Polba Mahavidyalaya, Polba, Hooghly
Session: 2024-2025
SEMESTER I, II, III AND IV COURSE WISE CREDIT DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020

Semester	Course Type with Code	Level	Course Title	Credit	Lect.	Tuto.	Pract./ Viva-voce	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Internal Assessment
I	Major/DS Course (Core) Code: MATH1011	100-199	Calculus, Geometry & Vector Calculus	4	3	1	0	75	60	0	15
	Minor Course Code: MATH1021	100-199	Calculus, Geometry & Vector Calculus	4	3	1	0	75	60	0	15
	Multi/Inter disciplinary Code: MATH1031		Trigonometry and Coordinate Geometry	3	2	1	0	50	40	0	10
	Ability Enhancement Course (AEC) [L_1-1 MIL] Code: AEC1041		Arabic/ Bengali/ Hindi/ Sanskrit/ Santali/ Urdu or Equvlnt. Course from SWAYAM /Any other UGC recognized platform	2	2	0	0	50	40	0	10
	Skill Enhancement Course (SEC) Code: MATH1051		Graph Theory	3	2	1	0	50	40	0	10
	Common Value Added (CVA) Course Code: CVA1061		Environmental Science/ Education	4	3	0	1	100	60	20	20
	Total			**20**				**400**			

Semester	Course Type with Code	Level	Name of the Course	Credit	Lect.	Tuto.	Pract./Viva-voce	Full Marks	Distribution of Marks		
									Theory	Pract./Viva-voce	Internal Assessment
II	Major/DS Course (Core) Code: MATH2011	100-199	Introductory Algebra & Number Theory	4	3	1	0	75	60	0	15
	Minor Course Code: MATH2021	100-199	Introductory Algebra & Number Theory	4	3	1	0	75	60	0	15
	Multi/Interdisciplinary Code: MATH2031		Algebra	3	2	1	0	50	40	0	10
	Ability Enhancement Course (AEC)[L_2-1] Code: AEC2041		English or Equvlnt. Course from SWAYAM/ /Any other UGC-recognized platform	2	2	0	0	50	40	0	10
	Skill Enhancement Course (SEC) Code: MATH2051		Programming in C	3	2	1	0	50	40	0	10
	Common Value Added (CVA) Course Code: CVA2061		Understanding India/Digital & Technological Solutions/Health & Wellness, Yoga Education, Sports & Fitness	4	3/3	1/0	0/1	100	80/60	0/20	20
Skill based vocational course (addl. 4 Cr) during summer term for 8 weeks, who will exit the programme after securing 40 cr.											
For UG Certificate 40 cr + Additional 4 cr (work based vocational course) = 44 cr. Students are allowed to re-enter within 3 years and complete the program within the stipulated max. period of 7 years											
	Total			**20**				**400**			

Semester	Course Type with Code	Level	Name of the Course	Credit	Lect.	Tuto.	Pract./Viva-voce	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Internal Assessment
III	Major/DS Course (Core) Code: MATH3011	200-299	Real Analysis I	5	4/3 or 0	1/0 or 0	0/2 or 5	75	60/40	0/20 or 60	15
	Major/DS Course (Core) Code: MATH3012	200-299	Linear Algebra	5	4/3 or 0	1/0 or 0	0/2 or 5	75	60/40	0/20 or 60	15
	Minor Course Code: MATH3021	200-299	Intermediate Level Course (Voc. Edn. &Trng.)	4	3/3 or 0	1/0 or 0	0/1 or 4	75	60/40	0/20 or 60	15
	Multi/Interdisciplinary Code: MATH3031		Calculus	3	2/2/0	1/0/0	0/1/3	50	40	0	10
	Ability Enhancement Course (AEC)[L_2-1] Code: AEC3041			2	2	0	0	50	40	0	10
	Skill Enhancement Course (SEC) Code: MATH3051		Mathematical Modelling	3	2/2/0	1/0/0	0/1/3	50	40	0	10
	Total			**22**				**375**			

Semester	Course Type with Code	Level	Name of the Course	Credit	Lect.	Tuto.	Pract./Viva-voce	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Internal Assessment
IV	Major/DS Course (Core) Code: MATH4011	200-299	Metric Spaces	5	4/3 or 0	1/0 or 0	0/2 or 5	75	60/40	0/20	15
	Major/DS Course (Core) Code: MATH4012	200-299	Group Theory & Ring Theory	5	4/3 or 0	1/0 or 0	0/2 or 5	75	60/40	0/20	15
	Major/DS Course (Core) Code: MATH4013	200-299	Multivariate Calculus & Tensor Calculus	5	4/3 or 0	1/0 or 0	0/2 or 5	75	60/40	0/20	15
	Minor Course Code: MATH4021	200-299	Intermediate Level Course (Voc. Edn. &Trng.)	4	3/3 or 0	1/0 or 0	0/1 or 4	75	60/40	0/20	15
	Ability Enhancement Course (AEC)[L_2-1] Code: AEC4041		English or Equvlnt. Course from SWAYAM	2	2	0	0	50	40	0	10
Skill based vocational course (addl. 4 Cr) during summer term for 8 weeks, who will exit the programme after securing 40 cr.											
For UG Certificate 40 cr + Additional 4 cr (work based vocational course) = 44 cr. Students are allowed to re-enter within 3 years and complete the program within the stipulated max. period of 7 years											
	Total			**21**				**350**			

Objectives

- To impart teaching so that the students could develop higher-order thinking capacities about the fundamental aspects of mathematics.
- To train the students with mathematical knowledge and computational techniques so that they can deal with the problems faced in different walks of life.
- To impart sophisticated mathematical skills so that students can undertake self-employment initiatives.
- To make the students capable of pursuing research work in various emerging fields of mathematics and its applications.

Pre-requisite

For major, minor and skill development courses, the students should possess the knowledge on the mathematics courses at (10+2) level. For multidisciplinary courses the students should possess the knowledge on the mathematics courses at secondary level.

Programme Outcomes

- Development of critical thinking for solving complex problems.
- Skills to characterise problems, formulate a hypothesis, evaluate and validate outcomes, and draw reasonable conclusions thereof.
- Development of the effective scientific and technical communications in both oral and written forms.

Programme Specific Outcomes

- Understanding the fundamental axioms in mathematics, and capability of developing ideas based on them.
- Development of mathematical reasoning and an understanding of the underlying fundamental structures of mathematics (i.e., sets, relations and functions, logical structure), and the relationship among them.
- Motivation for research studies in mathematics and related fields with real life applications.
- Knowledge in a wide range of mathematical techniques and applications of mathematical methods/tools in other scientific and engineering domains.
- Nurturing problem-solving skills, thinking, creativity through assignments, tutorials.
- Preparing for various competitive examinations at the national and international levels.

DETAILED SYLLABUS

SEMESTER – I

MAJOR COURSES

Course Code: MATH1011
Course Name: Calculus, Geometry &Vector Calculus
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To study calculus, geometry and vector calculus

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. higher order derivatives and its applications, concavity of curves, asymptotes and curve tracing techniques.
ii. reduction formula for integration of functions like $\sin nx$, $\sin^m x \sin^n x$ etc., area of surface of revolution, parametric curves etc.
iii. classification of conics and conicoids, polar equation of conics.
iv. vector valued functions and vector calculus.

Skills: The students would be able to

i. parametrize curves, sketch functions and plot them.
ii. visualize standard quadratic surfaces like cone, ellipsoid etc.
iii. apply calculus on vector valued functions.
iv. find gradient of scalar functions, divergence and curl of vector valued functions.

General competence: The students would gain

i. a general idea of advance calculus and its applications.
ii. the idea of solving complex problems using vector calculus and geometry.
iii. analytical and reasoning skills, which improve their thinking power and enhance their problem-solving ability.

Contents:

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b} \sin x$, $e^{ax+b} \cos x$, $(ax+b)^n sinx, (ax+b)^n cosx$, indeterminate forms, L'Hospital's rule, concavity of curves, points of inflection, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves. **[L-12H & T-4H]**

Reduction formulae, derivations and illustrations of reduction formulae for the integration of $sinnx$, $\cos nx$, $tannx$, $secnx$, $(logx)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution. **[L-10H & T-3H]**

Reflection properties of conics, translation and rotation of axes, general equation of second-degree, classification of conics, polar equations of conics, spheres, cylindrical surfaces. central conicoid, paraboloids, plane sections of conicoid, generating lines, classification of quadrics. **[L-11H & T-4H]**

Triple product of vectors, introduction to vector functions, algebraic operations on vector-valued functions, limits and continuity of vector functions, differentiation and partial differentiation of vector functions, gradient of a scalar function, divergence and curl of vector functions. [L-**12H & T-4H]**

Reading References:

Text Books:

1. Calculus - G.B. Thomas and R.L. Finney, 9th Ed., (Pearson Education, Delhi, 2005).
2. Calculus - M.J. Strauss, G.L. Bradley and K. J. Smith, 3rd Ed., (Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007).
3. Integral Calculus - K.C. Maity and R. K. Ghosh., (New Central Book Agency (P) Limited, 1999).
4. An Elementary Treatise on Coordinate Geometry of three-Dimensions–R.J.T. Bell, (MacMillan & Co.).
5. The Elements of Coordinate Geometry-S.L. Loney, (MacMillan & Co.).
6. Vector Analysis- K.C. Maity and R. K. Ghosh, (New Central Book Agency (P) Ltd. Kolkata, 1999).

Reference Books:

1. Calculus- T. M. Apostol, (Volumes I and II. Vol-I, 1966, Vol-II, 1968).
2. Calculus- H. Anton, I. Bivens and S. Davis, 7th Ed., (John Wiley and Sons (Asia) P. Ltd., Singapore, 2002).
3. Introduction to Calculus and Analysis - R. Courant and F. John, (Volumes I & II), (Springer-Verlag, New York, Inc., 1989).
4. Analytical Geometry of two and three-dimensions- N. Dutta and R. N. Jana, (Shredhar Prakashani).
5. Calculus and Mathematical Analysis- S. Goldberg, 1989.
6. Vector Calculus- J. Marsden, and Tromba, (McGraw Hill, 1987).
7. Schaum's outline of Vector Analysis- M.R. Spiegel, (McGraw Hill, 1980).
8. Vector Analysis with Applications - A. A. Shaikh and S. K. Jana, (Alpha Science International Ltd., 2009).

MINOR COURSES

Course Code: MATH1021
Course Name: Calculus, Geometry &Vector Calculus
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To study calculus, geometry and vector calculus

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. higher order derivatives and its applications, concavity of curves, asymptotes and curve tracing techniques.
ii. reduction formula for integration of functions like $\sin nx$, $\sin^m x \sin^n x$ etc., area of surface of revolution, parametric curves etc.
iii. classification of conics and conicoids, polar equation of conics.
iv. vector valued functions and vector calculus.

Skills: The students would be able to

i. parametrize curves, sketch functions and plot them.
ii. visualize standard quadratic surfaces like cone, ellipsoid etc.
iii. apply calculus on vector valued functions.
iv. find gradient of scalar functions, divergence and curl of vector valued functions.

General competence: The students would gain

i. a general idea of advance calculus and its applications.
ii. the idea of solving complex problems using vector calculus and geometry.
iii. analytical and reasoning skills, which improve their thinking power and enhance their problem-solving ability.

Contents:

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b} \sin x$, $e^{ax+b} \cos x$, $(ax+b)^n sinx, (ax+b)^n cosx$, indeterminate forms, L'Hospital's rule, concavity of curves, points of inflection, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves. **[L-12H & T-4H]**

Reduction formulae, derivations and illustrations of reduction formulae for the integration of $sinnx$, $\cos nx$, $tannx$, $secnx$, $(logx)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametriccurves, area of surface of revolution. **[L-10H & T-3H]**

Reflection properties of conics, translation and rotation of axes, general equation of second-degree, classification of conics, polar equations of conics, spheres, cylindrical surfaces. central conicoid, paraboloids, plane sections of conicoid, generating lines, classification of quadrics. **[L-11H & T-4H]**

Triple product of vectors, introduction to vector functions, algebraic operations on vector-valued functions, limits and continuity of vector functions, differentiation and partial differentiation of vector functions, gradient of a scalar function, divergence and curl of vector functions. [L-**12H & T-4H]**

Reading References:

Text Books:

1. Calculus - G.B. Thomas and R.L. Finney, 9th Ed., (Pearson Education, Delhi, 2005).
2. Calculus - M.J. Strauss, G.L. Bradley and K. J. Smith, 3rd Ed., (Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007).
3. Integral Calculus - K.C. Maity and R. K. Ghosh., (New Central Book Agency (P) Limited, 1999).
4. An Elementary Treatise on Coordinate Geometry of three-Dimensions–R.J.T. Bell, (MacMillan & Co.).
5. The Elements of Coordinate Geometry-S.L. Loney, (MacMillan & Co.).
6. Vector Analysis- K.C. Maity and R. K. Ghosh, (New Central Book Agency (P) Ltd. Kolkata, 1999).

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1. Calculus- T. M. Apostol, (Volumes I and II. Vol-I, 1966, Vol-II, 1968).
2. Calculus- H. Anton, I. Bivens and S. Davis, 7th Ed., (John Wiley and Sons (Asia) P. Ltd., Singapore, 2002).
3. Introduction to Calculus and Analysis - R. Courant and F. John, (Volumes I & II), (Springer-Verlag, New York, Inc., 1989).
4. Analytical Geometry of two and three-dimensions- N. Dutta and R. N. Jana, (Shredhar Prakashani).
5. Calculus and Mathematical Analysis- S. Goldberg, 1989.
6. Vector Calculus- J. Marsden, and Tromba, (McGraw Hill, 1987).
7. Schaum's outline of Vector Analysis- M.R. Spiegel, (McGraw Hill, 1980).
8. Vector Analysis with Applications - A. A. Shaikh and S. K. Jana, (Alpha Science International Ltd., 2009).

MULTIDISCIPLINARY COURSES

Course Code: MATH1031
Course Name: Trigonometric functions and coordinate geometry
(Credit: 3, Marks: 50)
Total Hours: Lecture - 30, Tutorial – 15

Objectives

To present the concepts of Trigonometric Functions, Straight Lines, Conic Sections and Introduction to Three - dimensional Geometry.

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. Trigonometric Functions.
ii. Straight Lines.
iii. Conic Sections.
iv. Introduction to Three - dimensional Geometry.

Skills: The students would be able to

i. solve the problem of Trigonometric Functions.
ii. solve the problem of Straight Lines.
iii. solve the problem of Conic Sections.
iv. solve the problem of Three - dimensional Geometry.

General competence: The students would gain

i. general idea of Trigonometric Functions, Straight Lines, Conic Sections and Introduction to Three - dimensional Geometry.
ii. analytical and reasoning skills, which improve their thinking power.

Contents:

Trigonometric Functions: Measurement of trigonometric angles, trigonometric functions and standard angles, trigonometric functions of associated angles, trigonometric functions of compound angles, transformations of sums and products of trigonometric functions, trigonometric functions of multiple angles, trigonometric functions of submultiple angles, general solution of the equations of trigonometric functions, properties of triangles. **[L-12H & T-6H]**

Two-dimensional geometry:

Straight line, circle, parabola, ellipse, hyperbola. **[L-12H & T-6H]**

Three - dimensional Geometry:

Coordinate axes and coordinate planes in three dimensions. Coordinates of a point. Distance between two points. **[L-6H & T-3H]**

Reading references:

Text Books:

1. Mathematics Part I - Textbook for Class XII, NCERT Publication
2. Mathematics Part II - Textbook for Class XII, NCERT Publication
3. Mathematics Exemplar Problem for Class XI, Published by NCERT
4. Elements of Mathematics - A. P. Baisnab and B. N. Ghatak, Oriental Book Company Pvt. Ltd.

Reference Books

1. Mathematics Exemplar Problem for Class XII, Published by NCERT
2. Mathematics for Class 12, R D Sharma, Dhanpat Rai Publications (P) LTD.
3. Mathematics for class 12, S.N.DE, Chhaya Prakashani Limited
4. Mathematics Class XII, Sandeep Garg, Dhanpat Rai Publications
5. Elements of Mathematics For Class XII (Vol-I and Vol-II), M.L. Bhargava, G.K Kharbanda, Anil Kathuria, Jeevan sons Publications

SKILL ENHANCEMENT COURSES

Course Code: MATH1051
Course Name: Graph Theory
(Credit: 3, Marks: 50)
Total Hours: Lecture -30, Tutorial – 15

Objectives

To study the basics of Graph theory and its applications.

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. undirected and directed graphs.
ii. ismorphism of graphs.
iii. Eulerian graphs, Hamiltonian graphs.
iv. various characterizations of trees with applications.
v. bipartite graph and its characterization.
vi. planar and non-planar graphs.
vii. colouring of a graph.
viii. matrix representation of graphs.

Skills: The students would be able to

i. assimilate various graph theoretic concepts and familiarize with their applications.
ii. efficiency in handling with discrete structures.
iii. efficiency in notions of matrix representation of graph, planarity.
iv. efficiency in solving concrete graph colouring problems.
v. solve real world problems that can be modelled by graphs.

General competence: The students would gain

i. general idea of graph theory and its real-life applications.
ii. understanding about graphic sequence.
iii. experience to apply Euler's formula.
iv. ability to use graphs for various map colouring problems.
v. idea about the application of graphs in computer science.

Contents

Definition, examples and basic properties of graphs, complete graphs, Havel-Hakimi theorem (Statement and its application), bi-partite graphs, isomorphism of graphs. **[L-8H & T-3H]**

Königsberg bridge problem, Eulerian graph, Hamiltonian graph, Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph. **[L-9H & T-3H]**

Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm. **[L-9H & T-3H]**

Planar and non-planar graphs, Euler's formula, colouring of graphs, four colour problem, five colour theorem. **[L-4H & T-1H]**

Reading references:

Text Books:

1. Graph Theory-N. S. Deo, (Prentice-Hall, 1974).
2. Introduction to Graph Theory - D. S. Malik, M. K. Sen & S. Ghosh, (Cengage Learning Asia, 2014).

Reference Books

1. A First Look at Graph Theory - J. Clark & D. A. Holton, (Allied Publishers Ltd., 1995).
2. Introduction to Graph Theory- Douglas Brent West, (Prentice Hall, 2001).
3. Graph Theory- Frank Harary, (Addison-Wesley, 1971).
4. Graph Theory with Applications- J. A. Bondy & U.S.R. Murty, (Macmillan, 1976).

SEMESTER – II

MAJOR COURSES

Course Code: MATH2011
Course Name: Introductory Algebra and Number Theory (Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To present a systematic introduction to number theory and basic course on algebra.

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. number theory which has wide applicability in advanced mathematics and also in various practical field, e.g., cryptography, computer science and many competitive exams.
ii. complex number and its properties which are equally indispensable tools for advanced studies and different practical field.
iii. a basic introduction to modern algebra which has wide applicability in different branch of sciences.

Skills:

The students would be able to

i. access and also generate different tricky examples and counter examples involving integers during their advanced study of ring theory and field theory.
ii. simplify a mathematical problem in different field of science using complex number.
iii. motivate themselves for future research after getting the glimpse of gateway of modern algebra from classical algebra and number theory and relate use of group, ring and field in different field of science.

General competence: The students would gain

i. descriptive idea of various properties of complex number.
ii. knowledge of richness in number theory.
iii. understanding in basic concepts of group, ring and field.
iv. expertise in solving many tricky problems in number theory, complex numbers.

Contents:

Algebra

Complex Numbers: De Moivre's theorem for rational indices and its applications.

Theory of equations: Fundamental Theorem of Algebra (Statement), Relation between roots and coefficients, Transformation of equation, Descarte's rule of signs, Cubic and biquadratic equations, Reciprocal equation, separation of the roots of equations, Strum's theorem.
Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. [L-**10H & T-4H]**

Partial order, total order relations, partitions of a set and its connection with equivalence relation, greatest lower bound, least upper bound, maximal, minimal elements, lattice, bounded lattice, modular lattice, distributive lattice, complemented lattice, statement of Zorn's lemma.

[L-**5H & T-2H]**

Semigroups, Monoids, Groups – examples including permutation group, Matrix groups $(M_{n\times n}(\mathbb{R}), GL_n(\mathbb{R}), SL_n(\mathbb{R}))$, Z_n, elementary properties of groups, generators and relations, order of an element of a group, Subgroups and examples of subgroups, cosets, normal subgroup, center of a group, cyclic groups, Lagrange's theorem, Rings, subrings, Ideals (left, right and two sided), integral domain, field, subfield – examples and basic properties, characteristic of a ring and field.

[L-**10H & T-4H]**

Number Theory

Well ordering principle of set of natural numbers, pigeon-hole principle, division algorithm, greatest common divisor (gcd), Euclidean algorithm, least common multiple (lcm), Linear Diophantine equation, prime numbers, relatively prime numbers and related properties including Euclid's lemma, fundamental theorem of arithmetic and its applications, perfect square and square free integers, congruences, solution of congruences, Binary and decimal representation of integer, Chinese remainder theorem and its application. Fermat's little theorem, Wilson's theorem, sum of two squares, Arithmetic function-$\phi(n), d(n), \sigma(n)$. [L-**20H & T-5H]**

Reading References:

Text books:

1. Classical Algebra- S. K. Mapa,8th Edition, (Sarat Book House).
2. Topics in Abstract Algebra – M.K. Sen, S. Ghosh, P. Mukhopadhyay, S. K. Maity, 3rd Edition (University Press).
3. Higher Algebra- S. K. Mapa,8th Edition, (Sarat Book House).
4. An introduction to Theory of Numbers- Niven, Ivan,S. Zuckerman Herbert, L. Montogomery Hugh,5th Edition, (Willey).
5. Elementary Number Theory- D. M. Burton, (Mc Graw Hill Education).

Reference Books:

1. Topics in Algebra – I. N. Herstein,2nd Edition, (Wiley).
2. Contemporary Abstract Algebra - Gallian, A. Joseph, Standard Edition, (Cengage India Private Limited).
3. Higher Algebra - S. Barnards, J. M. Child, (Arihant).
4. Algebra - M. Artin, 2nd Edition, (Pearson Education, India).
5. A first course in Abstract Algebra - J. B. Fraleigh7th Edition, (Pearson Education, India).

MINOR COURSES

Course Code: MATH2021
Course Name: Introductory Algebra and Number Theory
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To present a systematic introduction to number theory and basic course on algebra.

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. number theory which has wide applicability in advanced mathematics and also in various practical field, e.g., cryptography, computer science and many competitive exams.
ii. complex number and its properties which are equally indispensable tools for advanced studies and different practical field.
iii. a basic introduction to modern algebra which has wide applicability in different branch of sciences.

Skills:

The students would be able to

i. access and also generate different tricky examples and counter examples involving integers during their advanced study of ring theory and field theory.
ii. simplify a mathematical problem in different field of science using complex number.
iii. motivate themselves for future research after getting the glimpse of gateway of modern algebra from classical algebra and number theory and relate use of group, ring and field in different field of science.

General competence: The students would gain

i. descriptive idea of various properties of complex number.
ii. knowledge of richness in number theory.
iii. understanding in basic concepts of group, ring and field.
iv. expertise in solving many tricky problems in number theory, complex numbers.

Contents:

Algebra

Complex Numbers: De Moivre's theorem for rational indices and its applications.

Theory of equations: Fundamental Theorem of Algebra (Statement), Relation between roots and coefficients, Transformation of equation, Descarte's rule of signs, Cubic and biquadratic equations, Reciprocal equation, separation of the roots of equations, Strum's theorem.

Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. [L-**10H & T-4H]**

Partial order, total order relations, partitions of a set and its connection with equivalence relation, greatest lower bound, least upper bound, maximal, minimal elements, lattice, bounded lattice, modular lattice, distributive lattice, complemented lattice, statement of Zorn's lemma.

[L-**5H & T-2H]**

Semigroups, Monoids, Groups – examples including permutation group, Matrix groups $(M_{n\times n}(\mathbb{R}), GL_n(\mathbb{R}), SL_n(\mathbb{R}))$, Z_n, elementary properties of groups, generators and relations, order of an element of a group, Subgroups and examples of subgroups, cosets, normal subgroup, center of a group, cyclic groups, Lagrange's theorem, Rings, subrings, Ideals (left, right and two sided), integral domain, field, subfield – examples and basic properties, characteristic of a ring and field.

[L-**10H & T-4H]**

Number Theory

Well ordering principle of set of natural numbers, pigeon-hole principle, division algorithm, greatest common divisor (gcd), Euclidean algorithm, least common multiple (lcm), Linear Diophantine equation, prime numbers, relatively prime numbers and related properties including Euclid's lemma, fundamental theorem of arithmetic and its applications, perfect square and square free integers, congruences, solution of congruences, Binary and decimal representation of integer, Chinese remainder theorem and its application. Fermat's little theorem, Wilson's theorem, sum of two squares, Arithmetic function-$\phi(n), d(n), \sigma(n)$. [L-**20H & T-5H]**

Reading References:

Text books:

1. Classical Algebra- S. K. Mapa,8th Edition, (Sarat Book House).
2. Topics in Abstract Algebra – M.K. Sen, S. Ghosh, P. Mukhopadhyay, S. K. Maity, 3rd Edition (University Press).
3. Higher Algebra- S. K. Mapa,8th Edition, (Sarat Book House).
4. An introduction to Theory of Numbers- Niven, Ivan, S. Zuckerman Herbert, L. Montogomery Hugh,5th Edition, (Willey).
5. Elementary Number Theory- D. M. Burton, (Mc Graw Hill Education).

Reference Books:

1. Topics in Algebra – I. N. Herstein,2nd Edition, (Wiley).
2. Contemporary Abstract Algebra - Gallian, A. Joseph, Standard Edition, (Cengage India Private Limited).
3. Higher Algebra - S. Barnards, J. M. Child, (Arihant).
4. Algebra - M. Artin, 2nd Edition, (Pearson Education, India).
5. A first course in Abstract Algebra - J. B. Fraleigh7th Edition, (Pearson Education, India).

MULTIDISCIPLINARY COURSES

Course Code: MATH2031
Course Name: Algebra (Credit: 3, Marks: 50)
Total Hours: Lecture - 30, Tutorial – 15

Objectives

To present the concepts of Principle of Mathematical Induction, Complex Numbers and Quadratic Equations, Linear Inequality, Permutation and Combinations, Binomial Theorem, Sequence and Series, Matrices and Determinants.

Learning outcomes

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

Knowledge: The students would gain knowledge about

i. Principle of Mathematical Induction.
ii. Complex Numbers and Quadratic Equations.
iii. Linear Inequality, Permutation and Combinations.
iv. Binomial Theorem.
v. Sequence and Series.
vi. Matrices and Determinants

Skills: The students would be able to

i. solve the problem by using Principle of Mathematical Induction.
ii. solve the problem of Complex Numbers and Quadratic Equations.
iii. solve Linear Inequality, Permutation and Combinations.
iv. calculate Binomial Theorem, Sequence and Series.
v. calculate Matrices and Determinants.

General competence: The students would gain

i. general idea of Principle of Mathematical Induction, Complex Numbers and Quadratic Equations, Linear Inequality, Permutation and Combinations, Binomial Theorem, Sequence and Series, Matrices and Determinants.
ii. analytical and reasoning skills, which improve their thinking power.

Contents:

Mathematical induction, laws of indices, logarithm, complex numbers, quadratic equations, linear inequations, permutation and combination, binomial theorem, sequence and series. [**L-20H & T-10H]**

Matrices:

Types of matrix, operations on matrices, determinant, adjoint and inverse of a matrix, solution of linear simultaneous equations by matrix method **[L-10H & T-5H]**

Reading references:

Text Books:

1. Mathematics Part I - Textbook for Class XII, NCERT Publication
2. Mathematics Part II - Textbook for Class XII, NCERT Publication
3. Mathematics Exemplar Problem for Class XI, Published by NCERT
4. Elements of Mathematics - A. P. Baisnab and B. N. Ghatak, Oriental Book Company Pvt. Ltd, 2022.

Reference Books

1. Mathematics Exemplar Problem for Class XII, Published by NCERT
2. Mathematics for Class 12, R D Sharma, Dhanpat Rai Publications (P) LTD.
3. Mathematics for class 12, S.N.DE, Chhaya Prakashani Limited
4. Mathematics Class XII, Sandeep Garg, Dhanpat Rai Publications
5. Elements of Mathematics For Class XII (Vol-I and Vol-II), M.L. Bhargava, G.K Kharbanda, Anil Kathuria, Jeevansons Publications

SKILL ENHANCEMENT COURSES

Course Code: MATH2051
Course Name: Programming in C
(Credit: 3, Marks: 50)
Total Hours: Lecture -30, Tutorial – 15

Objectives

To learn the basics of C programming and its different features viz. branching & looping, array, user defined functions, structures and pointers

Learning outcomes

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

Knowledge: The students would gain knowledge about the

i. basics of C programming i.e., basic structure, keywords, identifiers, operators with operator precedence and associativity, input-output statements.
ii. concepts of branching & looping and array.
iii. user defined functions and their use.
iv. use of structures and pointers.

Skills: The students would be able to

i. learn the keywords, identifiers, different types of operators with precedence and associativity, use of formatted and non-formatted input-output statements.
ii. use branching and looping statements for decision making.
iii. learn the concepts of array, string handling arrays.
iv. use library and user-defined functions along with string handling functions.
v. write programs using structures and pointers.

General Competence: The students would gain

i. general idea about the writing of different C programs using branching & looping statements, arrays, functions, structures and pointers.
ii. program writing and reasoning skills which improve their thinking power.

Contents:

Introduction, basic structures, character set, keywords, identifiers, constants, variable-type declaration, operators: arithmetic, relational, logical, assignment, increment, decrement, conditional. [L- 3H & T- 1H]

Operator precedence and associativity, arithmetic expression, evaluation and type conversion, character reading and writing, formatted input and output statements. [L- 3H & T-1H]

Decision making (branching and looping): Simple and nested *if, if – else, switch, while, do-while, for* statements. [L- 5H & T-3H]

Concept of array variables, string handling with arrays – reading and writing, string handling functions. [L- 4H &T-2H]

User defined functions, call-by-value, call-by-reference functions and their uses, return values and their types, nesting of functions, recursion. [L- 5H & T-3H]

Structures: Declaration, initialization, nested structures, array of structures, array within structures. [L- 4H & T- 2H]

Pointers: Declaration, initialization, accessing variables through pointer, pointer arithmetic, pointers and arrays. [L- 6H & T-3H]

Reading references:

Text Books:

1. Programming in ANSI C-E. Balaguruswamy, (TMH, 2011).
2. Programming with C-B. S. Gottfried, (TMH, 2011).

Reference Books:

1. Programming with C-K. R. Venugopal and S. R. Prasad, (TMH, 1997).
2. The C Programming Language -Brian W. Kernighan and Dennis Ritchie, (Pearson Education India, 2015).
3. C Language and Numerical Methods-C. Xavier, (New Age International (P) Ltd. Pub, 2007).
4. The C Programming Language-Brian W. Kernighan / Dennis Ritchie, (Pearson Education India, 2015).

DETAILED SYLLABUS

SEMESTER – III

MAJOR COURSES

Course Code: MATH3011
Course Name: Real Analysis I (Credit: 5, Marks: 75)
Total Hours: Lecture -60, Tutorial – 15

Objectives:

To familiarize the students with the fundamental concepts of Real Analysis such as countable set, uncountable set, Archimedean property, completeness property, open set, closed set, compact set in $\mathbb{R}$. Also, to present the concepts of sequence of real numbers, series of real numbers, limit and continuity of real valued functions defined on subsets of $\mathbb{R}$.

Learning outcomes:

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

Knowledge: The students would gain knowledge about

i. Order property, Archimedean property, completeness property of $\mathbb{R}$.
ii. Countable set, uncountable set, limit point, interior point, open set, closed set, compact set in $\mathbb{R}$.
iii. Sequences, subsequence and series of real numbers.
iv. Limit, continuity and uniform continuity of real valued functions defined on subsets of $\mathbb{R}$ including their interrelationship.

Skills: The students would be able to

i. Characterize subsets of $\mathbb{R}$ which are open, closed, countable, uncountable, compact.
ii. Characterize sequences and subsequences in $\mathbb{R}$ which are convergent or divergent.
iii. Determine which infinite series of real numbers is convergent and which is not by using various test in their course.
iv. Calculate limit of real valued functions defined on subsets of $\mathbb{R}$.
v. Characterize real valued functions defined on subsets of $\mathbb{R}$ which are discontinuous, which continuous and which are uniformly continuous.

General Competence: The students would gain

i. Some fundamental concepts of real analysis which help them to learn all the branches of mathematics smoothly.
ii. Analytical and reasoning skills, which improve their thinking power.

Contents:

Review of algebraic and order properties of $\mathbb{R}$, idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$. Bounded above sets, bounded below sets, bounded sets, unbounded sets. Supremum and infimum. Completeness property of $\mathbb{R}$ and its equivalents. The Archimedean Property, dense sets in $\mathbb{R}$. Density of rational and irrational numbers in $\mathbb{R}$. Intervals, ε - neighbourhood of a point in $\mathbb{R}$, interior points of a set, open set, limit point of a set, isolated points, derived set, closed set. Interior, exterior, frontier and boundary of a set. Bolzano – Weierstrass Theorem for sets. Compact Sets in $\mathbb{R}$, Heine – Borel Theorem. **[L-20H & T-5H]**

Sequences of real numbers, bounded and unbounded sequences, convergent sequence, limit of a sequence and related Theorems. Monotonically increasing and decreasing sequences, relevant theorems, subsequences, theorems on monotone subsequence, Bolzano – Weirstrass theorem for sequences. Cauchy sequences, Cauchy's convergence criterion, lim sup, lim inf and associated theorems. **[L-13H & T-3H]**

Infinite series of real numbers, convergence and divergence of infinite series, Cauchy's convergence criterion, Abel's – Pringsheim's Theorem. Tests for convergence: Comparison Tests, D' Alembert's Ratio Test (Ratio Test), p - series, Cauchy's root test, Raabe's test, Gauss's test, Logarithmic test, De Morgan and Bertrand test, Integral test, Cauchy's condensation test. Alternating series, Leibnitz's test, Absolute and conditional convergence. Riemann's rearrangement theorem (statement only).
[L-12H & T-3H]

Limit of a function ($\varepsilon-\delta$ definition), sequential criteria for limits, divergence criteria, algebra of limits & theorems, infinite limits and limits at infinity. Continuous functions, sequential criteria for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, Bolzano's theorem on continuity, intermediate value theorem, fixed point theorem. Uniform continuity, non-uniform continuity criteria, theorems on uniform continuity. **[L-15H & T-4H]**

Suggested Books:

Text Books:

1. Introduction to Real Analysis - R.G. Bartle and D.R. Sherbert, (John Wiley and Sons (Asia) Pvt. Ltd., Singapore)(3rd Ed.,).
2. Mathematical Analysis- Tom M. Apostol, (Narosa Publishing House, 1981).
3. Calculus and mathematical Analysis- S. Goldberg.

Reference Books.

1. Introduction to Real Analysis - S. K. Mapa, (Sarat Book Distributors, Kolkata – 73).
2. Real Analysis - B.K. Lahiri & K.C. Roy, (World Press, Calcutta, 1988).
3. An Introduction to Analysis (Differential Calculus) - R.K. Ghosh & K.C. Maity, (New Central Book Agency (P) Ltd., Kolkata – 700009).
4. Mathematical Analysis - S. C. Malik & Savita Arora, (New Age International Publishers).

Course Code: MATH3012

Course Name: Linear Algebra (Credit: 5, Marks: 75)

Total Hours: Lecture -60, Tutorial – 15

Objectives:

To present a systematic introduction of the fundamental concepts of Linear Algebra and some of its applications.

Learning outcomes:

On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence. Linear algebra is a basic course in almost all branches of science.

Knowledge: The students would gain knowledge about

i. vector space and its dimension.
ii. linear transformation, transpose of a linear transformation and their matrix representation.
iii. system of linear equations and various methods to solve them.
iv. eigenvalues, eigenvectors, diagonalizability, canonical forms of a matrix.
v. inner product space, orthogonalization process, normal and self-adjoint operators.

Skills: The students would be able to

i. compute a basis and dimension of a vector space.
ii. compute matrix representation of matrix and its transpose,
iii. compute the characteristic polynomial, minimal polynomial, eigen value, eigen vector of a matrix as well as of a linear operator and use them in the basic diagonalization result.
iv. find canonical forms of a matrix
v. solve system of linear equations using Gaussian elimination method and matrix inversion method
vi. compute orthogonality of vectors in an inner product and applying Gram−Schmidt orthogonalization process they will obtain an orthonormal basis of an inner product space.

General competence: The students would gain

i. fundamental concepts of vector space, linear transformation, matrix representation of a linear transformation, solution methods of a system of equations, canonical forms of a matrix, diagonalization, orthogonalization, which will be useful for further studies in every branch of mathematics.
ii. analytical and reasoning skills, which improve their thinking power.

Contents:

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces, extension, deletion and replacement theorems. **[L-8H & T-2H]**

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

[L-12H & T-3H]

Elementary operations on matrices, row reduction and echelon forms of a matrix, rank of a matrix, characterization of invertible matrices using rank. Eigenvalues, Eigenvectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

[L-12H & T-3H]

System of linear equations, the matrix equation $Ax = b$, necessary and sufficient condition for consistency of a linear non-homogeneous system of equations, solution of systems of linear equations using Gaussian elimination method and matrix inversion method, solution sets of linear systems, applications of linear systems. **[L-8H & T-2H]**

Eigen spaces of a linear operator, diagonalizability, invariant subspaces, the characteristic polynomial and the minimal polynomial of a linear operator, diagonalization, Jordan canonical forms.

[L-12H & T-3H]

Inner product spaces and norms, Gram-Schmidt orthogonalization process, orthogonal complements and projections. **[L-4H & T-1H]**

Bilinear form, matrix associated with a bilinear form, quadratic form, rank, signature and index of a quadratic form, Sylvester's law of inertia (statement only), reduction of a quadratic form to normal form. **[L-4H & T-1H]**

Suggested Books:

Text books:

1. Linear Algebra - S. H. Friedberg, A.J. Insel & L.E. Spence, 4th edition (Prentice Hall of India pvt., 2004).
2. Linear Algebra - K. Hoffman, R. Kunze, 2nd edition (Pearson Education Limited, 2016).
3. Higher Algebra: Abstract and Linear - S. K. Mapa, (Levant Books, 2020) (1st Edition).

Reference books:

1. Linear Algebra- A Geometric Approach - S. Kumaresan, (Prentice Hall of India).
2. Linear Algebra - A. R. Rao & P. Bhimasankaram, 2nd Edition (Hindustan Book agency, 2000).
3. Topics in Algebra - I. N. Herstein, 2nd edition (John Wiley & Sons Inc (Sea) Pte Ltd, 2017).
4. Linear Algebra - S. K. Berberian (Oxford University Press, 1992).
5. Linear Algebra - S. Lang, (3rd edition) (Springer, 1987).
6. Basic Abstract Algebra - P. B. Bhattacharya, S. K. Jain & S. R. Nagpaul,, (2nd edition) (Cambridge University Press, 2014).
7. Linear Algebra Done Right - Sheldon Axler, (3rd edition) (Springer, 2015).

MULTIDISCIPLINARY COURSES

Course Code: MATH3031
Course Name: Calculus (Credit: 3, Marks: 50)
Total Hours: Lecture - 30, Tutorial – 15

Objectives:

To introduce the concepts of differential and integral calculus and their applications. Also, to give students a basic idea of ordinary differential equation.

Learning outcomes:

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

Knowledge: The students would gain knowledge about

(i) Limits and continuity of a function.
(ii) Derivative of a function
(iii) Integration of a function
(iv) applications of differential and integral calculus
(v) first order ordinary differential equations.

Skills: The students would be able to

(i) find the limits of a function,
(ii) check the continuity of a function,
(iii) find the derivatives of a real function
(iv) find the maximum or minimum values of a function
(v) integrate standard algebraic and trigonometric functions.
(vi) find the area enclosed by a curve.

General competence:

(i) The students would understand the importance of studying Calculus
(ii) They will gain a general idea of limits, continuity, derivatives and integration of a real Functions. Also, students will understand the basic notion of differential equations
(iii) Students analytical and reasoning skills will be improved, which ultimately enhance their thinking power.

Contents:

A brief history of the development of Calculus. Notion of variables and constants, idea of infinitesimals, Real Numbers and their properties, Intervals, Real Functions and their graphs. Monotone functions, even and odd functions, trigonometric functions. Limit of a Function and Limit Laws, Definition of a Limit, One-Sided Limits, Continuity, Continuity of important functions, Discontinuity. **[L-8H & T-4H]**

Differential Calculus: The Derivative as a Function, rules of differentiation, Differentiability, physical and geometrical significance of derivative, Derivatives of Trigonometric Functions, The Chain Rule.

Sign of the derivative and its significance. Local Maxima and minima of a real valued function.
[L-10H & T-5H]

Integral Calculus: Indefinite Integrals as anti-derivatives, standard results of Integration, The Definite Integral, properties of definite integrals, Integration as a limit of sum, Fundamental Theorem of Calculus, Area between curves. **[L-10H & T-5H]**

Ordinary Differential equation: Order & degree of a differential equation, Formation and solution of a differential equations, Differential equation of first order and first degree, simple applications.
[L-2H & T-1H]

Reading references:

Text Books:

1. Differential Calculus & Integral Calculus - R.K.Ghosh & K.C. Maity, (Books & Allied (P) Ltd).
2. An Introduction to Differential Equations - R.K.Ghosh & K.C. Maity, (Books & Allied (P) Ltd) (9th Edition).
3. Mathematics for Class 11 & 12 - S.N. Dey, (Chaya Prakashani).

Reference Books:

1. The History of the Calculus and Its Conceptual Development - Carl B. Boyer, (Dover Books on Mathematics).
2. Thomas' Calculus George B. Thomas , Joel Hass, Christopher Heil , Maurice D. Weir, Pearson .

SKILL ENHANCEMENT COURSES

Course Code: MATH3051
Course Name: Mathematical Modelling (Credit: 3, Marks: 50)
Total Hours: Lecture -30, Tutorial – 15

Objectives:

i. To provide fundamental concept of mathematical modelling,
ii. To discuss different types of models with the inclusion of linear, exponential, logistic, optimization, time series, simulation
iii. To discuss applicability of these models

Learning outcomes:

On successful completion of the course, the student will be well-conversed with the following outcomes

i. To gain knowledge about modelling
ii. To develop skill of model formation
iii. To update general competence

Knowledge:

i. Students to acquire basic knowledge concerning formation of various models
ii. Linear models help students to identify and estimate the relationship between variables, to analyze trends, to predict and make decisions from outcomes
iii. Exponential models help students to comprehend the rapid and often accelerating changes that occur in diverse natural and social systems
iv. Logistic model concerning real-world problems promote students to understand the limitations and saturation points of various processes
v. Optimization models empower students to take optimal decision and maximize the desired outcomes while considering real-world limitations and constraints
vi. Probabilistic/Stochastic models help students to handle uncertainty and make reasonable decisions by quantifying the likelihood of different outcomes
vii. Time series models facilitate students to analyze data, identify patterns, and make accurate predictions crucial for forecasting and understanding trends
viii. Simulation models provide powerful approach to study those systems in the event of non-availability of analytical solutions, support performance evaluation, risk analysis and decision support

Skill: Students to be

i. exposed to various mathematical models and their real-life applications
ii. benefited in simulations, understanding and predicting complex systems.

General competence:

i. To empower students the to understand the construction/framing mathematical models
ii. To analyze and solve the real-world problems mathematically
iii. To employ the usage of mathematical tools and techniques for the outcomes of those problems

Contents:

Overview of mathematical modelling and its applications in understanding real-world phenomena. Introduction to model classifications (Deterministic, Stochastic, Continuous, Discrete); Linear models and their applications; Usage of linear regression for modelling relationships between variables; Fitting linear models to data in analyzing trends and making predictions; Exponential model and its applications; Usage of exponential growth and decay models in population studies, finance, compound interest, half-life, and other relevant fields. **[L-8H & T-4H]**

Logistic models and their applications; Usage of logistic growth models in population studies, ecology, and epidemiology; Significance of logistic models in situations where growth is initially rapid but levels off over time. Optimization models and their applications; Use of linear programming and optimization techniques to maximize or minimize objectives; Importance of optimization models in resource allocation, production planning, and decision-making. Probabilistic/Stochastic models and their applications. **[L-12H & T-6H]**

Time series models and their applications; Importance of time series models in analyzing trends, seasonality, and forecasting future outcomes with applications. Introduction to simulation models and their applications; Monte Carlo simulation model, simulating deterministic features (area under a curve, volume under a surface) and other techniques for modelling uncertainty; Significance of simulation models in evaluating performance, risk analysis, decision support, random number generation. **[L-10H & T-5H]**

Suggested Books:

Text Books:

1. Mathematical Modeling: Models, Analysis, and Applications, Sandip Banerjee, Chapman and Hall/CRC.

2. A First Course in Mathematical Modeling, Frank R. Giordano, William P. Fox, and Steven B. Horton, Brooks/Cole.
3. Mathematical Models in Biology: An Introduction, Elizabeth S. Allman and John A. Rhodes, Cambridge University Press.
4. Practical Applied Mathematics: Modelling, Analysis, Approximation, Sam Howison, Cambridge University Press.

Reference Books:

1. Modelling with Mathematics: Authentic Problem Solving in Middle School, Nancy Butler Wolf, Heinemann.
2. Mathematical modelling, J. N. Kapur, New Age International Private Limited
3. Mathematical Modeling: Applications with GeoGebra, Jonas Hall and Thomas Lingefjärd, Wiley.
4. Mathematical Modeling, Mark. M. Meerschaert, Academic Press Inc.
5. Differential Equations and their applications, Zafar Ahsan, Prentice Hall India Learning Private Limited.

SEMESTER – IV

MAJOR COURSES

Course Code: MATH4011
Course Name: Metric Spaces (Credit: 5, Marks: 75)
Total Hours: Lecture -60, Tutorial – 15

Objectives:

Metric space is an indispensable intermediate in course of evolution of the general topological spaces. It generalizes the idea of distance between two points on the real line. In mathematics, a metric space is a set together with a distance. The distance is measured by a function called a metric or distance function. Metric spaces are the most general setting for studying many of the concepts of mathematical analysis and geometry.

Learning outcomes:

Students will be able to understand and appreciate the concept of a metric space by recognizing suitable examples. Students will be familiar with the fundamental notions of continuity, convergence and properties of completeness and compactness in a metric space.

Knowledge: Students will

i. be able to understand the distance function over the Euclidean spaces, space of all real valued continuous functions, sequence spaces etc.
ii. be able to learn the geometrical meaning of each of the metric properties.
iii. be able to classify the notion of open and closed balls for a given metric space.
iv. get exposure to the concept of continuity of functions.
v. learn the convergence of a sequence, the Cauchyness of a sequence in a given metric space.
vi. get exposure to the general notion of compactness property on a metric space and its analogue results in classical real and complex analysis.

Skills: Students would be

i. able to study the metric properties on a given metric space.
ii. able to study the topological properties of a metric space.
iii. motivated to work out various problems independently on the allied topics.
iv. influenced to study the analogue properties of a metric space in the space of real and complex numbers.

General Competence:

4. It helps the students to read and to learn further topics in analysis.
5. It motivates the students to make easier at understanding the use of functional analysis in applied problems.

Contents:

Metric spaces: Definition and examples. Open and closed balls, neighbourhood, interior points, open sets, interior of a set. limit points, closed sets, closure of a set, diameter of a set, boundedness of a set, exterior points, frontier points, boundary points, metric subspaces, equivalent metrics. **[L-8H & T-2H]**

Convergence of a sequence , Cauchy sequences, bounded sequences, complete metric spaces, dense sets, nowhere dense sets , sets of first and second category, Baire's category theorem, Cantor's intersection theorem, completion of a metric space, completeness property of $\mathbb{R}^n$, $C[a,b]$ with sup metric, l_p $(1 \leq p < \infty)$, incompleteness property of l_∞ and $C[a,b]$ with integral metric. **[L-12H & T-3H]**

Limit and continuity of mappings defined on metric spaces, sequential criterion of continuity, uniform continuity, homeomorphism, contraction mapping, Banach's Contraction Principle and its applications, viz. existence theorem on ODE (Picard's theorem), implicit function theorem, Fredholm integral equation, solution of a system of linear equations. **[L-8H & T-2H]**

Separated sets, connected sets, connectedness of a metric space and its properties, connectedness property under continuity, connected subsets of $\mathbb{R}$, components and relevant theorems. **[L-8H & T-2H]**

Open cover, compactness, countable compactness, sequential compactness, B-W compactness property, ϵ-net, totally bounded sets, coherence between compactness, completeness and totally boundedness property, Lebesgue number, Lebesgue covering lemma, equivalence of compactness, countable compactness, sequential compactness and B-W compactness property. Finite intersection property, compactness property using finite intersection property, compactness property under continuity and uniform continuity.

[L-16H & T-4H]

First and second countability of a metric space, separability and Lindelöf properties of a metric space.

[L-8H & T-2H]

Suggested Books:

Text books:

1. B. K. Lahiri, Elements of Functional Analysis, World Press, 1992.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
3. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, 2006.

Reference Books:

1. E. T. Copson, Metric spaces. Cambridge University Press,1968.
2. D. Gopal, A. Deshmukh, S. Ranadive, and S. Yadav, An introduction to Metric Spaces, Chapman & Hall, 2022.
3. A. K. Banerjee and A. Dey, Metric Spaces and Complex Analysis, New Age International Publishers, 2008.
4. B. Garai, An Introduction to Metric Spaces and Functional Analysis, Books and Allied, 2020.

Course Code: MATH4012

Course Name: Group Theory & Ring Theory (Credit: 5, Marks: 75)

Total Hours: Lecture -60, Tutorial – 15

Objectives:

Group and Ring are pivotal and initial steps to the learning modern algebra. Therefore, in this semester full stress on group and ring theory are implemented.

Learning outcomes:

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

Knowledge: The students would gain knowledge about

i. group theory which is enough for a student to appear at different competitive examination within India and abroad.
ii. ring theory which almost covers its basic areas that helps students to grasp advanced areas related to this subject by themselves.
iii. its wide applicability in different branch of sciences.

Skills: The students would be able to

i. understand the beauty of structures and structure preserving maps.
ii. simplify a mathematical problem in different field of science using group and ring theory.
iii. initiate tricks of action of groups on a set or set with one or more structures to crack intricated problems.
iv. identify nature of a groups, specifically finite or finitely generated abelian groups.

General competence: The students would gain

i. descriptive idea of group and ring theory.
ii. to properly analyze algebraic properties of ring of integers.
iii. knowledge of loss and gain in generalizing the algebraic concept of integers.
iv. of understanding categorical similarities of structures and their commonness in properties.
v. expertized in solving many tricky problems in group and ring theory.

Contents:

Group: Homomorphism, isomorphism, endomorphism, automorphism, inner automorphism, Quotient group, Isomorphism theorems (1st, 2nd and 3rd), Correspondence theorem, Normalizer of a set, Commutator subgroup, abelianization of a group-universal property and uniqueness, maximal normal subgroup, simple group, Dihedral group of order n and Quaternion group – their properties, Classification of all groups upto order 8, action of a group on a set - examples, representation of a group action in terms homomorphism, Cayley's theorem, stabilizer of a point and orbit of a point – their relation, free, faithful and transitive action, class equation, conjugacy class of an element, Burnside theorem, p-group and its properties (p prime), Cauchy's theorem on finite group, Sylow theorems (1st, 2nd, 3rd) – its application, Direct product, Direct sum – their differences and properties, semi-direct product of two groups, Representation of finite abelian group. **[L-40H & T-10H]**

Ring: Ring homomorphism, quotient ring, isomorphism theorems (1st, 2nd and 3rd), correspondence theorem, maximal ideal, prime ideal and primary ideal - their existence, relations, properties. Radical of an ideal, Jacobson radical of a ring, nil ideal, nilpotent ideal, irreducible and prime elements, Euclidean domain, Principal ideal domain, unique factorization domain – their properties, polynomial rings of one indeterminate over a field F and integral domain, $F[x]$, irreducible criteria of polynomials. **[L-20H & T-5H]**

Suggested Books:

Text books:

1. Bhattacharyya P. B., Jain S.K, Nagpaul S.R, Basic Abstract Algebra, Cambridge University Press, 2nd Edition.
2. Dummit S. David, Foote M. Richard, Abstract Algebra, Willey Student Edition, Second Edition.
3. Malik D.S., Mordeson N. John, Sen M.K, Fundamentals of Abstract Algebra, The McGrow-Hill Companies.

Reference Books:

1. Serre J.P, Finite Groups: An Introduction, International Press of Boston Inc.
2. Maclane Saunders, Birkhoff Garrett, Algebra: Third Edition, AMS Chelsea Publishing.
3. Artin, M, Algebra, 2nd Edition, Pearson Education, India.
4. Fraleigh, J.B, A first course in Abstract Algebra, 7th Edition, Pearson Education, India.
5. Cohn P.M, Basic Algebra: Groups, Rings, and Fields, Springer; First Edition.
6. Gallian, Joseph, A., Contemporary Abstract Algebra, Cengage India Private Limited, Standard Edition.

Course Code: MATH4013

Course Name: Multivariate Calculus & Tensor Calculus (Credit: 5, Marks: 75)

Total Hours: Lecture -60, Tutorial – 15

Objectives:

To present the concepts of function of several variables, their calculus and related various properties and applications. Also, to present the concept of tensor algebra, tensor calculus and their properties

Learning outcomes:

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

Knowledge: The students would gain knowledge about

i. functions of several variables, their calculus

ii. extrema of functions of n variables

iii. multiple integrals and their properties

iv. tensor calculus

Skills: The students would be able to

i. evaluate double limit, repeated limit etc. of functions of several variables,
ii. examine continuity of functions of several variables
iii. find partial and total derivatives of multivariate functions
iv. find extreme values of such functions, if they exist
v. calculate multiple integral of multivariate functions over certain domains, and so to find surface area and volumes of various shapes and bodies
vi. calculate various problems on tensor algebra and tensor calculus

General competence: The students would gain

i. general idea on limit, continuity, derivatives, integration of multivariate functions and general idea of tensors
ii. analytical and computing skills, which improve their visual and calculating powers.

Contents:

Multivariate Calculus (L-40H & T-10H)

Functions of several variables, repeated and double limits and continuity of functions of n variables. Partial derivatives, Euler's theorem, total derivative and differentiability, sufficient condition for differentiability. Chain rules, directional derivatives, Jacobian, the gradient, maximal and normal property of the gradient, tangent planes. Extrema of functions of n variables, method of Lagrange's undetermined multipliers, constrained optimization problems. **[L-20H & T-5H]**

Multiple integrals: Concept of double integral. Statement of existence theorem for continuous functions. Iterated or repeated integral, change of order of integration. Triple integral. Cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Transformation of double and triple integrals. Determination of volume and surface area by multiple integrals. Differentiation under the integral sign, Leibniz's rule.

[L-20H & T-5H]

Tensor Calculus (L-20H & T-5H)

Historical study of tensor. Concept of E^n. Tensor as a generalization of vector in E^2 , E^3 and E^n. Einstein's Summation convention. Kronecker delta. Algebra of tensor: Invariant, Contravariant and Covariant vectors. Contravariant, Covariant and mixed tensors. Symmetric and skew-symmetric tensors. Addition, subtraction and scalar multiplication of tensors. Outer product, inner product and contraction. Quotient law. **[L-8H & T-2H]**

Calculus of tensor: Riemannian space. Line element. Metric tensor. Reciprocal metric tensor. Raising and lowering of indices. Associated tensor. Magnitude of vector. Angle between two vectors. Christoffel symbols of different kinds and laws of transformations. Covariant differentiation. Gradient, divergence, curl and Laplacian. Ricci's theorem. Riemann-Christoffel curvature tensor. Ricci tensor. Scalar curvature. Einstein's space (Definition only). **[L-12H & T-3H]**

Suggested Books:

Text Books:

1. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001 18
2. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003

Reference Books:

1. Horst R. Beyer, Calculus and Analysis, Wiley, 2010.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
3. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
4. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), 2005.
5. S. N. Mukhopadhyay and S. Mitra, Mathematical Analysis, Volume – II, U. N. Dhur & Sons Pvt. Ltd., 2014
6. T. Apostol, Mathematical Analysis, Narosa Publishing House.
7. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
8. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
9. I. S. Sokolnikoff, Tensor Analysis: Theory and Applications, John Wiley and Sons, Inc., New York, 1951.
10. M. C. Chaki, A Text Book of Tensor Calculus, Calcutta Publishers, 2000.
11. U. C. De, A. A. Shaikh and J. Sengupta, Tensor Calculus, Alpha Science International Ltd; 2nd Revised Edition, 2007.

MINOR COURSES

Course Code: MATH4021
Course Name: Ordinary Differential Equations (Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives:

To study ordinary differential equations through analytic and qualitative approaches.

Learning outcomes:

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

Knowledge: The students would gain knowledge about

i. qualitative analysis of the ordinary differential equations.
ii. use of ordinary differential equations in different areas of mathematics.

Skills: The students would be able to

i. apply the solution techniques of the ordinary differential equations in different physical problems.
ii. solve the ordinary differential equations in different methods.
iii. apply the ordinary differential equations in different areas.

General competence: The students would gain

i. general idea about the solution techniques of ordinary differential equations.
ii. the distinct features of various types of ordinary differential equations.
iii. experience to solve differential equations using analytical approach.

Contents:

Picard's existence theorem (statement only) for $\frac{dy}{dx} = f(x, y)$ with $y = y_0, x = x_0$. Exact differential equations, condition of integrability. Equation of first order and first degree-exact equations and those reducible to exact form. Equations of first order higher degree-equations solvable for $p = \frac{dy}{dx}$, equations solvable for y, equations solvable for x, singular solutions, Clairaut's form. Singular solution as envelope to family of general solution to the equation.

[L-15H & T-5H]

Linear differential equations of second and higher order. Two linearly independent solutions of second order linear differential equation and Wronskian, general solution of second order linear differential equation, solution of linear differential equation of second order with constant coefficients. Particular integral (P.I.) for second order linear differential equation with constant coefficients for polynomial, sine, cosine, exponential function and for function as combination of them or involving them. Method of variation of parameters for P.I. of linear differential equation of second order. Homogeneous linear equation of n-th order with constant coefficients. Reduction of order of linear differential equation of second order when one solution is known. **[L-18H & T-6H]**

Simultaneous linear ordinary differential equation in two dependent variables. Solution of simultaneous equations of the form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$. Equation of the form (Paffian form) $Pdx + Qdy + Rdz = 0$. Necessary and sufficient condition for existence of integrals of the above. Qualitative studies of differential equations, Equilibrium points and their classifications, Phase plane analysis, Plotting of phase diagrams for some simple problems.

[L-12H & T-4H]

Suggested Books:

Text Books:

1. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co, 1897.
2. E.A. Coddington, N. Levinson, Theory of Ordinary Differential Equations, McGraw Hill, New York, 1955.
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

Reference Books:

1. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 2012.

2. G. F. Simmons, Differential Equations with Applications and Historical Notes, 2nd edition, McGraw Hill Education, 2017.

3. G. C. Layek, An Introduction to Dynamical Systems and Chaos, 2nd Edition, University Texts in the Mathematical Sciences, Springer, Singapore, 2024.

B.Sc. GENERAL (MATHEMATICS)

Course Structure: Semester V and VI Courses (as per CBCS)

Program Outcome:
After completion of the B.Sc. General program (as per CBCS), the students will be able to

PO No.	Program Outcomes
PO 1	Develop numerical and analytical skills and critical thinking that enable them to solve day-to-day problems
PO 2	Develop scientific, communicative, and numerical skills and make rewarding careers in science and education by facing challenging competitive exams.
PO 3	Gain scientific knowledge and skills that enable them to undertake further studies in an inter-disciplinary branch of science
PO 4	Apply scientific knowledge of principles, concepts, and results to their day-to-day life
PO 5	Enhance problem-solving skills

Programme Specific outcome

After the successful completion of this course, the student will be able to:

PSO1	Recall basic facts of mathematics and display knowledge of conventions such as notations, and terminology.
PSO2	Equipped with mathematical skills and techniques which can be applied in both academic and non-academic areas of work.
PSO3	Construct mathematical modeling of many physical phenomena.
PSO4	Face competitive examinations confidently using the acquired numerical skills and knowledge.
PSO5	Develop interest and a positive attitude towards mathematics as an interesting and valuable subject of study.

Semester	Course Code	Title	Credits
Discipline Specific Electives (DSE)			
Choices for DSE1A (Choose any one)			
V	BMG5DSE1A1	Matrices	6
	BMG5DSE1A2	Mechanics	6
	BMG5DSE1A3	Linear Algebra	6
Choices for DSE1B (Choose any one)			
VI	BMG6DSE1B1	Numerical Methods	6
	BMG6DSE1B2	Complex Analysis	6
	BMG6DSE1B3	Linear Programming	6
Skill Enhancement Courses (SEC)			
Choices for SEC3 (Choose any one)			
V	BMG5SEC31	Probability and Statistics	2

	BMG5SEC32	Mathematical Finance	2
	BMG5SEC33	Mathematical Modeling	2
Choices for SEC4 (Choose any one)			
VI	BMG6SEC41	Boolean Algebra	2
	BMG6SEC42	Transportaion and Game Theory	2
	BMG6SEC43	Graph Theory	2
	GRAND TOTAL		40

Semester-wise detailed syllabus

Discipline Specific Electives (DSE)

Choices for DSE1A (Choose any one)

SEMESTER – V	
Name of the Course: **Matrices**	
Course Code: **BMG5DSE1A1**	
Full Marks: 75	Credit: 6
Number of classes required: 60	

Course Objectives (BMG5DSE1A1)

The prime objectives of the course are:

- Work with matrices and determine if a given square matrix is invertible.
- Learn to solve systems of linear equations and application problems requiring them.
- Learn to compute determinants and know their properties.
- Learn to find and use eigenvalues and eigenvectors of a matrix.
- Learn about and work with vector spaces and subspaces.

Course Outcomes (BMG5DSE1A1)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Find the inverse of a square matrix.	PSO3
CO 2	Solve the matrix equation Ax = b using row operations and matrix operations.	PSO2, PSO4
CO 3	Find the determinant of a product of square matrices, of the transpose of a square matrix, and of the inverse of an invertible matrix.	PSO3
CO 4	Find the characteristic equation, eigenvalues and corresponding eigenvectors of a given matrix.	PSO1, PSO5
CO 5	Determine if a given matrix is diagonalizable.	PSO3

SEMESTER – V
Name of the Course: **Mechanics**
Course Code: **BMG5DSE1A2**

Full Marks: 75	Credit: 6
Number of classes required: 60	

Course Objectives (BMG5DSE1A2)

The prime objectives of the course are:

- Understand the various concepts of physical quantities and the related effects on different bodies using mathematical techniques.
- Emphasize knowledge building for applying mathematics in the physical world.
- To understand the concept of different forces and moments and their equilibrium concerning a coordinate system.
- To widen appreciation of the variety of phenomena covered by mechanics and the techniques available to handle them.

Course Outcomes (BMG5DSE1A2)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Understand the virtual work, stable and unstable equilibrium.	PSO5
CO 2	Solve the problems on the stability of near orbit, motion in a particle in 3D, and motion on a smooth sphere, cone, and any surface.	PSO2
CO 3	Understand the degree of freedom, D'Alembert's Principle, compound pendulum, and conservation of momentum and energy.	PSO1

SEMESTER – V	
Name of the Course: **Linear Algebra**	
Course Code: **BMG5DSE1A3**	
Full Marks: 75	Credit: 6
Number of classes required: 60	

Course Objectives (BMG5DSE1A3)

The prime objectives of the course are:

- To determine the eigen values and eigen vectors.
- To understand the concept of Algebra of linear transformations and matrices.
- Emphasize the application of techniques using the adjoint of linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.
- Understand the unique factorization domain and its applications, Cayley Hamilton theorem and its consequences, orthogonal projections and spectral theorem.

Course Outcomes (BMG5DSE1A3)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Use the definition and properties of linear transformations and matrices of linear transformations and change of basis, including kernel, range and isomorphism.	PSO3
CO 2	Demonstrate the ability to graphically or analytically analyze prime and maximal ideals, homomorphism and isomorphism theorem on rings and vector spaces.	PSO4, PSO5
CO 3	Demonstrate knowledge of inner product space, least squares approximation, normal and self-adjoint operator, spectral theorem.	PSO1, PSO2
CO 4	Demonstrate the ability of unique factorization domain and its applications, Cayley Hamilton theorem and its consequences, orthogonal projections and spectral theorem.	PSO5

Choices for DSE1B (Choose any one)

SEMESTER – VI	
Name of the Course: **Numerical Methods**	
Course Code: **BMG6DSE1B1**	
Full Marks: 75	Credit: 6
Number of classes required: 60	

Course Objectives (UMTMGE04)

The prime objectives of the course are:

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

Course Outcomes (UMTMGE04)

After completing the course, students will be able to

CO. No.	Course Outcome	PSOs Addressed
CO 1	Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.	PSO1
CO 2	Analyse and evaluate the accuracy of common numerical methods.	PSO2

SEMESTER – VI	
Name of the Course: **Complex Analysis**	
Course Code: **BMG6DSE1B2**	
Full Marks: 75	Credit: 6

Number of classes required: 60

Course Objectives (BMG6DSE1B2)

The prime objectives of the course are:

- To introduce the basic ideas of analysis for complex functions in complex variables with visualization through relevant practical.
- Understand Cauchy's theorems, series expansions, and calculation of residues.

Course Outcomes (BMG6DSE1B2)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Conceive the concepts of analytic functions and will be familiar with the elementary complex functions and their properties, and apply the concept and consequences of analyticity and the Cauchy Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra.	PSO1, PSO3
CO 2	Applies the theory to the application of the power series expansion of analytic functions, and understand the basic methods of complex integration and its application in contour integration.	PSO2
CO 3	Represent functions such as Taylor, power, and Laurent series, classify singularities and poles, find residues, and evaluate complex integrals using the residue theorem.	PSO4, PSO5

SEMESTER – VI	
Name of the Course: **Linear Programming**	
Course Code: **BMG6DSE1B3**	
Full Marks: 75	Credit: 6
Number of classes required: 60	

Course Objectives (BMG6DSE1B3)

The prime objectives of the course are:

- To develop the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research.
- Understand the Linear programming problems with applications to transportation, assignment and game problem.
- Understand the application of linear programming problems in manufacturing resource planning and financial sectors.

Course Outcomes (BMG6DSE1B3)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Formulate optimization problems and solve them using different methods.	PSO3
CO 2	Place a Primal linear programming problem into standard form and use the Simplex Method or Revised Simplex Method to solve it and find the dual, and identify and interpret the solution of the Dual Problem from the final tableau of the Primal problem.	PSO1, PSO2
CO 3	Explains the Transportation Problem and Assignment Problem, formulate them as an LPP and hence solve the problem.	PSO4
CO 4	To understand the theory of games for solving simple games.	PSO1, PSO2

Skill Enhancement Courses (SEC)

Choices for SEC 3 (Choose any one)

SEMESTER – V	
Name of the Course: **Probability and Statistics**	
Course Code: **BMG5SEC31**	
Full Marks: 50	Credit: 2
Number of classes required: 40	

Course Objectives (BMG5SEC31)

The prime objectives of the course are:

- To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.
- To render the students to several examples and exercises that blend their everyday experiences with their scientific interests.
- To extend and formalize knowledge of the theory of probability and use of Baye's theorem.
- To inculcate the concepts of random variables, mathematical expectation and correlation.
- Fostering the concept of discrete and continuous probability distributions.

Course Outcomes (BMG5SEC31)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Compute probabilities and conditional probabilities in appropriate ways.	PSO1, PSO3
CO 2	Solve word problems using combinatorial analysis.	PSO2

CO 3	Represent and statistically analyse data both graphically and numerically.	PSO4
CO 4	Demonstrate the ability of conditional probabilities statistically analyse data both graphically and numerically by presentation.	PSO5

SEMESTER – V	
Name of the Course: **Mathematical Finance**	
Course Code: **BMG5SEC32**	
Full Marks: 50	Credit: 2
Number of classes required: 40	

Course Objectives (BMG5SEC32)

The prime objectives of the course are:

- To provide an in-depth approach to credit risk modelling for the specific purpose of pricing fixed income securities and credit-risk derivatives.
- To explore the nature of factors underlying credit risk and develop models incorporating default risk.

Course Outcomes (BMG5SEC32)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Understand the mathematical foundations of quantitative finance	PSO1, PSO2
CO 2	Understand the standard and advanced quantitative methodologies and techniques of importance to a range of careers in investment banks and other financial institutions.	PSO2
CO 3	Create and evaluate potential models for the price of shares.	PSO3, PSO5
CO 4	Construct, evaluate and analyze models for investments and securities.	PSO3
CO 5	Apply scientific models and tools effectively.	PSO4

SEMESTER – V	
Name of the Course: **Mathematical Modeling**	
Course Code: **BMG5SEC33**	
Full Marks: 60	Credit: 2
Number of classes required: 40	

Course Objectives (BMG5SEC33)

The prime objectives of the course are:

- To introduce students to the elements of the mathematical modeling process;
- To present application-driven mathematics motivated by problems from within and outside mathematics;
- To exemplify the value of mathematics in problem solving; and
- To demonstrate connections among different mathematical topics.

Course Outcomes (BMG5SEC33)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Translate everyday situations into mathematical statements (models) which can be solved/analyzed, validated, and interpreted in context.	PSO1, PSO2
CO 2	Identify assumptions that are consistent with the context of the problem and which in turn shape and define the mathematical characterization of the problem.	PSO1
CO 3	Revise and improve mathematical models so that they will better correspond to empirical information and/or will support more realistic assumptions.	PSO2, PSO3
CO4	Assess the validity and accuracy of their approach relative to what the problem requires.	PSO4
CO5	Communicate mathematics in both oral and written form to a broad mathematical and lay audience, including the "end users" of a modeling problem, who may be utterly unfamiliar with the mathematics used.	PSO4, PSO5

Choices for SEC 4 (Choose any one)

SEMESTER – VI	
Name of the Course: **Boolean Algebra**	
Course Code: **BMG6SEC41**	
Full Marks: 50	Credit: 2
Number of classes required: 40	

Course Objectives (BMG6SEC41)

The prime objectives of the course are:

- To discuss connectives and well-formed formulas
- To explain Boolean functions and free Boolean algebras
- To explain representation and minimization of Boolean functions

Course Outcomes (BMG6SEC41)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Define Boolean algebra and sub-algebra	PSO1

CO 2	Explain Boolean functions and free Boolean algebras	PSO3
CO 3	Explain representation and minimization of Boolean functions	PSO4, PSO5

SEMESTER – VI	
Name of the Course: **Transportation and Game Theory**	
Course Code: **BMG6SEC42**	
Full Marks: 50	Credit: 2
Number of classes required: 40	

Course Objectives (BMG6SEC42)

The prime objectives of the course are:

- To understand the Linear programming problems with applications to transportation, assignment, and game problems.
- To understand the application of linear programming problems in manufacturing resource planning and financial sectors.
- To determine optimality conditions by using the Simplex method.
- To explain the traveling salesman problem and the game theory.
- To explain mixed strategies using linear programming techniques and algebraic methods.

Course Outcomes (BMG6SEC42)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Explain the Transportation Problem and Assignment Problem, formulate them as an LPP, and hence solve the problem.	PSO1, PSO2
CO 2	Understand the theory of games for solving simple games.	PSO2
CO 3	Determine optimality conditions by using the Simplex method. explain the traveling salesman problem	PSO3, PSO5
CO 4	Explain mixed strategies using linear programming techniques and algebraic methods	PSO4

SEMESTER – VI	
Name of the Course: **Graph Theory**	
Course Code: **BMG6SEC43**	
Full Marks: 60	Credit: 2
Number of classes required: 40	

Course Objectives (BMG6SEC43)

The prime objectives of the course are:

- Students will achieve command of the fundamental definitions and concepts of graph theory.
- Students will understand and apply the core theorems and algorithms, generating examples as needed, and asking the next natural question.
- Students will achieve proficiency in writing proofs, including those using basic graph theory proof techniques such as bijections, minimal counterexamples, and loaded induction.
- Students will work on clearly expressing mathematical arguments, in discussions and in their writing.
- Students will become familiar with the major viewpoints and goals of graph theory: classification, extremality, optimization and sharpness, algorithms, and duality.

Course Outcomes (BMG6SEC43)

After completing the course, students will be able to:

CO. No.	Course Outcome	PSOs Addressed
CO 1	Understand the concept of Graphs, which is an important tool for Mathematical Modelling	PSO1
CO 2	Understand different types of graphs and operations on graphs.	PSO2
CO 3	Relate real life problems or events with mathematical graphs.	PSO6
CO 4	Understand the concept of trees and algorithms to find special spanning trees.	PSO3
CO5	Understand directed graphs and its applications.	PSO2