RABINDRA MAHAVIDYALAYA

Champadanga, Hooghly, West Bengal

DEPARTMENT OF MATHEMATICS

PROGRAMME OFFERED 3-YEAR DEGREE /

4- YEAR HONOURS IN MATHEMATICS

Under Curriculum and Credit Framework for Undergraduate Programmes (CCFUP) as per NEP, 2020

Syllabus for Mathematics (CCFUP), University of Burdwan,

Effective from 2023-2024

PROGRAMME OUTCOME (PO)

PO1: Students will acquire basic Practical skills & Technical knowledge along with domain knowledge of different subjects in the science stream.

PO2: Scientific temper will be developed in Students.

PO3: Students will become employable; they will be eligible for career opportunities in Industry, or will be able to opt for entrepreneurship.

PO4: Students will possess basic subject knowledge required for higher studies, professional and applied courses like Management Studies, Law etc.

PO5: Students will be aware of and able to develop solution-oriented approach towards various Social and Environmental issues.

PROGRAMME SPECIFIC OUTCOME(PSO)

PSO1: A student should be able to recall basic facts about mathematics and should be able to display knowledge of conventions such as notations, terminology.

PSO2: A student should get adequate exposure to global and local concerns that explore them many aspects of mathematical sciences.

PSO3: Student is equipped with mathematical modeling ability, problem solving skills, creative talent and power of communication necessary for various kinds of employment.

PSO4: Student should be able to apply their skills and knowledge that is translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

PSO5: Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.

PSO6: The program fosters an appreciation of the

interconnections among different branches of Mathematics.

PSO7: Students gain sufficient knowledge to pursue higher studies in Mathematics and other branches of science.

COURSE OUTCOME (CO):
SEMESTER-I

Course Code: MATH1011 (MAJOR COURSE)
Course Name: Calculus, Geometry &Vector Calculus

On completion of this portion of the course, a student will be able to:

CO1: Understand the nature of Hyperbolic functions.
CO2: Find higher order derivatives and apply the Leibnitz rule to solve problems related to such derivatives.

CO3:HelptounderstandbasicofCalculusandit'sapplicationsuchasknowledgeaboutconcavity,c onvexity, points of inflection, asymptotes, envelopes, rectilinear asymptotes (Cartesian & parametric form only) of a curve and tracing a curve

CO4: Derivation of reduction formula in Integral Calculus and gain knowledge to find arc length, area of surface evolution, parametric curves etc.

CO5: Help to learn the concept of Analytical Geometry as like : Reflection properties of conics, translation and rotation of axes, classification of conics, polar equations of conics, Spheres, Cylindrical surfaces. Central conicoids , paraboloids, plane sections of conicoids, Generating lines, classification of quadrics.

CO6: Gain knowledge vector valued functions and vector calculus.

CO7: Find gradient of scalar functions, divergence and curl of vector valued functions. CO7: Use of software to plot curves and graphically obtain the surface of revolution of curves.
CO8: Visualize and graphically demonstrate geometric figures and classify different geometric solids using teaching aid - preferably free softwares.

Course Code: MATH1021 (MINOR COURSE)
Course Name: Calculus, Geometry &Vector Calculus

On completion of this portion of the course, a student will be able

to: CO1: Understand the nature of Hyperbolic functions.
CO2: Find higher order derivatives and apply the Leibnitz rule to solve problems related to such derivatives.

CO3: Help to understand basic of Calculus and it's application such as knowledge about concavity, convexity, points of inflection, asymptotes, envelopes, rectilinear asymptotes (Cartesian & parametric form only) of a curve and tracing a curve

CO4: Derivation of reduction formula in Integral Calculus and gain knowledge to find arc length, area of surface evolution, parametric curves etc.

CO5: Help to learn the concept of Analytical Geometry as like: Reflection properties of conics, translation and rotation of axes, classification of conics, polar equations of conics, Spheres, Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of

quadrics.

CO6: Gain knowledge vector valued functions and vector calculus.

CO7: Find gradient of scalar functions, divergence and curl of vector valued functions. CO7: Use of software to plot curves and graphically obtain the surface of revolution of curves.
CO8: Visualize and graphically demonstrate geometric figures and classify different geometric solids using teaching aid - preferably free softwares.

Course Code: MATH1051 (SKILL ENHANCEMENT COURSE)
Course Name: Graph Theory
On completion of this portion of the course, a student will be able to:

CO1: Define graphs, complete graphs, bipartite graphs, isomorphism of graphs CO2: Interpret the concept of Eulerian and Hamiltonian graphs.
CO3: Apply matrix representation to analyze graphs. CO4: Create examples of trees and spanning trees.
CO5: Analyze and compare planar and non-planar graphs.
CO6: Evaluate the effectiveness of different graph coloring strategies.

SEMESTER-II

Course Code: MATH2011 (MAJOR COURSE)
Course Name: Introductory Algebra and Number Theory

On completion of this portion of the course, a student will have a clear-cut understanding of some important concepts of Classical Algebra, Abstract Algebra & Number theory as follows:

CO1: Prove how certain number theoretical theorems can be applied to solve simple Diophantine equations.

CO2: Explain theory of congruence with examples.

CO3: Explain Euler's phi functions and its properties.

CO4: Know about primitive roots of primes and continued fractions.

CO5:Know about relation between roots and coefficients, transformation of the equation, Descartes rule of signs.

CO6: Find the solution of cubic equation by Cardan's method and the solution of biquadratic equation by Ferrari's method.

CO7: Know about the Cauchy-Schwartz inequality and the inequality involving AM≥GM≥HM. CO8:Help to understand Groups, permutation groups, Matrix groups with various examples.

CO9: Know about subgroups, coset, normal subgroup, cyclic group with examples.

CO10: Prove Lagrange's theorem and by apply this theorem to solve various problems of group theory.

CO11: Know about ring, ideals ,integral domain ,field with examples and its properties.

Course Code: MATH2021 (MINOR COURSE)
Course Name: Introductory Algebra and Number Theory

On completion of this portion of the course, a student will have a clear cut understanding of some important concepts of Classical Algebra, Abstract Algebra & Number theory as follows:

CO1: Prove how certain number theoretical theorems can be applied to solve simple Diophantine equations.

CO2: Explain theory of congruence with examples.

CO3: Explain Euler's phi functions and its properties.

CO4: Know about primitive roots of primes and continued fractions.

CO5:Know about relation between roots and coefficients, transformation of the equation, Descartes rule of signs.

CO6: Find the solution of cubic equation by Cardan's method and the solution of biquadratic equation by Ferrari's method.

CO7: Know about the Cauchy-Schwartz inequality and the inequality involving AM≥GM≥HM.

CO8:Help to understand Groups, permutation groups, Matrix groups with various examples. CO9: Know about subgroups, coset, normal subgroup, cyclic group with examples.

CO10: Prove Lagrange's theorem and by apply this theorem to solve various problems of group theory.

CO11: Know about ring, ideals, integral domain, field with examples and its properties.

Course Code: MATH2051 (SKILL ENHANCEMENT COURSE)
Course Name: Programming in C
On completion of this portion of the course, a student will be able to:

CO1: Uses of different types of operators with precedence, formatted and non-formatted input output statements, branching and looping statements for decision making.

CO2: Help to understand the concept of array variables.
CO3: How to use User-defined function along with string handling function.
CO4: Know about the writing of different C programming using structures and pointers. CO5: Understand the importance of C programming which are very good programming tools for solving many real life problems.

SEMESTER-III

Course Code: MATH3011 (MAJOR COURSE)
Course Name: Real Analysis I
On completion of this portion of the course, a student will be able to:
CO1: Concept of countable sets, uncountable sets, bounded and unbounded sets in $\mathbb{R}$, supremum and infimum of a set and their properties
CO2: Know about Archimedean property of $\mathbb{R}$ and its applications.
CO3: Understand the concept of interior point, open set, limit point of a set, isolated point, derived set, closed set.
CO4: Explain the theory of Bolzano-Weierstrass for set and Heine-Borel theorem. CO5: Learn about real sequence, bounded sequence which are convergent and non-convergent.
CO6: Find the relation between the limit of a set and the limit of a convergent sequence of distinct elements.
CO7: Know about the sequences which are Cauchy sequence and its convergent criteria. CO8:Determine which infinite series of real numbers is convergent and which is not convergent by using various test such as comparison tests, De Morgan tests, D'Alembert's ratio test, p-series, Cauchy's root test, Raabe's test, Gauss test, Logarithmic test, integral test.
CO9: Calculate which alternating series of real numbers is convergent by using Leibnitz test.
CO10: Know about Absolute and conditional convergence.
CO11: Learn about limit of functions, sequential criterion for limits, Algebra of limits for functions, effect of limit on inequality involving functions, infinite limit and limit at infinity. Some important examples of limits.
CO12: Gain knowledge about continuity and uniform continuity of real valued functions defined on subsets of $\mathbb{R}$ including their inter relationship.
CO13: Explain Bolzano's theorem of continuity, intermediate value theorem, fixed point theorem and apply these theorem to solve various problems of real numbers.

Course Code: MATH3012 (MAJOR COURSE)
Course Name: Linear Algebra

On completion of this portion of the course, a student will be able to:

CO1: Know about Vector spaces and its properties.
CO2: How to find a basis and dimension of a vector space.
CO3: Find rank and nullity of a linear transformation and also matrix representation

of a linear transformation.
CO4: Calculate the transpose of a linear transformation and its matrix representation
CO5: Know about invertibility and isomorphisms of a linear transformation.
CO6: Find rank of a matrix by using elementary operations.
CO7: Evaluate eigen values and eigen vectors of a matrix and also find the inverse of a matrix by using Cayley-Hamilton theorem.
CO8: Solve the systems of linear equations by using Gaussian elimination method and matrix inversion method.
CO9: Find the characteristic polynomial and the minimal polynomial of a linear operator and canonical forms of a matrix.
CO10: Know about Inner product spaces, norms and its properties.
CO11: Obtain an orthonormal basis of an inner product spaces by applying Gram-Schmidt orthogonalization process.
CO12: How to reduce a quadratic form to normal form by orthogonal transformation.

Course Code: MATH3051 (SKILL ENHANCEMENT COURSE)
Course Name: Mathematical Modelling

On completion of this portion of the course, a student will be able to:

CO1: Gain knowledge about modelling and formation of various models and their real life application.
CO2: Estimate relationship between variables by using of linear regression for modelling. CO3: Know about Exponential models which help to comprehend the rapid and often accelerating changes that occur in diverse natural and social systems.
CO4: Know about Logistic models and their applications in population studies, ecology and epidemiology
CO5: Define optimization models and their applications and use of linear programming and optimization techniques to minimize or maximize objectives.
CO6: Gain knowledge about importance of optimization model in resource allocation, production planning, decision making.
CO7: Know about time series models and their application and importance of time series models in analyzing trends, seasonality and forecasting future outcomes with applications. CO8: Analyze and solve the real world problems mathematically.

SEMESTER-IV

Course Code: MATH4011 (MAJOR COURSE)
Course Name: Metric Spaces

On completion of this portion of the course, a student will be able to understand and appreciate the concept of a metric space as follows:
CO1: understand and appreciate the concept of a metric space , open set, closed sets and be able to recognize standard examples
CO2: Analyze the properties of open and closed balls, neighbourhoods, interior and exterior points, and boundaries of sets in metric spaces.

CO3: Explore concepts such as limit points, closure, boundedness, and equivalent metrics CO4: Demonstrate knowledge of convergence, Cauchy sequences and bounded sequences. CO5: Understand the role of completeness in metric spaces and explore dense and nowhere dense sets.
CO6: Apply key theorems like Baire's category theorem, Cantor's intersection theorem and the completion of metric spaces.
CO7: Analyze the completeness and incompleteness properties of spaces like $\mathbb{R}^n$, C[a,b], l_p, l_∞.
CO8: Evaluate limits, continuity and uniform continuity of mapping in metric spaces.
CO9: Utilize concepts like homeomorphisms and Banach's contraction principle for solving problems including ODEs and implicit function.
CO10: Analyze the properties of connectedness, separated sets and connected subsets in $\mathbb{R}$. And establish the role of continuity in maintaining connectedness.
CO11: Understand and apply properties like open cover, sequential compactness and B-W compactness and explore the relationships between compactness, completeness and boundedness and use tools like lebesgue covering lemma.
CO12: Assess the first and second countability of a metric space and explore separability and Lindelöf properties in various metric spaces.

Course Code: MATH4012 (MAJOR COURSE)
Course Name: Group Theory & Ring Theory

On completion of this course, students will gain a strong theoretical and practical foundation in group theory and ring theory as follows:

CO1: Define and explore homomorphisms, isomorphisms, automorphisms and releted concepts like inner automorphism and endomorphism.
CO2: Analyze quotient groups, commutator subgroups, characteristic subgroups and simple groups and study specific groups like the dihedral and quaternion groups.
CO3: Understand and apply isomorphism theorems (1^{st}, 2^{nd},3^{rd}) and the correspondence theorem.
CO4: Study concepts like normalizers, maximal normal subgroups and their role in group classification.
CO5: Explore the action of a group on a set, representation via homomorphisms, and Cayley's theorem.
CO6: Analyze stabilizers, orbits, class equations, and conjugacy classes. Apply theorems like Burnside's theorem and study p-groups, Cauchy's theorem, and Sylow theorems.
CO7: Differentiate between direct product and direct sum of groups and analyze their properties and also Study the semi-direct product and the representation of finite abelian groups.
CO8: Define ring homomorphisms and study quotient rings along with the isomorphism theorems (1st, 2nd, and 3rd). Understand and explore maximal, prime, and primary ideals, including their existence and properties.
CO9: Investigate irreducible and prime elements and their roles in ring theory. Explore advanced ring structures like Euclidean domains, Principal Ideal Domains (PIDs), and Unique Factorization Domains (UFDs).
CO10: Analyze polynomial rings F[x] over a field F, integral domains, and

irreducibility criteria for polynomials.

Course Code: MATH4013 (MAJOR COURSE)
Course Name: Multivariate Calculus & Tensor Calculus

On completion this course, students will master concepts in multivariable calculus and tensor calculus as follows:
CO1: Analyze the continuity and limits of functions of n-variables, including repeated and double limits.
CO2: Understand and apply partial derivatives, Euler's theorem, and total differentiability. Utilize chain rules, directional derivatives, Jacobians, and gradients in problem-solving.
CO3: Determine tangent planes and solve extrema problems using the method of Lagrange multipliers for constrained optimization.
CO4: Comprehend the concept and computation of double and triple integrals.Apply changes in the order of integration and transformations in different coordinate systems (cylindrical and spherical).
CO5: Use multiple integrals for determining volumes, surface areas, and solving real-world problems.
CO6: Understand and apply Leibniz's rule for differentiation under the integral sign. CO7: Understand the historical development and concept of tensors as a generalization of vectors in E_2, E_3 and E_n.
CO8: Familiarize with Einstein's summation convention, Kronecker delta, and basic algebra of tensors.
Perform operations like addition, subtraction, scalar multiplication, outer and inner products, and contraction.
CO9: Apply the quotient law for tensor operations.
CO10: Explore Riemannian space, line elements, and metric tensors.
CO11: Compute and interpret the magnitude of vectors, angles between vectors, and transformations involving Christoffel symbols. Perform covariant differentiation and compute gradient, divergence, curl, and Laplacian of tensor fields.
CO12: Analyze Riemann-Christoffel curvature tensors, Ricci tensors, and scalar curvatures. CO13: Develop an understanding of Einstein's space and its applications.

Course Code: MATH4021 (MINOR COURSE)
Course Name: Ordinary Differential Equations

By completing this course, students will develop a strong foundation in solving and analyzing differential equations of various types and orders. Also they will be able to..

CO1: Understand and analyze Picard's existence theorem (statement only) for initial value problems.
CO2: Solve exact differential equations and identify conditions for integrability.
CO3: Work with equations of first order and higher degrees, including those solvable for p

$=\frac{dy}{dx}$, y or x.

CO4: Identify and solve singular solutions, including Clairaut's equations, and understand singular solutions as envelopes to families of general solutions.

CO5: Solve second-order linear differential equations and understand the concept of linearly independent solutions and the Wronskian. Derive general solutions for second-order equations with constant coefficients and compute particular integrals (P.I.) for various types of functions.

CO6: Apply the method of variation of parameters to find particular solutions.

CO7: Solve homogeneous linear equations of n-th order with constant coefficients and reduce the order of second-order equations when one solution is known.

CO8: Solve systems of simultaneous linear ordinary differential equations involving two dependent variables.

Work with differential equations of the form $\frac{dx}{P}=\frac{dy}{Q}=\frac{dz}{R}$.

CO9: Analyze and solve equations in Paffian form $Pdx + Qdy + Rdz = 0$, with a focus on the necessary and sufficient conditions for the existence of integrals.

CO10: Conduct qualitative studies of differential equations, including equilibrium points and their classifications.

CO11: Perform phase plane analysis and plot phase diagrams for simple problems, enhancing understanding of system behavior.

SEMESTER - V

Course Code: MATH5011 (MAJOR COURSE)
Course Name: Real Analysis - II

To familiarize the students with the fundamental properties of differentiability, with the concepts of bounded variations of real valued functions real variables and with the fundamental concepts of Riemann integration, sequence and series of functions. On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1: The students would gain knowledge about

i. Caratheodory's theorem on differentiability

ii. Rolle's theorem, Lagrange's and Cauchy mean value theorem, intermediate value property of derivatives

iii. curvature

iv. Taylor's and Maclaurin's expansion theorems and their applications.

v. functions of bounded variations

vi. Darboux integration, Riemann integration and their equivalency

vii. necessary and sufficient condition for Riemann integrability and basic properties of Riemann integral

viii. fundamental theorem integral calculus

ix. improper integrals and their properties

x. integrals containing an arbitrary parameter

CO2: The students would be able to

i. examine differentiability of a given function

ii. verify applicability of Rolle's theorem, Lagrange's and Cauchy mean value theorem, intermediate value property
iii. compute Taylor's and Maclaurin's series expansion of a given function and to apply Taylor's theorem to inequalities
iv. examine whether a function is of bounded variation or not
v. examine Riemann integrability of a given function
vi. compute Riemann integral of an integrable function
vii. characterize the class of all Riemann integrable functions
viii. examine convergence of various improper integrals
ix. to evaluate integrals using differentiation under the sign of integration.

CO3: Students would gain
i. fundamental concepts of differentiability and various properties like Caratheodory theorem, Rolle's theorem, Lagrange's and Cauchy mean value theorem, intermediate value property of derivatives, Taylor's and Maclaurin's expansion theorems, functions of bounded variations
ii. . fundamental concepts of Riemann integration, improper integrals and integrals containing an arbitrary parameter
iii. analytical and reason skills, which improve their thinking power.
iv.

Course Code: MATH5012 (MAJOR COURSE)
Course Name: Probability, Statistics & Linear Programming Problem

Objectives To equip students with the knowledge of Probability, Statistics, and Linear Programming. On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1:The students would gain knowledge about
i. mathematical foundations of Probability, Statistics including problem solving.
ii. mathematical foundations of Linear Programming including solution techniques.

CO2: The students would be able to
i. learn Probability, Statistics and their applications.
ii. construct Linear Programming problems from physical problems.
iii. formulate real-world problems using Linear Programming and solve them using appropriate techniques like simplex method.

CO3: The students would gain
i. general idea about the Probability, Statistics and Linear Programming.
ii. to solve the problems of Probability, Statistics and Linear Programming.

Course Code: MATH5013 (MAJOR COURSE)
Course Name: Differential Equations and Vector Analysis

Objectives To study differential equations through analytic approach and to acquire deep knowledge on vector analysis. On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1: Students would gain knowledge about use of differential equations in different areas of mathematics.

Ii. different aspects of vector analysis

CO2: I. Students would be able to apply the solution techniques of the differential equations in different physical problems.
II. solve the differential equations in different methods and can apply the differential equations in different areas.
III. apply vector analysis in different areas.
CO3:The students would gain
i. general idea about the solution techniques of differential equations.
ii. idea on the distinct features of various types of differential equations.
iii. experience to solve differential equations using analytical approach.
iv. general idea about vector analysis and its applications.

SEMESTER - VI

Course Code: MATH6011 (MAJOR COURSE)
Course Name: Introductory Numerical Analysis

Objectives To study numerical analysis to solve numerical problems that approximately emphasize error estimation. On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1: The students would gain knowledge about
i. Solving systems of linear and nonlinear equations using various numerical methods.
ii. Numerical integration is performed using different techniques.
iii. Conducting error analysis for these methods.
CO2: The students would be able to
i. Apply numerical solution techniques to a variety of physical problems.
ii. Conduct error analysis of numerical methods.
CO3: The students would gain
i. A broad understanding of computational techniques and algorithms for numerical methods.
ii. The ability to implement algorithms in a programming language.
iii. Skills for obtaining numerical solutions to physical problems.

Course Code: MATH6012 (MAJOR COURSE)
Course Name: Sequence and Series of functions & Elements of Complex Analysis

On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1:The students would gain knowledge about
i. sequence of functions and their basic properties
ii. series of functions and their basic properties
iii. Fourier series and its basic properties

iv. power series, radius of convergence of a power series and basic properties of a power series
v. . limit, continuity, differentiability of complex valued functions of complex variables and their properties, Cauchy-Riemann equations
vi. power series, absolute and uniform convergence, Cauchy-Hadamard theorem and their basic properties
vii. definite integral, contour integral, Cauchy's integral formula, Cauchy-Goursat theorem, Liouville's theorem, maximum modulus theorem, Laurent series.

CO2: The students would be able to
i. examine point-wise and uniform convergence of sequences of functions and their interrelationship
ii. examine convergence of various series of functions and also properties of the sum functions
iii. compute Fourier series, Fourier coefficients of periodic functions
iv. compute radius convergence of a power series, their integrability and differentiability criterion
v. . examine existence of limit, continuity and differentiability of complex valued functions of complex variables
vi. examine absolute and uniform convergence of various series of functions and also properties of the sum functions
vii. compute radius of convergence of a power series
viii. compute definite and contour integral of a complex valued functions of complex variables
ix. compute Laurent series expansion

CO3:The students would gain
i. sequence of functions, series of functions, Fourier series and power series, which will be useful for further studies in every branch of mathematics
ii. fundamental concepts of limit, continuity, differentiability of complex valued functions of complex variables, definite integral and contour integral, power series, absolute and uniform convergence
iii. analytical and reasoning skills, which improve their thinking power.

Course Code: MATH6013 (MAJOR COURSE)
Course Name: Partial Differential Equations

On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1: The students would gain knowledge about
i. qualitative analysis of the partial differential equations.
ii. . uses of partial differential equations in different areas of mathematics.

CO2: The students would be able to
i. apply the solution techniques of the partial differential equations in different physical problems.
ii. solve the non-linear partial differential equations.

CO3: The students would gain
i. general idea of solution techniques of partial differential equations.
ii. understanding about the distinct features of linear and non-linear partial differential equations.
iii. experience to solve partial differential equations

Course Code: MATH6014 (MAJOR COURSE)
Course Name: Mechanics

On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence.

CO1: The students would gain knowledge about
i. mathematical formalisms of statics, hydrostatics and dynamics.
ii. forces, friction, stable and unstable equilibrium and pressure of a fluid.
iii. virtual work, central force field and principal axes. Page 53 of 53

CO2: The students would be able to
i. describe the motion of a mechanical system.
ii. describe motion of a projectile.
iii. solve some physical systems moving under some forces in three dimensions.
CO3: The students would gain
I. general idea of statics, hydrostatics and dynamics which will be useful for further studies in theoretical physics.
II. knowledge about fundamental mechanical processes in nature.
III. experience to construct approximate mechanical models using mathematical tools.