SYLLABUS FOR B.A/B.SC. (HONOURS) IN MATHEMATICS

Under Choice Based Credit System (CBCS)
Effective from 2017-2018

The University of Burdwan
Burdwan-713104
West Bengal
Outlines of Course Structures

The main components of this syllabus are as follows:

1. **Core Course**
   - A course, that should compulsorily be studied by a candidate as a core requirement, is termed as a core course.

2. **Elective Course**
   - **2.1 Discipline Specific Elective (DSE) Course**: A course, which may be offered by the main discipline/subject of study, is referred to as Discipline Specific Elective.
   - **2.2 Generic Elective (GE) Course**: An elective course, chosen generally from an unrelated discipline/subject of study with intention to seek an exposure, is called a Generic Elective Course.

3. **Ability Enhancement Course (AEC)**
   - The Ability Enhancement Course may be of two kinds:
     - **3.1 Ability Enhancement Compulsory Course (AECC)**
     - **3.2 Skill Enhancement Course (SEC)**

### Details of Courses of B.A./B.Sc. (Honours) under CBCS

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Core Course (14 papers)</strong></td>
<td>Theory + Practical 14×(4+2)=84</td>
<td>14×75=1050</td>
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<tr>
<td><strong>2. Elective Course (8 Papers)</strong></td>
<td>Theory +Tutorial 14×(5+1)=84</td>
<td></td>
</tr>
<tr>
<td>A. DSE (4 Papers)</td>
<td>4×(4+2)=24</td>
<td>4×75=300</td>
</tr>
<tr>
<td>B. GE (4 Papers)</td>
<td>4×(4+2)=24</td>
<td>4×75=300</td>
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<tr>
<td><strong>3. Ability Enhancement Course</strong></td>
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</tr>
<tr>
<td>A. AECC (2 Papers)</td>
<td>4×1=4 2×1=2</td>
<td>100 50</td>
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<tr>
<td>AECC1 (ENVS)</td>
<td>4×1=4 2×1=2</td>
<td></td>
</tr>
<tr>
<td>AECC2 (English/MIL)</td>
<td></td>
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</tr>
<tr>
<td>B. SEC (2 Papers)</td>
<td>2×2=4</td>
<td>2×50=100</td>
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<td><strong>Total Credit</strong></td>
<td>142</td>
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<td><strong>Total Marks = 1900</strong></td>
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<tr>
<td>I</td>
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<td>SEC</td>
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<tr>
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<td>GE</td>
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To be offered by other discipline.

Total:

Semester wise Course Structures

3
<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Type</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
<th>Total class hrs./week</th>
<th>Marks</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CC</td>
<td>BMH5CC11</td>
<td>Partial Differential Equations and Applications</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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</tr>
<tr>
<td></td>
<td>CC</td>
<td>BMH5CC12</td>
<td>Mechanics I</td>
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Choose any one from the following courses for Discipline Specific Electives.

<table>
<thead>
<tr>
<th>Semester</th>
<th>DSE</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
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<th>Credit</th>
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<tbody>
<tr>
<td>V</td>
<td></td>
<td>BMH5DSE11</td>
<td>Linear Programming</td>
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<td></td>
<td></td>
<td>BMH5DSE12</td>
<td>Number Theory</td>
<td>5:1:0</td>
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<td>75</td>
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<tr>
<td></td>
<td></td>
<td>BMH5DSE13</td>
<td>Point Set Topology</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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Choose any one from the following courses for Discipline Specific Electives.

<table>
<thead>
<tr>
<th>Semester</th>
<th>DSE</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
<th>Total class hrs./week</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>BMH5DSE21</td>
<td>Probability &amp; Statistics</td>
<td>5:1:0</td>
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<td></td>
<td></td>
<td>BMH5DSE22</td>
<td>Portfolio Optimization</td>
<td>5:1:0</td>
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<td></td>
<td></td>
<td>BMH5DSE23</td>
<td>Boolean Algebra and Automata Theory</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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<table>
<thead>
<tr>
<th>Semester</th>
<th>CC</th>
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<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
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<th>Credit</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>BMH5CC13</td>
<td>Metric Spaces and Complex Analysis</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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<td></td>
<td></td>
<td>BMH5CC14</td>
<td>Ring Theory and Linear Algebra II</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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Choose any one from the following courses for Discipline Specific Electives.

<table>
<thead>
<tr>
<th>Semester</th>
<th>DSE</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
<th>Total class hrs./week</th>
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<th>Credit</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>BMH6DSE31</td>
<td>Mathematical Modeling</td>
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<td>75</td>
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<tr>
<td></td>
<td></td>
<td>BMH6DSE32</td>
<td>Industrial Mathematics</td>
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<td>75</td>
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<tr>
<td></td>
<td></td>
<td>BMH6DSE33</td>
<td>Group Theory II</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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Choose any one from the following courses for Discipline Specific Electives.

<table>
<thead>
<tr>
<th>Semester</th>
<th>DSE</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
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<th>Credit</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>BMH6DSE41</td>
<td>Bio Mathematics</td>
<td>5:1:0</td>
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<td>75</td>
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<tr>
<td></td>
<td></td>
<td>BMH6DSE42</td>
<td>Differential Geometry</td>
<td>5:1:0</td>
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<td>75</td>
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<tr>
<td></td>
<td></td>
<td>BMH6DSE43</td>
<td>Mechanics II</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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Optional Dissertation or project work in place of one Discipline Specific Elective (DSE) Paper.

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<th>Semester</th>
<th>PW</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
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<tr>
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<td></td>
<td>BMH6PW01</td>
<td>Project Work</td>
<td>0:0:6</td>
<td>6</td>
<td>75</td>
<td>6</td>
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</table>
Detailed Syllabus

Course: BMH1CC01

Calculus, Geometry & Differential Equations (Marks: 75)

Total lecture hours: 60

Unit -1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b} \sin x$, $e^{ax+b} \cos x$, $(ax+b)^n \sin x$, $(ax+b)^n \cos x$, concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L’Hospital’s rule, applications in business, economics and life sciences. 12L

Unit-2: Reduction formulae, derivations and illustrations of reduction formulae for the integration of $\sin nx$, $\cos nx$, $\tan nx$, $\sec nx$, $(\log x)^n$, $\sin^n \times \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Techniques of sketching conics. 12L

Unit -3: Reflection properties of conics, translation and rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid. 12L

Unit – 4: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. 12L

Graphical Demonstration (Teaching Aid) 12L

1. Plotting of graphs of function $e^{ax+b}$, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ and to illustrate the effect of $a$ and $b$ on the graph
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in Cartesian coordinates/polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using Cartesian coordinates

Books Recommended:

- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- G.F.Simmons, Differential Equations, Tata Megraw Hill.
- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and Mathematical analysis.

Course: BMH1CC02

Algebra (Marks: 75)

Total lecture hours: 60

Unit -1: Polar representation of complex numbers, n-th roots of unity, De Moivre’s theorem for rational indices and its applications. 5L

Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs, Cubic and biquadratic equations, reciprocal equation, separation of the roots of equations, Strum’s theorem 8L

Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality .4L

Unit -2: Equivalence relations and partitions, 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. 15L

Unit -3: Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. 10L
Unit 4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Vector spaces, Subspaces of $\mathbb{R}^n$, dimension of subspaces of $\mathbb{R}^n$, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. 18L

Books Recommended:

- Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
- K.B. Dutta, Matrix and linear algebra.
- K. Hoffman, R. Kunze, Linear algebra.
- W.S. Burnstine and A.W. Panton, Theory of equations.

Course: BMH2CC03

Real Analysis (Marks: 75)

Total lecture hours: 60

Unit-1: Review of Algebraic and Order Properties of $\mathbb{R}$, $\varepsilon$-neighbourhood of a point in $\mathbb{R}$. Idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets. Suprema and Infima. Completeness Property of $\mathbb{R}$ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in $\mathbb{R}$, Heine-Borel Theorem. 20L


Unit-3: 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, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence. 15L

Graphical Demonstration (Teaching Aid) 10L

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
5. Cauchy’s root test by plotting nth roots.
6. Ratio test by plotting the ratio of nth and (n+1)th term.

**Books Recommended:**

- S. Goldberg, *Calculus and mathematical analysis*.

**Course : BMH2CC04**

**Differential Equation and Vector Calculus (Marks : 75)**

**Total lecture hours: 60**

**Unit-1**: Lipschitz condition and Picard’s Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler’s equation, method of undetermined coefficients, method of variation of parameters. **20L**

**Unit-2**: Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. **20L**

**Unit-3**: Equilibrium points, Interpretation of the phase plane
Power series solution of a differential equation about an ordinary point, solution about a regular singular point. **6L**

**Unit- 4**: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. **10L**

**Graphical Demonstration (Teaching Aid) : 4L**

1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

**Books Recommended**:

- M.R. Speigel, *Schaum’s outline of Vector Analysis*
SYLLABUS FOR
GENERIC ELECTIVES OF MATHEMATICS
(For Other Honours Discipline)

Under Choice Based Credit System (CBCS)
Effective from 2017-2018

The University of Burdwan
Burdwan-713104
West Bengal

Generic Electives of Mathematics
<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Type</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Credit Pattern (L:T:P)</th>
<th>Total class hrs./week</th>
<th>Marks</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>GE</td>
<td>BMOHD1GE11</td>
<td>Calculus, Geometry &amp; Differential Equations</td>
<td>5:1:0</td>
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<td></td>
<td>GE</td>
<td>BMOHD1GE12</td>
<td>Algebra</td>
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<td>GE</td>
<td>BMOHD1GE13</td>
<td>Real Analysis</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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<tr>
<td>II</td>
<td>GE</td>
<td>BMOHD2GE21</td>
<td>Differential Equations and Vector Calculus</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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<tr>
<td></td>
<td>GE</td>
<td>BMOHD2GE22</td>
<td>Theory of Real Functions &amp; Introduction to Metric Spaces</td>
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<td>6</td>
<td>75</td>
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<tr>
<td></td>
<td>GE</td>
<td>BMOHD2GE23</td>
<td>Group Theory I</td>
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<td>75</td>
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<td>III</td>
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<td>BMOHD3GE31</td>
<td>Numerical Methods &amp; Numerical Methods Lab</td>
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<td>8</td>
<td>75 (50+25)</td>
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<tr>
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<td>BMOHD3GE32</td>
<td>Ring Theory and Linear Algebra I</td>
<td>5:1:0</td>
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<td>BMOHD3GE33</td>
<td>Number Theory</td>
<td>5:1:0</td>
<td>6</td>
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<td>IV</td>
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<td>BMOHD4GE41</td>
<td>Multivariate Calculus</td>
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<td>Mathematical Modeling</td>
<td>5:1:0</td>
<td>6</td>
<td>75</td>
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</table>

Course :BMOHD1GE11
Calculus, Geometry & Differential Equations (Marks : 75)

Total lecture hours: 60

Unit -1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type 
\[ e^{ax+b} \sin x, e^{ax+b} \cos x, (ax+b)^n \sin x, (ax+b)^n \cos x, \] concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L’Hospital’s rule, applications in business, economics and life sciences. 12L

Unit-2 : Reduction formulae, derivations and illustrations of reduction formulae for the integration of \( \sin nx, \cos nx, \tan nx, \sec nx, (\log x)^n, \sin^n x \sin^m x, \) parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Techniques of sketching conics. 12L

Unit -3: Reflection properties of conics, translation and rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid. 12L

Unit – 4: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. 12L

Graphical Demonstration (Teaching Aid)  12L

1. Plotting of graphs of function \( e^{ax+b}, \log(ax+b), 1/(ax+b), \sin(ax+b), \cos(ax+b), |ax+b| \) and to illustrate the effect of \( a \) and \( b \) on the graph
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in Cartesian coordinates/polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using Cartesian coordinates.

Books Recommended :

Course: BMOHD1GE12

Algebra (Marks: 75)

Total lecture hours: 60

Unit -1: Polar representation of complex numbers, n-th roots of unity, De Moivre’s theorem for rational indices and its applications. 5L

Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs, Cubic and biquadratic equations. 6L

Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. 4L

Unit -2: Equivalence relations and partitions, 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. 15L

Unit -3: Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. 10L

Unit 4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. 20L

Books Recommended:
Course: BMOHD1GE13

Real Analysis (Marks: 75)

Total lecture hours: 60

Unit-1: Review of Algebraic and Order Properties of $\mathbb{R}$, $\varepsilon$-neighbourhood of a point in $\mathbb{R}$. Idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets. Suprema and Infima. Completeness Property of $\mathbb{R}$ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in $\mathbb{R}$, Heine-Borel Theorem. 20L


Unit-3: 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, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence. 15L

Graphical Demonstration (Teaching Aid) 10L

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
5. Cauchy's root test by plotting nth roots.
6. Ratio test by plotting the ratio of nth and (n+1)th term.

Books Recommended:
- Tom M. Apostol, Mathematical Analysis, Narosa Publishing House
- Courant and John, Introduction to Calculus and Analysis, Vol I, Springer
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- Terence Tao, Analysis I, Hindustan Book Agency, 2006
- S. Goldberg, Calculus and mathematical analysis.

Course: BMOHD2GE21

Differential Equation and Vector Calculus (Marks: 75)

Total lecture hours: 60

Unit-1: Lipschitz condition and Picard’s Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler’s equation, method of undetermined coefficients, method of variation of parameters. 20L

Unit-2: Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. 20L

Unit-3: Equilibrium points, Interpretation of the phase plane, Power series solution of a differential equation about an ordinary point, solution about a regular singular point. 6L

Unit-4: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. 10L

Graphical Demonstration (Teaching Aid): 4L
1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

Books Recommended:
- Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
- Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.
- G.F. Simmons, Differential Equations, Tata McGraw Hill
- M.R. Speigel, Schaum’s outline of Vector Analysis

Course: BMOHD2GE22

Theory of Real Functions & Introduction to Metric Space (Marks: 75)

Total lecture hours: 60

Unit-1: Limits of functions (ε - δ approach), 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, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem. 18L

Unit-2: Differentiability of a function at a point and in an interval, Caratheodory’s theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle’s theorem. Mean value theorem, intermediate value property of derivatives, Darboux’s theorem. Applications of mean value theorem to inequalities and approximation of polynomials. 15L

Unit-3: 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 \( (1+x)^n \). Application of Taylor’s theorem to inequalities. **15L**

**Unit-4**: Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. **12L**

**Books Recommended**:

5. Tom M. Apostol, Mathematical Analysis, Narosa Publishing House
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer

**Course :BMOHD2GE23**

**Group Theory–I (Marks : 75)**

**Total lecture hours: 60**

**Unit-1**: Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups. **10L**

**Unit-2**: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. **5L**

**Unit-3**: Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange’s theorem and consequences including Fermat’s Little theorem. **20L**

**Unit-4**: External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy’s theorem for finite abelian groups. **10L**

**Unit-5**: Group homomorphisms, properties of homomorphisms, Cayley’s theorem, properties of isomorphisms. First, Second and Third isomorphism theorems. **15L**
Books Recommended:


Course: BMOHD3GE31

Numerical Methods & Numerical Methods Lab

(Theory: 50 & Practical: 25)

Total lecture hours: 60


Unit-2: Transcendental and Polynomial equations: Bisection method, Newton’s method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods. 7L

Unit-3: System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU Decomposition 7L


Numerical differentiation: Methods based on interpolations, methods based on finite differences. 7L


The algebraic eigenvalue problem: Power method.

Approximation: Least square polynomial approximation 9L

Unit-6: Ordinary Differential Equations: The method of successive approximations, Euler’s method, the modified Euler method, Runge-Kutta methods of orders two and four. 5L

Unit-7: Numerical Methods Lab 40L

List of practical (using C programming)

1. Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + .... + 1/N.
2. Enter 100 integers into an array and sort them in an ascending order.
3. Solution of transcendental and algebraic equations by
   a. Bisection method
c. Secant method.
d. Regula Falsi method.

4. Solution of system of linear equations
   a. LU decomposition method
   b. Gaussian elimination method
   c. Gauss-Jacobi method
   d. Gauss-Seidel method

5. Interpolation
   a. Lagrange Interpolation
   b. Newton Interpolation

6. Numerical Integration
   a. Trapezoidal Rule
   b. Simpson’s one third rule
   c. Weddle’s Rule
   d. Gauss Quadrature

7. Method of finding Eigenvalue by Power method

8. Fitting a Polynomial Function

9. Solution of ordinary differential equations
   a. Euler method
   b. Modified Euler method
   c. Runge Kutta method

**Books Recommended:**

- Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
Course : BMOHD3GE32

Ring Theory and Linear Algebra I (Marks : 75)

Total lecture hours: 60

Unit 1: Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. 20L

Unit 2: Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients. 10L

Unit 3: Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. 15L

Unit 4: Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix. 15L

Books Recommended:

Course : BMOHD3GE33
Number Theory (Marks : 75)

Total lecture hours: 60

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. 20L

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. 20L

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. 20L

Books Recommended:

Course : BMOHD4GE41
Multivariate Calculus (Marks : 75)

Total lecture hours: 60

Unit-1: Functions of several variables, limit and continuity of functions of two or more variables Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems. 25L

Unit-2: Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals. 20L

Unit-3: Definition of vector field, divergence and curl. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. 10L
Unit-4: Green’s theorem, surface integrals, integrals over parametrically defined surfaces. Stoke’s theorem, The Divergence theorem. 5L

Books Recommended:

- Tom M. Apostol, Mathematical Analysis, Narosa Publishing House
- Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
- W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
- Terence Tao, Analysis II, Hindustan Book Agency, 2006

Course: BMOHD4GE42

Linear Programming (Marks: 75)

Total lecture hours: 60

Unit 1: Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison. 22L

Unit 2: Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. 8L

Unit 3: Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem. 18L
Unit 4: Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games. 12L

Books Recommended:

Course: BMOHD4GE43

Partial Differential Equations and Applications (Marks: 75)

Total lecture hours: 60


Unit 2: Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms. 10L


Unit 4: Central force. Constrained motion, varying mass, tangent and normal components of acceleration, modelling ballistics and planetary motion, Kepler's second law. 10L

Graphical Demonstration (Teaching Aid) 10L

1. Solution of Cauchy problem for first order PDE.

2. Finding the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.

4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

   (a) $u(x,0) = \phi(x), u_x(x,0) = \psi(x), x \in \mathbb{R}, t > 0$.
   (b) $u(x,0) = \phi(x), u_x(x,0) = \psi(x), u(0,t) = 0, x \in (0,\infty), t > 0$.

5. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

   (a) $u(x,0) = \phi(x), u(0,t) = a, u(l,t) = b, 0 < x < \ell, t > 0$.
   (b) $u(x,0) = \phi(x), x \in \mathbb{R}, 0 < t < T$.

Books Recommended:

- Miller, F. H., Partial Differential Equations, John Wiley and Sons.

Course: BMOHD4GE44

Mathematical Modelling (Marks: 75)

Total lecture hours: 60

The modeling process. Arguments from scales: Dimensional analysis 8L
Arguments from data: Least squares, parameter estimation. 8L
Linear models: Generalized least squares estimators. 9L
Mathematical models in biology: Population models, predator-prey systems. 10L
Stability analysis: Equilibria, oscillations, growth and decay. 10L
Difference equations: Modeling of traffic flows. 8L
Poisson process: Waiting in line. 7L

Books Recommended: