The University of Burdwan

SYLLABUS FOR 3-YEAR DEGREE/4-YEAR HONOURS IN MATHEMATICS

Under Curriculum and Credit Framework

for

Undergraduate Programmes (CCFUP) as per NEP, 2020

With effect from 2023-2024

Preamble

Undergraduate (UG) Programme is of either 3 or 4-year duration, with multiple entry and exit points and re-entry options, with appropriate certifications such as:

- UG Certificate after completing 1 year (2 Semesters) of study in the chosen fields of study
- UG Diploma after 2 years (4 Semesters) of study
- Bachelor's Degree after 3 years (6 Semesters) programme of study
- Bachelor's Degree (Honours) after 4 years (8 Semesters) programme of study
- Bachelor's Degree (Honours with research) after 4 years (8 Semesters) programme of study, if the students complete a rigorous Research Project/ Dissertation in their major area(s) of study in the 4th year of a Bachelor's Degree.

The courses offered at the UG level are grouped into eight broad categories which along with the minimum credit requirements are as follows.

Broad Category of Course	**Credit requirement**		
	3-year UG Degree Prog.	**4-year UG Honours Prog.**	
		With RP	**Without RP**
Major (Core)	64	94	106
Minor	28	36	36
Multidisciplinary	09	09	09
Ability Enhancement Courses (AEC)	08	08	08
Skill Enhancement Courses (SEC)	09	09	09
Value Added Courses common for all UG students	08	08	08
Summer Internship	02	02	02
Research Project/Dissertation*	---	12	---
Total	128	178	178

*Honours students not undertaking research will pursue three major courses (each is of 4 credits) for 12 credits in lieu of a Research Project/Dissertation.

SEMESTER WISE & COURSE WISE CREDIT & MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020 FOR 3-YR. DEGREE/4-YR. HONOURS PROGRAMME(S)

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: 1041		MIL(L_1):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	1/0	0/1	100	80/60	0/20	20
	Total			**20**				**400**			

SEMESTER WISE & COURSE WISE CREDIT & MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020 FOR 3-YR. DEGREE/4-YR. HONOURS PROGRAMME(S)

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 Eng.] Code: ENGL2041		Functional 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
	Total			**20**				**400**			

Students exiting the programme after securing 40 credits will be awarded UG Certificate in the relevant Discipline /Subject provided they secure additional 4 credits in skill based vocational courses offered during summer term of second semester.

SEMESTER WISE & COURSE WISE CREDIT & MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020 FOR 3-YR. DEGREE/4-YR. HONOURS PROGRAMME(S)

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	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH3012	200-299	Linear Algebra	5	4	1	0	75	60	0	15
	Minor Course (Vocational Education &Training) Code: MSR3021 Or Code: HRM3021 Or Code: RSA3021	200-299	Medical Sales Representative Or Human Resource Management Or Retail Sales Associate	4	3	1	0	75	60	0	15
	Multi/Interdisciplinary Code: MATH3031		Calculus	3	2	1	0	50	40	0	10
	Ability Enhancement Course (AEC)[L_1-2 MIL] Code: 3041		MIL(L_1):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: MATH3051		Mathematical Modelling	3	2	1	0	50	40	0	10
	Total			**22**				**375**			

SEMESTER WISE & COURSE WISE CREDIT & MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020 FOR 3-YR. DEGREE/4-YR. HONOURS PROGRAMME(S)

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	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH4012	200-299	Group Theory & Ring Theory	5	4	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH4013	200-299	Multivariate Calculus & Tensor Calculus	5	4	1	0	75	60	0	15
	Minor Course (For the students chosen Mathematics as minor subject in Sem-I or II) Code: MATH4021	200-299	Ordinary Differential Equations	4	3	1	0	75	60	0	15
	Minor Course (Other than Mathematics) Code: ……4021	200-299		4	3/3	1/0	0/1	75	60/40	0/20	15
	Ability Enhancement Course (AEC)[L_2-2] Code: ENGL4041		Language and Creativity or Equvlnt. Course from SWAYAM	2	2	0	0	50	40	0	10
	Total			**25**				**425**			

Students exiting the programme after securing 87 credits will be awarded UG Diploma in the relevant Discipline /Subject provided they secure additional 4 credits in skill based vocational courses offered during summer term of fourth semester.

SEMESTER WISE & COURSE WISE CREDIT & MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020 FOR 3-YR. DEGREE/4-YR. HONOURS PROGRAMME(S)

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
V	Major/DS Course (Core) Code: MATH5011	300-399	Real Analysis - II	5	4	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH5012	300-399	Probability, Statistics & Linear Programming Problem	5	4	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH5013	300-399	Differential Equations and Vector Analysis	5	4	1	0	75	60	0	15
	Minor Course (Vocational Education &Training) Code: MSR5021 Or Code: HRM5021 Or Code: RSA5021	200-299	Medical Sales Representative Or Human Resource Management Or Retail Sales Associate	4	3	1	0	75	60	0	15
	Internship (for all students) Code: INT5081			2	0	0	2	50	0	50	0
									Project/Field Diary: 30 + Viva-Voce: 20		
	Total			**21**				**350**			

SEMESTER WISE & COURSE WISE CREDIT & MARKS DISTRIBUTION STRUCTURE UNDER CCFUP AS PER NEP, 2020 FOR 3-YR. DEGREE/4-YR. HONOURS PROGRAMME(S)

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
VI	Major/DS Course (Core) Code: MATH6011	300-399	Introductory Numerical Analysis	4	3	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH6012	300-399	Sequence and Series of functions & Elements of Complex Analysis	4	3	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH6013	300-399	Partial Differential Equations	4	3	1	0	75	60	0	15
	Major/DS Course (Core) Code: MATH6014	300-399	Mechanics	4	3	1	0	75	60	0	15
	Minor Course (Vocational Education &Training) Code: MSR6021 Or Code: HRM6021 Or Code: RSA6021	200-299	Medical Sales Representative Or Human Resource Management Or Retail Sales Associate	4	3	1	0	75	60	0	15
	Total			**20**				**375**			
	Grand Total **(Sem: I to VI)**			**128**				**2325**			

Students who want to undertake 3-year UG programme will be awarded UG Degree in the relevant Discipline /Subject upon securing 128 credits.

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 $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n \sin x$, $(ax+b)^n \cos x$, 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 $sinnx$, $\cos nx$, $\tan nx$, $\sec nx$, $(\log x)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution. **[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 $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n \sin x$, $(ax+b)^n \cos x$, 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 $\sin nx$, $\cos nx$, $\tan nx$, $\sec nx$, $(\log x)^n$, $\sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of 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).

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).

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-4H]**

Königsberg bridge problem, Eulerian graph, Hamiltonian graph, Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph. **[L-9H & T-4H]**

Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm. **[L-9H & T-5H]**

Planar and non-planar graphs, Euler's formula, colouring of graphs, four colour problem, five colour theorem. **[L-4H & T-2H]**

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).

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 – Weierstrass 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, 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, (3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore).
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.

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.

Skills: The students would be able to

i. compute a basis and dimension of a vector space.
ii. compute matrix representation of a linear transformation 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, Cauchy – Schwarz inequality, parallelogram law, Pythagorean theorem, 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 integrals, properties of definite integrals, integration as a limit of sum, fundamental theorem of integral calculus, area between curves. **[L-10H & T-5H]**

Ordinary differential equation: Order and 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]

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

Reference Books:

1. Metric spaces - E. T. Copson, (Cambridge University Press,1968).
2. An introduction to Metric Spaces, D. Gopal, A. Deshmukh, S. Ranadive, and S. Yadav, (Chapman & Hall, 2022).
3. Metric Spaces and Complex Analysis- A. K. Banerjee and A. Dey, (New Age International Publishers, 2008).
4. An Introduction to Metric Spaces and Functional Analysis- B. Garai, (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 of modern algebra. Therefore, in this course importance on group and ring theory is 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 can be correlated with other branches of mathematics.

ii. ring theory which almost covers its basic areas that helps students to grasp advanced areas related to this subject by themselves.

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, characteristic subgroup, maximal normal subgroup, simple group, dihedral group of order n and quaternion group – their properties, classification of all groups upto order 8. **[L-16H & T-4H]**

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, 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.

[L-16H & T-4H]

Direct product, Direct sum – their differences and properties, semi-direct product of two groups, Representation of finite abelian group. **[L-8H & T-2H]**

Ring: Ring homomorphism, quotient ring, isomorphism theorems (1st, 2nd and 3rd), correspondence theorem, maximal ideal, prime ideal and primary ideal - their existence, relations, properties. **[L-8H & T-2H]**

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-12H & T-3H]**

Suggested Books:

Text books:

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

Reference Books:

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

i. To present the concepts of function of several variables, their calculus and related various properties and applications.
ii. 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 several 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 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 and its converse for functions of three variables, total derivative and differentiability, sufficient condition for differentiability. Chain rules, directional derivatives, Schwarz theorem, Young's theorem, 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. Multivariable Calculus, Concepts and Contexts, 2nd Ed.- James Stewart, (Brooks /Cole, Thomson Learning, USA, 2001 18)
2. Tensor Calculus: A Concise Course- B. Spain, (Dover Publications, 2003)

Reference Books:

1. Calculus and Analysis- Horst R. Beyer, (Wiley, 2010).
2. Calculus, 9th Ed.- G. B. Thomas and R. L. Finney, (Pearson Education, Delhi, 2005).
3. Calculus, 3rd Ed.- M. J. Strauss, G. L. Bradley and K. J. Smith, (Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007).
4. Basic Multivariable Calculus- E. Marsden, A. J. Tromba and A. Weinstein, (Springer (SIE), 2005).

5. Mathematical Analysis, Volume – II- S. N. Mukhopadhyay and S. Mitra, (U. N. Dhur & Sons Pvt. Ltd., 2014)
6. Mathematical Analysis- T. Apostol, (Narosa Publishing House).
7. Introduction to Calculus and Analysis Vol II - Courant and John, (Springer)
8. Principles of Mathematical Analysis- W. Rudin, (Tata McGraw-Hill).
9. Tensor Analysis: Theory and Applications- I. S. Sokolnikoff, (John Wiley and Sons, Inc., New York, 1951).
10. A Text Book of Tensor Calculus- M. C. Chaki, (Calcutta Publishers, 2000).
11. Tensor Calculus- U. C. De, A. A. Shaikh and J. Sengupta, (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 functions and for functions 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. Introductory Course in Differential Equations- D. Murray, (Longmans Green and Co, 1897).
2. Theory of Ordinary Differential Equations- E.A. Coddington, N. Levinson, McGraw Hill, (New York, 1955).
3. Differential Equations- S. L. Ross, (3rd Ed., John Wiley and Sons, India, 2004).

Reference Books:

1. Elementary Differential Equations and Boundary Value Problems- Boyce and Diprima, (Wiley, 2012).
2. Differential Equations with Applications and Historical Notes- G. F. Simmons, (2nd edition, McGraw Hill Education, 2017).
3. An Introduction to Dynamical Systems and Chaos- G. C. Layek, (2nd Edition, University Texts in the Mathematical Sciences, Springer, Singapore, 2024).

SEMESTER – V

MAJOR COURSES

Course Code: MATH5011
Course Name: Real Analysis - II
(Credit: 5, Marks: 75)
Total Hours: Lecture -60, Tutorial – 15

Objectives

To familiarize the students with the fundamental properties of differentiability, with the concepts of bounded variations of real valued functions real variables and with the fundamental concepts of Riemann integration, sequence and series of functions.

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. Caratheodory's theorem on differentiability
ii. Rolle's theorem, Lagrange's and Cauchy mean value theorem, intermediate value property of derivatives
iii. curvature
iv. Taylor's and Maclaurin's expansion theorems and their applications.
v. functions of bounded variations
vi. Darboux integration, Riemann integration and their equivalency
vii. necessary and sufficient condition for Riemann integrability and basic properties of Riemann integral
viii. fundamental theorem integral calculus
ix. improper integrals and their properties
x. integrals containing an arbitrary parameter

Skills: The students would be able to

i. examine differentiability of a given function
ii. verify applicability of Rolle's theorem, Lagrange's and Cauchy mean value theorem, intermediate value property
iii. compute Taylor's and Maclaurin's series expansion of a given function like $sinx, cosx, e^{ax}, (1+x)^n, \log(1+x)$ and to apply Taylor's theorem to inequalities
iv. examine whether a function is of bounded variation or not
v. examine Riemann integrability of a given function
vi. compute Riemann integral of an integrable function
vii. characterize the class of all Riemann integrable functions
viii. examine convergence of various improper integrals
ix. to evaluate integrals using differentiation under the sign of integration.

General competence: The students would gain

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

Contents:

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, intermediate value property of derivatives, Darboux's theorem. Application of differential calculus: Curvature. **[L-10H & T-2H]**

Taylor's theorem with Lagrange's and Cauchy's form of remainders, extrema, Taylor's series and Maclaurin's expansions of exponential and trigonometric functions like $sinx, cosx, e^{ax}$, $(1+x)^n, \log(1+x)$etc. Application of Taylor's theorem to inequalities. **[L-7H & T-2H]**

Functions of bounded variations and related theorems, Lipschitz's condition, Lipschitz's function and bounded variation, Variation function. Jordan theorem, necessary and sufficient condition for a function to be of bounded variation. **[L-6H & T-1H]**

Riemann Integration: Definition of a partition of $[a, b]$, upper and lower sums, inequalities of upper and lower sums, definition of Riemann integration, Darboux's theorem, necessary and sufficient condition of Riemann integrability, Definition of Riemann integration by Riemann sum, and equivalence of two definitions. Riemann integrability of monotone and continuous functions on a finite closed interval $[a, b]$. Properties of Riemann integral; integration by parts, integration by substitution, Fundamental theorem of integral calculus, First and Second mean value theorems, intermediate value theorem for integrals. **[L-20H & T-5H]**

Improper integrals, convergence of improper integrals, Cauchy criterion, absolute and conditional convergence, tests for convergence of type I and type II integrals: all types of comparison tests, limit tests, μ - test for convergence of type I and type II integrals, tests for convergence of integrals like $\int_0^\infty \frac{sin\,x}{x}dx$, $\int_0^\infty \frac{|sin\,x|}{x}dx, \int_0^\infty \frac{sin^2 x}{x^2}dx$, $\int_0^\infty e^{-x^2}dx$, $\int_0^{\frac{\pi}{2}} log sin\,x\,dx$, $\int_0^1 \frac{log\,x}{\sqrt{x}}dx, \int_1^2 \frac{\sqrt{x}}{log\,x}dx$, Abel's & Dirichlet's tests for convergence, convergence of Gamma and Beta functions. Properties of Gamma and Beta functions, Relation between gamma and beta functions and associated integrals. Evaluation of improper integrals like:

$\int_0^\infty \frac{sin\,x}{x}dx$, $\int_0^\infty \left(\frac{sin\,x}{x}\right)^2 dx, \int_0^\infty e^{-x^2}dx, \int_0^{\frac{\pi}{2}} \log \sin x\,dx, \int_0^\infty log\left(x+\frac{1}{x}\right)\frac{dx}{1+x^2}$, etc. **[L-12H & T-3H]**

Integrals containing an arbitrary parameter: Differentiation under the sign of integration, $\int_c^d \left\{\int_a^b f(x,y)dx\right\}dy = \int_a^b \left\{\int_c^d f(x,y)dy\right\}dx$, Weierstrass's M-test, Evaluation of different types of integrals. **[L-5H & T-2H]**

Reading References:

Text Books:

1. Introduction to Real Analysis- R.G. Bartle and D.R. Sherbert, 3rd Ed., (John Wiley and Sons (Asia) Pvt. Ltd., Singapore).
2. Introduction to Real Analysis- S. K. Mapa, (Sarat Book Distributors, Kolkata).

Reference Books:

1. Principles of Mathematical Analysis- W. Rudin, (McGraw-Hill).
2. Mathematical Analysis- T. M. Apostol, (Narosa Publishing House).
3. Methods of Real Analysis- R. R. Goldberg, (Oxford & IBH Publishing).
4. A first course in Real Analysis- M. H. Protter and C. B. Morrey, (Springer Nature).

5. Real Analysis- B.K. Lahiri & K.C. Roy, (World Press, Calcutta, 1988).
6. Mathematical Analysis- S. C. Malik & Savita Arora, (New Age International Publishers).
7. The Theory of Calculus, Undergraduate Texts in Mathematics- K. A. Ross, (Elementary Analysis, Springer (SIE), Indian reprint, 2004).
8. Elements of Real Analysis- Charles G. Denlinger, (Jones & Bartlett (Student Edition), 2011).
9. Integral Calculus- Santi Narayan, (S. Chand, 2005).
10. An introduction to Analysis (Integral Calculus)- R. K. Ghosh and K. C. Maity, (New Central Book Agency (P) Limited, 12th Edition, 2013).

Course Code: MATH5012
Course Name: Probability, Statistics & Linear Programming Problem
(Credit: 5, Marks: 75)
Total Hours: Lecture -60, Tutorial – 15

Objectives
To equip students with the knowledge of Probability, Statistics, and Linear Programming.

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. mathematical foundations of Probability, Statistics including problem solving.
ii. mathematical foundations of Linear Programming including solution techniques.

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

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

Probability & Statistics

Contents:
Prerequisite: [Concept of mathematical probability, addition and multiplication rules of probability. Independent event, total probability, Bayes' theorem, Bernoulli trials, Binomial distribution. Boole's inequality, Bonferroni's inequality; Poisson trials and Poisson law of probability, Multinomial law]

Random variables, Discrete and continuous distribution functions: Poisson, exponential, uniform, normal, gamma, beta, Cauchy distributions, Transformation of random variables. **[L-5H & T-2H]**

Discrete and continuous distribution in two dimension, Marginal distribution, Bivariate uniform distribution, Bivariate Normal distribution, Transformation of two dimensional random variables, Conditional distribution, Mathematical expectation in one and two variables, Moments, Measures of skewness and kurtosis, Moment generating function, Characteristic function, Uniqueness of characteristic function (statement only) Conditional expectation, covariance, co-relation coefficient, Regression curves, χ^2, F and t distributions, convergence in probability, convergence in law.

[L-9H & T-2H]

Tchebycheff's inequality, Bernoulli's limit theorem, Law of large numbers, Concept of asymptotically normal distribution, De-Moivre-Laplace limit theorem, Central limit theorem in case of equal components. **[L-5H & T-1H]**

Sampling theory, simple random sampling, sampling distribution of the statistic; χ^2, t and F-distributions of the statistic. Theory of estimation, point estimation, unbiasedness, minimum variance, consistency, efficiency, sufficiently, maximum likelihood method; Interval estimation –confidence interval, approximate confidence interval. **[L-8H & T-2H]**

Testing of hypothesis, Neyman-Pearson lemma, Likelihood ratio testing, application to Normal (m, σ)-population, Pearsonian χ^2-test for goodness of fit. Theory of errors. **[L-3H & T-1H]**

Linear Programming

Contents:

Prerequisite: [General introduction to optimization problem, Definition of L.P.P., Mathematical formulation of the problem, Canonical & Standard form of L.P.P., Basic solutions, feasible, basic feasible & optimal solutions].

Reduction of a feasible solution to basic feasible solution. Hyperplanes, Convex sets and their properties, Convex functions, Extreme points, Convex feasible region, Convex polyhedron, Polytope, Supporting hyperplane, Separating hyperplane. **[L-4H & T-1H]**

Fundamental theorem of L.P.P., Replacement of a basis vector, Improved basic feasible solutions, Unbounded solution, Condition of optimality, Simplex method, Simplex algorithm, Artificial variable technique (Big M method, Two phase method), Inversion of a matrix by Simplex method, Solution of simultaneous equations by Simplex method. **[L-8H & T-2H]**

Duality in L.P.P.: Concept of duality, Fundamental properties of duality, Fundamental theorem of duality, Duality & Simplex method, Dual simplex method and algorithm. **[L-6H & T-1H]**

Transportation Problem (T.P.): Mathematical formulation, Existence of feasible solution, Loops and their properties, Initial basic feasible solutions (different methods, like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Optimal solutions, Degeneracy in T.P., Unbalanced T.P., Special cases in T.P. Assignment Problem (A.P.): Mathematical formulation, Solution methods of A.P., Hungarian method, Restrictions on assignments, maximization problem, unbalanced assignment problem. **[L-6H & T-2H]**

Theory of Games: Introduction, Two-person zero-sum games, Minimax and Maximin principles, Minimax and Saddle point theorems, Pure and Mixed Strategies games without saddle points, Minimax (Maximin) criterion, Dominance rules, Solution methods of games without saddle point: Algebraic method, Graphical method. **[L-6H & T-1H]**

Reading References:

Text Books:

1. Mathematical Statistics with Applications-Irwin Miller and Marylees Miller and John E. Freund, 7th Ed., (Pearson Education, Asia, 2006).
2. Introduction to Probability Models- Sheldon Ross, 9th Ed., (Academic Press, Indian Reprint, 2007).
3. Ground work of Mathematical Probability and Statistics- A. Gupta, (Academic publishers, 1983).
4. Linear Programming- G. Hadley, (Addison – Wesley, 1963).
5. Advanced Operations Research- A. K. Bhunia and L. Sahoo, (Asian Books Pvt. Ltd., 2011)
6. Operations Research - An Introduction- H. A. Taha, (Prentice-Hall, 1997)

Reference Books:

1. Introduction to the Theory of Statistics- Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, 3rd Ed., (Tata McGraw- Hill, Reprint 2007)
2. First Course in Probability- S. Ross, (Pearson Education, 2012).
3. An Introduction to Probability Theory and its Applications- W. Feller, Vol-I, (Wiley, Third Edition, 1968).
4. An Introduction to Probability Theory and its Applications- W. Feller, Vol-II, (Wiley, Second Edition, 1971).
5. Probability and Statistics- K. Mukherjee, (New Central Book Agency; First Edition, 2012).
6. Introduction to Mathematical Statistics- R. V. Hogg, J. W. Mekenard and A.T. Craig, (Pearson Education, 2005).
7. Mathematical Probability- A. Banerjee, S. K. De & S. Sen, (U. N. Dhur & Sons Pvt. Ltd., Revised 3rd Edition).
8. Elements of Probability and Statistics- A. P. Baisnab, & M. Jas, (TMH, 1993).
9. Schaum's Outline of Operations Research- R. Bronson and G. Naadimuthu, (Schaum's Outline, 2nd Edition, 1997).
10. Linear Programming and Game Theory- J.G. Chakravorty and P.R. Ghosh, (Moulik Library, 2009).
11. Operations Research – Theory and Applications- J. K. Sharma, (Macmillan, 2007).

Course Code: MATH5013
Course Name: Differential Equations and Vector Analysis
(Credit: 5, Marks: 75)
Total Hours: Lecture -60, Tutorial – 15

Objectives

To study differential equations through analytic approach and to acquire deep knowledge on vector analysis.

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. use of differential equations in different areas of mathematics.
ii. different aspects of vector analysis

Skills: The students would be able to

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

General competence: The students would gain

i. general idea about the solution techniques of differential equations.
ii. idea on the distinct features of various types of differential equations.
iii. experience to solve differential equations using analytical approach.
iv. general idea about vector analysis and its applications.

Contents:

Basic concepts and terminology, Peano's theorem, Existence and uniqueness, Lipschitz condition and Picard's Theorem (Statement only). Lagrange and Clairaut equations, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Computations of exponential matrices, Method of fundamental solution. Equilibrium points and their classifications, Phase plane analysis, Qualitative study of simple pendulum, Plotting of phase diagram for some simple problems. **[L-19H & T-3H]**

Systems of linear differential equations, Types of linear systems, Differential operators, 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, Euler's equation, Method of undetermined coefficients, Method of variation of parameters. **[L-19H & T-4H]**

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, Bernoulli equation: Applications in engineering, finance and physics.

Power series solution of a differential equation about a regular singular point, Properties of the solutions of Legendre equation and Bessel equation. **[L-14H & T-4H]**

Properties of solenoidal and irrotational vector field, integration of vector functions, Line integrals, Fundamental theorem for line integrals, Green's theorem, Surface integrals, Stoke's theorem, Gauss divergence theorem and their applications. **[L- 8H & T-4H]**

Reading References:

Text Books:

1. Differential Equations- S.L. Ross, 3rd Ed., (John Wiley and Sons, India, 2004).
2. Introductory Course in Differential Equations- D. Murray, (Longmans Green and Co, 1897).
3. Vector Analysis- K.C. Maity and R.K. Ghosh, (New Central Book Agency (P) Ltd., Kolkata, India).
4. Vector Analysis with Applications- A. A. Shaikh and S. K. Jana, (Alpha Science International Ltd., 2009).

Reference Books:

1. Elementary Differential Equations and Boundary Value Problems- Boyce and Diprima, (Wiley, 2012).
2. Differential Equations- G. F. Simmons, (Tata McGraw Hill, 1991).
3. Ordinary Differential Equations- G. Birkhoff & G. Rota, (4th edition, Wiley, 1989).
4. Theory of Ordinary Differential Equations- E. A. Coddington, N. Levinson, (McGraw Hill, New York, 1955).
5. Schaum's outline of Vector Analysis- M.R. Spiegel, (Tata McGraw-Hill, 2009).

SEMESTER – VI

MAJOR COURSES

Course Code: MATH6011
Course Name: Introductory Numerical Analysis
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To study numerical analysis to solve numerical problems that approximately emphasize error estimation.

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. Solving systems of linear and nonlinear equations using various numerical methods.
ii. Numerical integration is performed using different techniques.
iii. Conducting error analysis for these methods.

Skills: The students would be able to

i. Apply numerical solution techniques to a variety of physical problems.
ii. Conduct error analysis of numerical methods.

General competence: The students would gain

i. A broad understanding of computational techniques and algorithms for numerical methods.
ii. The ability to implement algorithms in a programming language.
iii. Skills for obtaining numerical solutions to physical problems.

Contents:

Algorithms, Numerical Convergence, Numerical Stability, Errors: Relative, Absolute, Percentage, Round off, Truncation; General formula for errors, Propagation of errors in arithmetic calculations. **[L-1H & T-1H]**

Finding Roots of Transcendental and Polynomial Equations: Bisection method, Newton-Raphson method, secant method, Regula-Falsi method, fixed point iteration. Rates and conditions of convergence of these methods. **[L-7H & T-2H]**

Solutions of the System of Linear Algebraic Equations: Direct methods: Gaussian Elimination and Gauss Jordan methods. Iterative methods: Gauss Jacobi method, Gauss-Seidel method, and their convergence, Operational count of each of the above methods. **[L-8H & T-3H]**

Interpolation: Weierstrass approximation theorem (statement only), Finite difference operators, Difference tables and propagation of errors, Noise level; theory of polynomial interpolation, Lagrange and Newton's interpolation, Errors, Gregory forward and backward difference interpolations, Central difference interpolations, Inverse interpolation.
Numerical Differentiation: Methods based on interpolation; methods based on finite differences. Bounds of Error. **[L-12H & T-3H]**

Numerical Integration: Newton Cotes' quadrature formula without the derivation of error. Degree of precision, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule, Weddle's rule, Boole's rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule, Gauss quadrature formula. Geometrical significances and errors in each of the above methods. **[L-12H & T-4H]**

Ordinary Differential Equations: Picard's successive approximations, Taylor series method, Euler's method, the modified Euler method, and Runge-Kutta methods of orders two and four including errors. Geometrical significances. **[L-5H & T-2H]**

Reading References:

Text Books:

1. Introduction to Numerical Analysis- A. Gupta and S. C. Bose, (Academic Publishers, 2009).
2. Numerical Methods for Scientific and Engineering-M.K. Jain, S.R.K. Iyengar and R.K. Jain, (2012).
3. An Introduction to Numerical Analysis- K. E. Atkinson, (John Wiley and Sons, 1978).

Reference Books:

1. Applied Numerical Analysis- C.F. Gerald and P.O. Wheatley, (Pearson Education, India, 2008).
2. A First Course in Numerical Methods- Uri M. Ascher and Chen Greif, 7th Ed., (PHI Learning Private Limited, 2013).
3. Numerical Mathematical Analysis- James B. Scarborough, (Oxford and IBH publishing co, 1966).

Course Code: MATH6012
Course Name: Sequence and Series of functions & Elements of Complex Analysis
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To familiarize the students with

i. the concepts of sequence and series of functions, Fourier and power series
ii. the fundamental concepts of limit, continuity, differentiability, integrability of complex valued functions of complex variables and also with power series, uniform and absolute convergence.

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

Skills: The students would be able to

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

General competence: The students would gain

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

Sequence and Series of functions

Contents:

Pointwise and uniform convergence of sequence of functions, theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions, theorems on continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-test**.** **[L-10H & T-3H]**

Fourier series: Definition of Fourier coefficients and Fourier series, Riemann – Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions. **[L- 7H & T-3H]**

Power series, radius of convergence, Cauchy – Hadamard theorem, differentiation and integration of power series; Abel's theorem, Weierstrass Approximation Theorem. **[L- 5H & T-2H]**

Elements of Complex Analysis

Contents:

Regions in the complex plane, stereographic projections. Complex valued functions of complex variable, limits, limits involving the point at infinity, continuity and differentiability of functions, algebra of continuous functions, analytic functions, examples of analytic functions, Cauchy-Riemann equations, sufficient condition for analyticity, determination of harmonic conjugate. **[L-8H & T-2H]**

Power series, absolute and uniform convergence, radius of convergence, circle of convergence, sum function of a power series, term-by-term differentiations, Cauchy-Hadamard theorem, exponential function, logarithmic function, trigonometric functions and their derivatives. **[L-5H & T-2H]**

Definite integrals of functions, contour integrals and its examples, rectifiable path, smooth curve, Jardon's curve, ML-inequality, Cauchy's fundamental theorem (statement only), Cauchy's integral formula, entire function, Liouville's theorem. **[L-10H & T-3H]**

Reading References:

Text Books:

1. Introduction to Real Analysis- R. Bartle and D.R. Sherbert, (John Wiley and Sons., 2003).
2. Introduction to Real Analysis- S. K. Mapa, (Sarat Book Distributors, Kolkata).
3. Functions of complex Analysis- S. Ponnusamy, (Alpha Science International, 2005).
4. The functions of Complex variable- J. B. Conway, (Springer-Verlag, New York Heidelberg Berlin, 1973).

Reference Books:

1. The Elementary Analysis: The Theory of Calculus- K. A. Ross, (Springer, 2004).
2. Mathematical Analysis- Tom M. Apostol, (Narosa Publishing House, 2002).
3. Theory of functions of a complex variable- S. Narayan and P. K. Mittal, (S. Chand and company limited, 2005).
4. Complex Analysis- K. C. Pal, (New central Book Agency, 2020).
5. Complex Analysis- J. Bak and D. J. Newman, 2nd Edition, (Undergraduate Texts in Mathematics, Sringer-Verlag, New York, Inc., New York 1977).
6. Complex Variables and Applications- James Ward Brown and Ruel V. Churchill, 8th Edition, (McGrew-Hill International Edition, 2009).
7. A Textbook of Complex Analysis- Dipak Kr. Ghosh, (New central Book Agency, 2020).
8. Metric spaces and complex analysis- A. K. Banerjee and A. Dey, (New Age International Publishers Ltd 2008).

Course Code: MATH6013
Course Name: Partial Differential Equations
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives

To familiarize the students with

i. linear and non-linear partial differential equations through analytic and qualitative approaches.
ii. how to apply partial differential equations in various physical systems.

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 partial differential equations.
ii. uses of partial differential equations in different areas of mathematics.

Skills: The students would be able to

i. apply the solution techniques of the partial differential equations in different physical problems.
ii. solve the non-linear partial differential equations.

General competence: The students would gain

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

Contents:
Partial Differential Equations – Basic concepts and Definitions. Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.
[L-15H & T-5H]
Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic, elliptic. Reduction of second order Linear Equations to canonical forms. **[L-12H & T-4H]**
The Cauchy problem of 2nd order partial differential equation, Monge's cone, Monge's method of solving second order PDEs, Initial and Boundary Value Problems, Equations with non-homogeneous boundary conditions, Non-Homogeneous Wave Equation, D' Alembert's method, Method of separation of variables: Solving the Vibrating String Problem, Solution of the Heat Conduction problem. **[L-18H & T-6H]**

Reading References:

Text Books:
1. Introduction to Partial Differential Equations- K. Sankara Rao., (PHI Learning)
2. An elementary course in Partial Differential Equations – T. Amarnath, (Alpha Science Int. Ltd., 2003).
3. Partial Differential Equations – P. Prasad and R. Rabindran, (New Age Int. Publications).
4. Elements of Partial Differential Equations – I. N. Sneddon, (Dover Publications, 2006).

Reference Books:
1. A First Course in Partial Differential Equations: with Complex Variables and Transform Methods- H. F. Weinberger, (Dover Books on Mathematics).
2. Introduction to Partial Differential Equations- P. J. Olver, (Springer).
3. Partial Differential Equations for Scientists and Engineers- S. J. Farlow, (Dover Publications).
4. Numerical Methods for Partial Differential Equations- S. C. Chapra and R. P. Canal., (McGraw-Hill Education)
5. An Introduction to Difference Equations- S. R. Hastings., (Dover Publications)
6. Ordinary and Partial Differential Equation, M. D. Raisinghania, (S. Chand & Company Ltd.)
7. Partial Differential Equations: An Introduction (2nd edition)- W. A. Strauss., (John Wiley and Sons Limited).

Course Code: MATH6014
Course Name: Mechanics
(Credit: 4, Marks: 75)
Total Hours: Lecture -45, Tutorial – 15

Objectives
To impart knowledge and understanding of fundamental concepts of forces in three dimensions, stable and unstable equilibrium, simple harmonic motions, motion of a particle under central force, motion of a projectile, moments and products of inertia, D'Alembert's principle, equilibrium of fluid and floating body.

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. mathematical formalisms of statics, hydrostatics and dynamics.
ii. forces, friction, stable and unstable equilibrium and pressure of a fluid.
iii. virtual work, central force field and principal axes.

Skills: The students would be able to

i. describe the motion of a mechanical system.
ii. describe motion of a projectile.
iii. solve some physical systems moving under some forces in three dimensions.

General competence: The students would gain

i. general idea of statics, hydrostatics and dynamics which will be useful for further studies in theoretical physics.
ii. knowledge about fundamental mechanical processes in nature.
iii. experience to construct approximate mechanical models using mathematical tools.

Contents:

Basic concepts - composition and resolution of forces acting at a point, moments, couples; Co-planar forces – conditions of equilibrium, astatic equilibrium; Friction - equilibrium of a particle on a rough curve; Virtual work – principle of virtual work for a coplanar system; Centre of gravity – centre of gravity of an arc, a plane area, a solid and surface of revolution; Forces in three dimensions - general conditions of equilibrium, stable and unstable equilibrium, Poinsot's central axis; Equilibrium of flexible string, derivation of equilibrium condition - common catenary, catenary of uniform strength. **[L-10H & T-3H]**

Simple harmonic motion; Damped and forced vibrations; Components of velocity and acceleration; Motion of a projectile in a resisting medium; Motion of a particle under central force; Apses and apsidal distances; Kepler's laws of motion; Motion under the inverse square law; Stability of orbits; Disturbed orbits; Motion of artificial satellites; Motion with varying mass. **[L-20H & T-7H]**

Moments and products of inertia; Theorems of parallel and perpendicular axes; Angular momentum of a rigid body about a fixed point and about fixed axes; Inertia matrix, Principal axes; Kinetic energy of a rigid body rotating about a fixed point; Momental Ellipsoid; Coplanar distributions of forces; General motion of a rigid body; D'Alembert's Principle. **[L-9H & T-3H]**

Equilibrium of fluid in a given field of force; Pressure in a heavy homogeneous liquid; Equilibrium of floating bodies. **[L-6H & T-2H]**

Reading References:

Text Books:

1. Elements of Statics and Dynamics I and II- S. L. Loney, (2004).
2. Hydrostatics- J. M. Kar, (K.P. Basu Publishing, 1982).

Reference Books:

1. An Elementary Treatise on the Dynamics of particle and of Rigid Bodies- S. L. Loney, (2017).
2. Analytical Statics - M. C. Ghosh, (Shreedhar Prakashani, 2010).
3. Hydrostatics- M. M. Rahman, (The Info Library, 2020).
4. Textbook of Dynamics- F. Chorlton, (CBS Publishers & Distributors, 2005).
5. A Textbook on Statics- R. S. Verma, (Pothishala, 1962).
6. Hydrostatics- A.S. Ramsey, (Cambridge University Press).
7. Dynamics (Part I)- A. S. Ramsey, (Cambridge University Press, 1952).
8. Statics- M. M. Rahman, (New Central Book Agency (P) Ltd, 2004).