, Group properties, Abelian Groups, Simple examples, Order of a group, Order of an element of a group, Subgroups and related theorems, Cosets, Lagrange's theorem.	
Reference Books	
▸ T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhauser, 2006. ▸ E.G. Goodaire and M.M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.	

- D.C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
- K.B. Dutta, Matrix and Linear Algebra. Prentice-Hall of India Pvt. Ltd., 2004.
- K. Hoffman, R. Kunze, Linear Algebra, 2nd Ed., Pearson, 2018.
- W.S. Burnstine and A.W. Panton, Theory of Equations, Wentworth Press, 2016.

3.3 Core T3C–Real Analysis

Real Analysis	
	6 Credits
Course Objectives: This course will enable the students to: i) understand many properties of the real line $\mathbb{R}$ and learn to define sequence in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$. 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) recognize the series, properties of series and different test for convergence of series.	
Course Specific Outcomes: The student acquires deep **l**earning of real analysis starting with ε-δ and acquiring the knowledge of calculation of surface area by double integration and volume by triple integration.	
Unit 1	
Rational numbers, Irrational numbers, Real number system, Order properties, Supremum and infimum, Ordered Completeness property. Real sequences, Bounded sequences, Limit of a sequence, Convergent, Divergent and Oscillatory sequences, Limit theorems, Sandwich theorem, Monotone sequences, Monotone Convergence theorem, Cauchy's general principle of convergence and its applications, Infinite series: Convergence and Divergence, Series of positive terms, Convergency test: Comparison test and its limit forms, D' Alembert's ratio test.	
Unit 2	
Definition of limit of a function, ε-δ approach and sequential approach, Infinite limits and limits at infinity, Continuity of a function, ε-δ approach and sequential approach, Discontinuity and its types, Differentiability at a point and at an interval, Darbaux property, Rolle's theorem, Mean Value theorems (Lagrange's and Cauchy's form), Taylor's theorem – different types of remainders, Infinite Taylor's series, Maclaurin's theorem – finite and infinite form, Infinite series expansion of well-known functions, Relative extrema.	
Unit 3	
Functions of several variables, Limits – Simultaneous and Repeated, Continuity of functions of more than one variable, Directional derivatives, Partial derivatives, Total differentiation, Sufficient condition of total differentiability, Homogeneous functions, Euler's theorem.	

Unit 4

Double integrals over rectangular and non-rectangular regions, Double integrals in Polar coordinates, Triple integrals over parallelepiped and solid regions. Area by double integral and volume by triple integrals, Cylindrical and Spherical coordinates, Change of variables in double and triple integrals.

Reference Books

- R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
- G.G. Bilodeau, Paul R. Thie, G. E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
- B.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, NewYork,1994.
- T.M. Apostol, Mathematical Analysis, Narosa Publishing House, 2002.
- R. Courant and F. John, Introduction to Calculus and Analysis, Vol I, Springer, 1998.
- W. Rudin, Principles of Mathematical Analysis, 3rd Ed., Tata McGraw-Hill, 2017.
- T. Tao, Analysis I, Hindustan Book Agency, 2006.
- K.C. Ghosh and R.K. Maity, An Introduction to Analysis: Differential Calculus (Part I), New Central Book Agency (P) Ltd., 2011.
- K.C. Ghosh and R.K. Maity, An Introduction to Analysis: Integral Calculus, New Central Book Agency (P) Ltd., 2013.

3.4 Core T4D- Differential Equations and Vector Calculus

Differential Equations and Vector Calculus	
	6 Credits

Course Objectives: This course will enable the students to:
i) understand the genesis of ordinary differential equations.
ii) learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
iii) understand the knowledge of Vector Algebra and Vector calculus.

Course Specific Outcomes: This course specifically enables the students to

i) grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

ii) formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day-to-day problems arising in physical, chemical and biological disciplines.

Unit 1

First order first degree Ordinary Differential Equations (ODE): Exact equations, conditions of exactness, Integrating factors, Properties, Linear equations, Bernoulli's equations, First order but not first degree: Solvable for *p*, *x* and *y*, Singular solutions, Lagrange's and Clairaut's equations. Higher order linear ODE with constant coefficients: C.F., P.I. and General solutions, Principle of Super position for homogeneous equations, D-operator method for P.I., Method of undetermined coefficients.

Unit 2

Lipschitz's condition and Picard's theorem (Statement); Wronskian and its basic properties and applications, Higher order ODE with variable coefficients, Cauchy-Euler type equations, Method of variation of parameters, Solution of a second order ODE when one integral of the CF is known, Simultaneous Linear ODE: Type – I and Type – II, Operator method for type I, Solution of simultaneous ODE of type II, Pfaffian differential equations, Integrability condition, Condition of exactness, Solution of Pfaffian differential equations.

Unit 3

Product of three or more vectors, Applications of vectors in Geometry: Vector equation of Straight lines, Angle bisectors, Vector equations of plane, Different forms, Distance of a point from a plane, Shortest distance, Vector equation of a sphere, Applications to Mechanics: Resultant force, Moments, Torque, Lami's theorem and Varignon's theorem.

Unit 4

Vector valued functions with one independent variables, Limits, Continuity, Differentiation of vector functions, Constant vectors, Conditions of constancy of a vector function, Definition of vector field, Directional derivatives, Gradient vector, Maximal and Normal properties of gradient, Divergence and Curl and their properties, Line integrals, Conservative vector field, Surface and Volume integrals.

Reference Books

- E. Kreyszig, Advanced Engineering Mathematics 10th Ed. J. Wiley & Sons, 2011.
- B. Rai & D.P. Choudhury, Ordinary Differential Equations - An Introduction. Narosa Publishing House Pvt. Ltd. New Delhi, 2006.
- S.L. Ross, Differential Equations, 3rd Ed., Wiley, 2007.
- G.F. Simmons. Differential Equations with Applications and Historical Notes 3rd Ed., CRC Press. Taylor & Francis, 2017.
- J.E. Marsden, Anthony Tromba, Vector Calculus, 6th Ed., McGraw Hill, 2011.
- K.C. Maity, and R.K. Ghosh, Vector Analysis, 7th Ed., New Central Book Agency (P) Ltd. Kolkata (India), 2011.

- M.R. Speigel, Schaum's Outline of Vector Analysis. McGraw-Hill Education, 1959.

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4. Discipline Specific Electives Subjects Syllabus

4.1 DSE T1A–Linear Algebra and Linear Programming Problems

Linear Algebra and Linear Programming Problems	
	6 Credits
Course Objectives: The course will enable the students to i) recognize the fundamental concept of Ring, Field and its consequences. ii) acquire the knowledge of three theorems of Isomorphisms, congruences on a Ring . iii) employ the concept of orthogonality and orthonormality. iv) analyze and solve linear programming models of real-life situations.	
Course Specific Outcomes: This course specifically enables to the students- i) the concept of eigenvalues and eigenvectors of matrix. ii) learn about the applications of artificial variable techniques and transportation problems.	
Unit 1	
Matrices: Rank, Elementary operations, Elementary matrices, Complex matrices, Hermitian, Skew Hermitian and Unitary matrices, Vector Spaces, Examples of Vector spaces, Subspaces, Linear combination, Linear span, Linearly dependent and independent set of vectors, Properties, Basis and dimension of a vector space, Finite and infinite dimensional vector spaces, Examples, Theorems on basis and dimensions.	
Unit 2	
Row and Column spaces, Rank and Nullity of row and column spaces, Invariance, System of linear equations, its matrix form, Homogeneous and Non-homogeneous systems, Solution space of homogeneous system, Fundamental theorem of Linear algebra, Linear Transformations, Examples, Range and Null spaces, Kernel, Rank and nullity of Linear Transformation, Sylvester's law, Eigen values and Eigen vectors, Properties of Eigen values and Eigen vectors, Matrix Polynomials, Cayley-Hamilton theorem and its applications.	
Unit 3	

Introduction of Linear Programming Problems (LPP), Solutions, Basic Solutions (BS), Feasible Solutions (FS), Basic Feasible Solutions (BFS), Degeneracy, Convex Combinations, Convex and Non-convex sets, Examples, Extreme Points, Basic properties, Convex Polyhedron, Convex hull, Fundamental Theorem, Theory of Simplex method, Optimality and unboundedness, Simplex algorithm, Artificial variable techniques, Big-M method and infeasibility.

Unit 4

Duality, Formulation of primal-dual problems, their relationship, Basic properties of primal-dual problems, Fundamental theorem of Duality, Duality and Simplex method, Dual Simplex method, Transportation Problems (TP), Mathematical formulation, Balanced TP, Initial BFS of a TP, North-West corner method, matrix method, VAM for finding IBFS, Algorithm of solving balanced TP, Unbalanced TP.

Reference Books

- S.H. Friedberg, A.J. Insel & L.E. Spence, Linear Algebra 4th Ed. Prentice-Hall of India Pvt. Ltd., 2003.
- K. Hoffman & R. Kunze, Linear Algebra (2nd edition). Prentice-Hall, 2015
- M. Gel'fand, Lectures on Linear Algebra. Dover Publications, 1989.
- M.S. Bazaraa, J.J. Jarvis & H.D. Sherali, Linear Programming and Network Flows, 4th Ed. John Wiley & Sons, 2010.
- G. Hadley, Linear Programming. Narosa Publishing House, 2002.
- F.S. Hillier & G.J. Lieberman, Introduction to Operations Research, 10th Ed., McGraw-Hill Education, 2015.
- H.A. Taha, Operations Research: An Introduction,10th Ed., Pearson, 2017.
- P.R. Thie & G.E. Keough. An Introduction to Linear Programming and Game Theory, 3rd Ed., Wiley India Pvt. Ltd., 2014.

4.2 DSE T1A–Statics and Dynamics

Statics and Dynamics	
	6 Credits

Course Objectives: The course will enable the students to

i) familiarize with subject matter, which has been the single centre, to which were drawn mathematicians, physicists, astronomers, and engineers together.

ii) understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system.

iii) determine the centre of gravity of some materialistic systems and discuss the equilibrium of concurrent forces.

Course Specific Outcomes: This course specifically enables to the students-

i) deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.

ii) learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.

Unit 1

Forces, Various types, Composition and Resolution of forces, Equilibrium of Concurrent forces, Parallel forces, Moment of a force, Couples, Friction, Centre of mass and Centre of gravity, Frictions, Laws of statical friction, Coefficient of friction and angle of friction.

Unit 2

Virtual work: Principle of Virtual work, Simple problems, Common Catenary: Suspension of strings, Related problems, Stability of a body: Equilibrium, Stable, Unstable, Test of stability: Energy test.

Unit 3

Particle Dynamics: Velocity, Acceleration, Equation of motion, Newton's Laws of motion, Rectilinear motion, Motion in a variable acceleration, Simple Harmonic Motion (SHM), Damped Oscillation, Forced Oscillation, Two dimensional motion – Cartesian and Polar Coordinates, Radial and Cross radial components of velocity and acceleration, Central Force, Equation of motion under central force, Pedal form, Angular momentum, Apse, Apsidal angle, Apsidal distance, Planetary motion, Kepler's Law of motion, Tangential and normal components of velocity and acceleration.

Unit 4

Work, Power, Energy, Kinetic and Potential energy, Conservative force, Conservation of Mechanical energy, Impulse of a force, Impulsive force, Principle of conservation of linear momentum, Collision of elastic bodies: Impact, Coefficient of restitution, Newton's empirical law, Related problems.

Reference Books

- S.L. Loney, An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books, 2006.
- P.L. Srivatava, Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad, 1964.
- J.L. Synge & B. A. Griffith, Principles of Mechanics. McGraw-Hill, 1949.
- S. Ramsey, Statics. Cambridge University Press, 2009.
- S. Ramsey, Dynamics. Cambridge University Press, 2009.
- R.S. Varma, A Text Book of Statics. Pothishala Pvt. Ltd. Loney, 1962.

4.3 DSET 1B– Number Theory

Number Theory	
	6 Credits
Course Objectives: The course will enable the students to i) learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, Wilson's theorem and their consequences. ii) learn about number theoretic functions, modular arithmetic and their applications. iii) familiarize with Euler's phi-function and their consequences.	
Course Specific Outcomes: This course specifically enables the students to i) knowing about the concept of the congruences with composite moduli. ii) application of public key encryption, in particular, RSA.	
Unit 1	
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.	
Unit 2	
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.	
Unit 3	
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. Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.	
Reference Books	
▸ D.M. Burton, Elementary Number Theory (7th edition). McGraw-Hill, 2007. ▸ G.A. Jones & J. Mary Jones, Elementary Number Theory. Springer, 2005. ▸ N. Robbins, Beginning Number Theory (2nd edition). Narosa, 2007.	

4.4 DSE T1B– Probability and Statistics

Probability and Statistics	
	6 Credits
Course Objectives: The course will enable the students to i) understand the concept of random experiment and probability. ii) understand distributions in the study of the joint behaviour of two random variables.	
Course Specific Outcomes: This course specifically enables the students to i) axiomatic idea of probability and its related topics. ii) statistical inference, point estimation and its properties.	
Unit 1	
Sample space, Axiomatic definition of Probability, One dimensional Probability distribution, Random variable, Distribution functions – Discrete and continuous, Properties of distribution functions, Probability mass density, Density functions, Binomial, Poisson, Normal, Exponential, Beta, Gamma, Cauchy distributions, Two dimensional Probability distribution, Distribution functions, Marginal distribution functions, Marginal density functions, Conditional distribution and density functions.	
Unit 2	
One dimensional Expectation, Mean, Variance, Standard deviation, Moments, Central moments, Mean and Variance of Binomial, Poisson and Normal distribution, Expectation in two dimensions, Moments in bivariate distributions, Covariance, Correlation Coefficients and its properties, Conditional Mean and variance, Regression lines, Regression coefficients, Convergence in Probability, Tchebycheff's inequality, Tchebycheff's theorem, Bernoulli's Law, Law of Large numbers, Central limit theorem for equal components (Statement).	
Unit 3	
Sampling Theory, Types of Sampling, Sample Mean, Sample Variance, Sampling distributions, Statistical Inference: Estimation, Point Estimation, Properties: Unbiasedness, Consistency, Efficiency, Sufficiency, Method of Maximum Likelihood, Interval Estimation.	
Reference Books	
▸ R.V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007. ▸ I. Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006. ▸ S. Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.	

5. Skill Enhancement Subjects Syllabus

5.1 SEC T1–Basic Numerical Methods

Basic Numerical Methods	
	2 Credits
Course Objectives: The course will enable the students to: i) obtain numerical solutions of algebraic and transcendental equations. ii) find numerical solutions of system of linear equations and check the accuracy of the solutions. iii) learn about various interpolating and extrapolating methods.	
Course Specific Outcomes: This course specifically enables the students to i) solve initial and boundary value problems in differential equations using numerical methods. ii) apply various numerical methods in real life problems.	
Unit1	
Approximate numbers and Significant figure, Computational errors: Rounding, Truncation, Absolute, Relative and Percentage errors, Forward and backward differences, different operators, Interpolation, Error in interpolation, Newton's forward, backward interpolations, Newton's divided difference, Lagrange's interpolation.	
Unit2	
Numerical integration: Newton Cote's formula, Trapezoidal, Simpson's one third rule, Geometrical interpretation, Errors. Solution of first order ODE (Initial Value Problems): Euler's method, Picard's method, R. K methods – 2nd and 4th order.	
Unit 3	
Solution of Algebraic and Transcendental equations: Bisection, Fixed Point Iteration method, Geometry, Convergency, Newton Raphson's method, Geometry, Convergency, Method of False Position. Solution of system of linear equations: Gaussian Elimination, Gauss Seidel method, Partial and Complete Pivoting.	
Reference Books	
▸ B. Bradie, A Friendly Introduction to Numerical Analysis. Pearson, 2006. ▸ C.F. Gerald & P. O. Wheatley, Applied Numerical Analysis (7th edition), Pearson Education, India, 2008. ▸ F.B. Hildebrand, Introduction to Numerical Analysis: (2nd edition). Dover Publications, 2013. ▸ M.K. Jain, S.R.K. Iyengar & R.K. Jain, Numerical Methods for Scientific	

and Engineering Computation (6th edition). New Age International Publishers, 2012.

- R.J. Schilling & S.L. Harris, Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole, 1999.

5.2 SEC T2–Graph Theory and Mathematical Logic

Graph Theory and Mathematical Logic	
	2 Credits
Course Objectives: The course will enable the students to i) study graph theory with various types of graphs and their application. ii) study the mathematical applications to the real world. iii) familiarize with propositional logic and their consequences.	
Course Specific Outcomes: The student acquires the knowledge of i) path and circuits of the Graph theory specifically Eulerian circuits. ii) shortest path and the problem of travelling salesman. iii) assimilating the concept of mathematical logic with their applications.	
Unit 1	
Definition of Graphs, Examples, Basic properties, Pseudo graphs, Complete graphs, Bi-partite graphs, Isomorphism of graphs.	
Unit 2	
Eulerian circuits, Eulerian graphs, Semi-Eulerian graphs, Related theorems, Hamiltonian cycles, Related theorems, Representation of graphs by matrix, the adjacent matrix, Incidence matrix, Weighted graphs.	
Unit 3	
Travelling salesman problem, Shortest path, Trees and their properties, Spanning tree, Dijkstra's algorithm, Warshall algorithm.	
Unit 4 Introduction, Propositions, Truth table, Negation, Conjunction and disjunction, Implications, Biconditional propositions, Converse, Contrapositive and inverse propositions, Precedence of logical operators, Propositional equivalence: Logical equivalence, Predicates and quantifiers: Introduction, Quantifiers, Binding variables and negations.	
Reference Books	

- B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
- E.G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
- R.E. Hodel, An Introduction to Mathematical Logic. Dover Publications, 2013.
- Y.I. Manin, A Course in Mathematical Logic for Mathematicians (2nd edition). Springer, 2010
- E. Mendelson, Introduction to Mathematical Logic (6th edition). Chapman & Hall/CRC, 2015
- S.M. Srivastava, A Course on Mathematical Logic (2nd edition). Springer, 2013.

5.3 SEC T3–Programming Using C

Programming Using C	
	2 Credits
Course Objectives: The course will enable the students to i) understand and apply the programming concepts of C which is important for mathematical investigation and problem solving. ii) use mathematical library functions for computational objectives. iii) familiarize with Syntax and/or error of the different command and their consequences.	
Course Specific Outcomes: The student acquires the knowledge of i) representing the outputs of programs visually in terms of well formatted text and plots. ii) identifying the specific decision making loops and commands.	
Unit 1	
Programming in C: C character set, Keywords, Basic data types, Numeric constants and variables, C operators, Expressions, C statements, Assignment statements, I/O statements.	
Unit 2	
Control statements: Decision making and looping statements in C, Break, Continue and Goto statements, Simple programs.	
Unit 3	
Subscripted variables, Concept of arrays and array variables in C, Rules for one and two dimensional array, Simple programs.	
Unit 4	

Sub programs: Concept of sub programs in C, Purpose of sub programs, Definition of functions and function prototypes, Library functions, Main functions.

Reference Books

- B.W. Kernighan and D.M. Ritchi, The C-Programming Language, 2nd Ed.(ANSI Refresher), Prentice Hall, 1977.
- E. Balagurnsamy, Programming in ANSI C, Tata McGraw Hill, 2004.
- Y. Kanetkar, Let Us C ; BPB Publication, 1999.
- C. Xavier, C-Language and Numerical Methods, New Age International, 1999.
- V. Rajaraman, Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

9.4 SEC T4–Boolean Algebra

Boolean Algebra	
	2 Credits
Course Objectives: The course will enable the students to i) learn about the basic properties of ordered sets, lattices and their types. ii) understand Boolean algebra, switching circuits and their applications.	
Course Specific Outcomes: The student acquires the knowledge of i) modular and distributive lattices in Boolean algebras. ii) assimilating the Karnaugh diagrams concepts and familiarize with examples.	
Unit1	
Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributive lattices, Boolean algebras.	
Unit2	
Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and minimization of switching circuits using Boolean algebra.	
Reference Books	
► B.A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990. ► E.G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003. ► R. Lidl and G. Pilz, Applied Abstract Algebra, 2nd Ed., 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, 2nd Ed., Addison-Wesley, 2001. ► H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997. ► J.A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006	