Semester-III

Course Type	Title of the Course	Credit	Full Marks	Lecture Hour
Major Course MATH3011	**Real Analysis** I	**5** (Theory-05)	**75** (Theory-60, Internal Assessment–15)	**60** (Lecture -45, Tutorial –15)
Major Course MATH3012	**Linear Algebra**	**5** (Theory-05)	**75** (Theory-60, Internal Assessment–15)	**60** (Lecture -45, Tutorial – 15)
Minor Course MSR3021	**Medical Sales Representative - Module 1**	**4** (Theory-05)	(Theory-60, Internal Assessment–15)	**60** (Lecture -45, Tutorial – 15)
Multi/ Interdisciplinary ENGL3031	**Practical English Grammar and Usage**	**3** (Theory-03)	**50** (Theory-40,Internal Assessment–10)	**40** (Lecture -30, Tutorial – 10)
AEC (L1-1 MIL) BENG3041	**Bangla Choto Golpo O Kobita**	**2** (Theory-02)	**50** (Theory-40,Internal Assessment–10)	**30**
SEC MATH3051	**Mathematical Modelling**	**3** (Theory-03)	**50** (Theory-40, Internal Assessment–10)	**45**
		Total Credit = 22	**Total Marks = 400**	

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).

THE UNIVERSITY OF BURDWAN

Minor Course under Vocational Education & Training

Course Code: MSR3021

Course Title: Medical Sales Representative –Module 1

Total Credit: 4 (Lecture -3, Tutorial -1)

Duration: 60 Hours

Detailed Syllabus – Third Semester

Orientation Module (Duration: 4 Hrs.)

- Collect information of key persons at hospitals, pharmacies and dealers
- Summarize the healthcare ecosystem including relevant govt. scheme, social security benefits
- Gather information about health and other relevant standards and the possible company's tie up with various regulatory bodies and authorities
- Explain regulatory authorities and government policies, rules and regulations (CDSCO/NPPA/ MRTP Act) and their impact on business dynamics, relevant to Life Sciences industry.

Understand Role of MSR and Regulations for MSR (Duration: 6 Hrs.)

- Perform the occupation effectively as per company's standard guidelines
- Recall the organization structure and employment benefits in Life Sciences organizations
- Outline the role of MSR, required skills and knowledge (As per qualification pack) including its career path as well as identify the MCI code of conduct guidelines for MSR and UCP-MP Act
- Practice soft communication skills while communicating with doctors, physicians, pharmacists & cross functional colleagues.

Major Stakeholders and Sale & Distribution System in Pharma & Bio Pharma (Duration: 5 Hrs.)

- Follow-up with key persons at hospitals, pharmacies and dealers to ensure smooth coordination with product distribution related stakeholders
- Describe drug distribution system of pharmaceutical, vaccines, ayurvedic and homeopathic products and role of various stakeholders involved like CFA, distributor, stockist, and liasioning agents.

THE UNIVERSITY OF BURDWAN

Minor Course under Vocational Education & Training

Course Code: MSR3021

Course Title: Medical Sales Representative –Module 1

Total Credit: 4 (Lecture -3, Tutorial -1)

Duration: 60 Hours

Detailed Syllabus – Third Semester

Understanding of Human Body: Anatomy and Physiology (Duration:12 Hrs.)

- Summarize technical/ scientific data presentations and briefings about product and market
- Use the basics of general anatomy, physiology, and various systems of the human body while performing the product presentation to healthcare professionals
- Correlate medical specialties and their common diseases.

English Speaking and Personality Development Part 1 (Duration: 33 Hrs.)

- Understanding the communication process.
- The different types of communication methods.
- Communicating in English.
- First Language (Mother Tongue) Interference.
- Importance of Listening when learning English.
- Time Management.

Reference Books on Medical Sales Representative

1. Community Pharmacy Handbook - Jon Waterfield
2. Essential of Pharmaceutical Chemistry - Donald Cairns
3. Pharmaceutical Innovation and Access to Medicines- OECD 2018
4. Essential of Human Physiology for Pharmacy- Laurie Kelly
5. Textbook of Organic Medicinal and Pharmaceutical Chemistry 11th edition- Wilson and Gisvold's
6. Review of Medical Physiology 26th Edition- Gannong
7. Soft Skill for everyone- Jeff Butterfeild

INTERDISCIPLINARY COURSE

ENGL3031: Practical English Grammar and Usage
[3 Cr, Full Marks: 50 (Theory: 40 + IA: 10), LH: 45 hrs]

COURSE OBJECTIVES:

This course has been designed with a view to reinforcing the students' competency in English grammar and usage as acquired at the secondary level. Already acquired linguistic skills in English will be consolidated and expanded so that students may competently use English in emerging domains of knowledge or in various socio-cultural circumstances.

Parts of Speech and Usage (LH: 20)
Nouns: Kinds of Nouns and their Usage
Pronouns: Kinds of Pronouns and their Usage
Adjectives: Kinds of Adjectives and their Usage
Articles and Determiners: Usage
Adverbs: Kinds of Adverbs and their Usage
Prepositions: Usage
Conjunctions: Usage
Verbs: Auxiliaries and Main Verbs, Modal and Semi-modal Verbs: Usage
Transitive and Intransitive Verbs: Usage
Finite and Non-Finite Verbs: Usage

Sentence (LH: 15)
Types of Sentence (Simple, Compound and Complex) and Clause and their Usage
Tense and Time
Types of Simple Sentences (Declarative, Interrogative, Imperative, Optative, Exclamatory): Form and Function

Concord (LH: 10)
Concord of Number, Number system of Nouns and Verbs, Concord of Person, Concord System in Different Constructions

COURSE OUTCOME:

This course of study will help the students to capitalize on their acquired knowledge of English and make them comfortable in using English effectively in different social, cultural and academic situations.

4.AEC(L1-2)

BENG3041

বাংলা ছোটোগল্প ও কবিতা

এই পাঠ্যসূচির উদ্দেশ্য হল বাংলা সাহিত্যের আধুনিক কালের বাংলা ছোটগল্প ও কবিতা সম্পর্কে শিক্ষার্থীদের অবহিত করা।

একক -১

বাংলা ছোটগল্প – রবীন্দ্রনাথ ঠাকুর – একরাত্রি, প্রভাত মুখোপাধ্যায় – আদরিনী, বনফুল – তাজমহল।

একক -২

একালের কবিতা – দিনেশ দাস – কেরাণী, পেমেন্দ্র মিত্র – মানে, শক্তি চট্টোপাধ্যায় – অবনী বাড়ি আছো।

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).

Lesson Plan
Subject: Mathematics (Major)

Semester: III
Paper: MATH3011 (Real Analysis I) Total Lectures = 60

Unit 1 (Real Number System)	**Total Lectures =20**
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, - 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.	
Lecture Serial	**Topics of Discussion**
Lecture 1	Review of algebraic and order properties of $\mathbb{R}$
Lecture 2	$\mathcal{E}$-neighbourhood of a point in $\mathbb{R}$
Lecture 3	Some theorems and problems on neighbourhood of a point in $\mathbb{R}$
Lecture 4	Idea of countable sets, some examples and theorems
Lecture 5	Example of uncountable sets and uncountability of $\mathbb{R}$
Lecture 6	Bounded above, Bounded below, Bounded sets and their examples
Lecture 7	Supremum, infimum of a subset of $\mathbb{R}$ with examples
Lecture 8	Completeness property of $\mathbb{R}$ and it's equivalent properties
Lecture 9	Archimedean property of $\mathbb{R}$ and it's examples
Lecture 10	Density property of rational and irrational numbers
Lecture 11	Open intervals, closed intervals and their properties
Lecture 12	Limit point and isolated point of a set in $\mathbb{R}$ and related theorems and problems
Lecture 13	Interior point of a set in $\mathbb{R}$ and concept of open sets with examples
Lecture 14	Theorems and problems related to open sets
Lecture 15	Introduction of closed sets and some examples of closed sets
Lecture 16	Theorems and problems on closed sets
Lecture 17	Derived set of a set in $\mathbb{R}$ and its properties
Lecture 18	Bolzano-Weierstrass property and it's verification with some examples
Lecture 19	Open cover of a set in $\mathbb{R}$ and concept of compactness in $\mathbb{R}$
Lecture 20	Heine-Borel theorem and some problems related to compactness.
Unit 2 (Sequence of real numbers)	**Total lectures =13**
CONTENTS 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.	
Lecture Serial	**Topics of Discussion**
Lecture 21	Introduction of sequence of real numbers with various examples
Lecture 22	Concept of bounded above, bounded below and bounded sequence with examples
Lecture 23	Definition of convergent sequence and limit of a sequence with examples
Lecture 24	Relation between bounded and convergent sequences
Lecture 25	Limit superior and limit inferior, theorems and problems

Lesson Plan
Subject: Mathematics (Major)

Lecture 26	Limit theorems: Addition, subtraction and multiplication by a scalar with examples and counter examples
Lecture 27	Limit theorems: Multiplication, Division, Modulus with examples and counter examples
Lecture 28	Introduction of monotone sequences with examples
Lecture 29	Monotone convergence theorems and its applications
Lecture 30	Introduction of sub sequence and divergence criterion
Lecture 31	Some problems with sub sequence theorem and Bolzano-Weierstrass
Lecture 32	Introduction of Cauchy sequence with examples
Lecture 33	The relation between convergence and Cauchy sequences and Cauchy criterion for convergence

Unit 3 (Series of real numbers)	**Total lectures =12**
CONTENTS 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, - 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).	
Lecture Serial	**Topics of Discussion**
Lecture 34	Introduction of infinite series with examples and sequence of partial sums of a series
Lecture 35	Convergence and Divergence of a series with examples
Lecture 36	Cauchy criterion for convergence of an infinite series with applications.
Lecture 37	Comparison test and limit comparison test with applications
Lecture 38	D' Alembert's ratio test with applications
Lecture 39	Raabe's test with applications
Lecture 40	D‟ Morgan and Bertrand's test with applications
Lecture 41	Cauchy's integral test with applications
Lecture 42	Cauchy's n^{th} root test with applications
Lecture 43	Gauss‟ test with applications
Lecture 44	Alternating series and Leibnitz's test with some applications.
Lecture 45	Absolute and conditional convergence with some examples

Unit 4 (Limit & Continuity of real valued functions)	**Total Lectures =15**
CONTENTS Limit of a function (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.	
Lecture Serial	**Topics of Discussion**
Lecture 46	$\varepsilon - \delta$ definition of limit of a function with examples
Lecture 47	Uniqueness of limit and sequential criterion of limit. Same sign property.
Lecture 48	Limit theorems: Sum, difference and scalar multiplication of functions
Lecture 49	Limit theorems: product, ratio of functions
Lecture 50	Sandwich theorem with applications

Lesson Plan
Subject: Mathematics (Major)

Lecture 51	Cauchy's principle with examples
Lecture 52	Concept of one-sided limits and infinite limits with examples
Lecture 53	Continuity of a function with examples and some theorems
Lecture 54	Sequential criterion of continuity and some applications.
Lecture 55	Continuity of sum, difference, product, ratio of two continuous functions
Lecture 56	Examples of some important continuous functions and composite functions
Lecture 57	Various type of discontinuity with examples
Lecture 58	Same sign property, the relation between continuity and boundedness, Intermediate value property
Lecture 59	Relation between monotone function and continuous function, some theorems related to open, closed sets and continuity
Lecture 60	Uniform continuity: Definition, theorems and some problems.

Lesson Plan
Subject: Mathematics (Major)

Semester: III
Paper: MATH3012 (Linear Algebra) Total Lectures = 60

Unit- 1	**Total Lectures =08**
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.	
Lecture 1	Definition of Vector space V over a field F. Examples of different vector spaces, some important properties of vector space, few useful theorems.
Lecture 2	Definition: Subspace of a vector space, Examples, Few theorems on subspace. Theorem: The intersection of a family of subspaces of a vector space is a subspace of that vector space. Theorem: The union of two subspaces of a vector space is not, in general, a subspace of that space. Algebra of subspaces: Linear sum of subspaces. Theorems and examples.
Lecture 3	Definition: Linear combination, linear span, spanning set. Examples for clear understanding of these definitions. Theorem: Let V be a vector space over a field F and let S be a non- empty subset of V. Then the set W of all linear combinations of the vectors in S forms a subspace of V and this is the smallest subspace containing the set S. Problem discussion.
Lecture 4	Linear dependence and linear independence, verification with examples. Theorem: If the set of vectors $\{\alpha 1, \alpha 2, \ldots., \alpha n\}$ in a vector space V over a field F be linearly dependent, then at least one of the vectors of the set can be expressed as a linear combination of the remaining others. Deletion Theorem.
Lecture 5	Proof of Deletion Theorem. Solving problems by applying Deletion Theorem. Basis and Dimension. Example of bases for a vector space and the corresponding dimension of the vector space.
Lecture 6	Finite and infinite dimensional vector spaces. Example of finite and infinite dimensional vector spaces. Proof of Replacement Theorem. Solving problems by applying Replacement Theorem.
Lecture 7	Proof of Extension Theorem. Application of Extension Theorem to solve various problems. Coordinates of vectors.
Lecture 8	Quotient Space definition and properties of quotient space. Theorem: Let V be a vector space over a field F and W be a subspace of V. Then dim V=dim U + dim W.
Unit- 2	**Total Lectures =12**

Lesson Plan
Subject: Mathematics (Major)

CONTENTS Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations, Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.	
Lecture 9	Definition of linear transformation. Example of various type of linear transformation.
Lecture 10	Theorem on existence of unique linear transformation for two given vector space over a same field. Application of this theorem on different problems.
Lecture 11	Definition of kernel of a linear transformation, examples, few important theorems on kernel of a linear transformation.
Lecture 12	Null space, Range space: Definition and examples; Nullity and Rank of a linear transformation.
Lecture 13	Proof of the Theorem: Let V and W be vector space over the field F and let T be a linear transformation from V into W. Suppose that V is finite dimensional. Then rank (T) + nullity (T)=dim V. Application of this theorem.
Lecture 14	Theorem: If A is an m × n matrix with entries in the field F, then Row rank (A) = Column rank (A). Problem discussion.
Lecture 15	Algebra of Linear Transformation: Addition of two linear transformations, multiplication of linear transformations. Important properties and theorems.
Lecture 16	Invertibility of linear transformation, non-singular linear transformation, theorem and properties.
Lecture 17	Theorem: Let V and W be finite-dimensional vector space over the field F such that dim (V) =dim (W). If T is linear transformation from V into W, the following are equivalent: T is invertible T is non-singular T is onto.
Lecture 18	Isomorphism: Definition and examples. Theorem: Let V and W be finite-dimensional vector space over the field F. Now V and W will be isomorphic iff dim (V) =dim (W). Few more theorem and properties.
Lecture 19	Theorem: Let V be an n dimensional vector space over the field F. Then V is isomorphic toFn. More theorem and properties.
Lecture 20	Matrix representation of a linear transformation. Results and properties. Algorithm for finding matrix for a given linear transformation.
Unit- 3	**Total Lectures =12**

Lesson Plan
Subject: Mathematics (Major)

CONTENTS 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.	
Lecture 21	Elementary operations on matrices.
Lecture 22	Row reduced and echelon form of matrix.
Lecture 23	Rank of a matrix.
Lecture 24	Some problems on finding echelon form and rank of a matrix.
Lecture 25	Finding Inverse of a matrix with row operations.
Lecture 26	Characterization of invertible matrices using rank.
Lecture 27	Characteristic equation of a matrix.
Lecture 28	Eigen values and Eigen vectors of a matrix.
Lecture 29	Some more problems on Eigen values and Eigen vectors of a matrix.
Lecture 30	**Cayley-Hamilton Theorem**
Lecture 31	Finding the inverse of a matrix by **Cayley-Hamilton Theorem**.
Lecture 32	Some more problems on **Cayley-Hamilton Theorem.**
Unit- 4	**Total Lectures =08**
CONTENTS 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.	
Lecture 33	System of linear equations, the matrix equation $Ax = b$
Lecture 34	Necessary and sufficient condition for consistency of a linear non-homogeneous system of equations.
Lecture 35	Solution of systems of linear equations using Gaussian elimination method
Lecture 36	Some more problems by Gaussian elimination method.
Lecture 37	Solution of systems of linear equations using matrix inversion method.
Lecture 38	Some more problems by matrix inversion method.
Lecture 39	Solution sets of linear systems.
Lecture 40	Applications of linear systems.

Lesson Plan
Subject: Mathematics (Major)

Unit- 5	**Total Lectures =12**
CONTENTS Eigen spaces of a linear operator, diagonalizability, invariant subspaces, the characteristic polynomial and the minimal polynomial of a linear operator, diagonalization, Jordan canonical forms.	
Lecture 41	Eigen Space of a linear operator
Lecture 42	Some examples and problems on eigen space of a linear operator.
Lecture 43	Diagonalizability of a linear operator.
Lecture 44	Some problems on diagonalizability.
Lecture 45	Invariant subspaces with some examples.
Lecture 46	The characteristic polynomial of a linear operator.
Lecture 47	Some more problems.
Lecture 48	The minimal polynomial of a linear operator.
Lecture 49	Some more problems.
Lecture 50	Diagonalization of a linear operator.
Lecture 51	Jordan Canonical forms of matrices.
Lecture 52	Some more related problems**.**
Unit- 6	**Total Lectures =04**
CONTENTS Inner product spaces and norms, Cauchy – Schwarz inequality, parallelogram law, Pythagorean theorem, Gram-Schmidt orthogonalization process, orthogonal complements and projections.	
Lecture 53	Inner product spaces and norms.
Lecture 54	Cauchy – Schwarz inequality, parallelogram law, Pythagorean theorem.
Lecture 55	Gram-Schmidt orthogonalization process.
Lecture 56	Orthogonal complements and projections.
Unit- 7	**Total Lectures =04**
CONTENTS 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.	
Lecture 57	Bilinear form, matrix associated with a bilinear form.
Lecture 58	Quadratic form, rank, signature and index of a quadratic form.
Lecture 59	Sylvester's law of inertia (statement only), reduction of a quadratic form to normal form.
Lecture 60	Some more related problems.

Lesson Plan
Subject: Mathematics (Major)

Semester: III

Paper: MATH3051 (Mathematical Modeling)

Total Lectures = 45

Unit- 1	**L-8H & T-4H**
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.	
Lecture 1	Overview of mathematical modelling and its applications in understanding real-world phenomena.
Lecture 2	Classifications and discussion on different kind of Mathematical Model viz. Deterministic, Stochastic, Continuous & Discrete.
Lecture 3	Discussion on Linear models with examples. Application of different Linear models.
Lecture 4	Usage of linear regression for modelling relationships between variables. Fitting linear models to data in analyzing trends and making predictions.
Lecture 5	General discussion on exponential model and its applications.
Lecture 6	Usage of exponential growth and decay models in population studies.
Lecture 7	Application of exponential growth and decay models in finance and compound interest.
Lecture 8	Application of exponential growth and decay models half-life, and other relevant fields.
Lecture 9	General discussion on mathematical modeling by constructing a flowchart.
Lecture 10	Discussion on simple real world problems by constructing a suitable mathematical model.
Lecture 11	Discussion on simple real world problems by constructing a suitable mathematical model.
Lecture 12	Discussion on simple real world problems by constructing a suitable mathematical model.
Unit- 2	**Total L-12H & T-6H**
CONTENTS 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.	
Lecture 13	**Introduction to Logistic Models** Introduce the concept of logistic models and their applications. Discussion on the significance of logistic models in population studies, ecology, and epidemiology.

Lesson Plan
Subject: Mathematics (Major)

Lecture 14	Derive of the logistic growth equation and explain its components Discuss on the characteristics of logistic growth curves Providing examples of logistic growth models in population studies and ecology
Lecture 15	Discuss the applications of logistic models in epidemiology and other fields Providing case studies of logistic models in real-world scenarios Assigning homework problems on logistic models
Lecture 16	**Introduction to Optimization Models** Introducing the concept of optimization models and their applications Discussing the importance of optimization models in resource allocation, production planning, and decision-making. Providing examples of optimization models.
Lecture 17	**Linear Programming** Introducing the concept of linear programming and its applications Discussing the graphical method of solving linear programming problems. Providing examples of linear programming problems.
Lecture 18	**Optimization Techniques** Discussing the simplex method and other optimization techniques Providing examples of optimization models in real-world scenarios Assigning homework problems on optimization models.
Lecture 19	**Introduction to Probabilistic/Stochastic Models** Introducing the concept of probabilistic/stochastic models and their applications. Discussing the importance of probabilistic/stochastic models in decision-making under uncertainty. Providing examples of probabilistic/stochastic models.
Lecture 20	**Random Variables and Probability Distributions** Discussing the concept of random variables and probability distributions Introducing the concept of expected value and variance. Providing examples of random variables and probability distributions.
Lecture 21	**Applications of Probabilistic/Stochastic Models** Discussing the applications of probabilistic/stochastic models in finance, insurance, and other fields. Providing case studies of probabilistic/stochastic models in real-world scenarios. Assigning homework problems on probabilistic/stochastic models
Lecture 22	**Case Study - Logistic Models in Population Studies** Presenting a case study of logistic models in population studies Discussing the application of logistic models in predicting population growth. Providing examples of logistic models in population studies.
Lecture 23	**Case Study - Optimization Models in Resource Allocation** Presenting a case study of optimization models in resource allocation Discussing the application of optimization models in allocating resources efficiently. Providing examples of optimization models in resource allocation.
Lecture 24	**Probabilistic/Stochastic Models in Finance** Presenting a case study of probabilistic/stochastic models in finance Discussing the application of probabilistic/stochastic models in predicting stock prices. Providing examples of probabilistic/stochastic models in finance.

Lesson Plan
Subject: Mathematics (Major)

Lecture 25	**Advanced Topics in Logistic Models** Discussing advanced topics in logistic models, such as non-linear logistic models. Providing examples of advanced logistic models. Assigning homework problems on advanced logistic models.
Lecture 26	**Advanced Topics in Optimization Models** Discussing advanced topics in optimization models, such as integer programming and dynamic programming. Providing examples of advanced optimization models. Assigning homework problems on advanced optimization models.
Lecture 27	**Advanced Topics in Probabilistic/Stochastic Models** Discussing advanced topics in probabilistic/stochastic models, such as Markov chains and queuing theory. Providing examples of advanced probabilistic/stochastic models. Assigning homework problems on advanced probabilistic/stochastic models.
Lecture 28	**Review of Mathematical Modeling Concepts** Reviewing the key concepts of mathematical modeling, including logistic models, optimization models, and probabilistic/stochastic models Providing examples of mathematical modeling in real-world scenarios Assigning homework problems on review topics
Lecture 29	**Project Presentations - Logistic Models**
Lecture 30	**Project Presentations - Logistic Models**
Unit- 3	**Total L-10H & T-5H**
CONTENTS 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.	
Lecture 31	**Introduction to Time Series Models** Introducing the concept of time series models and their applications Discussing the importance of time series models in analyzing trends, seasonality, and forecasting future outcomes. Providing examples of time series models in real-world scenarios.
Lecture 32	**Types of Time Series Models** Discussing the different types of time series models, including ARIMA, SARIMA, and ETS. Explaining the components of each model and their applications. Providing examples of each model.
Lecture 33	**Time Series Analysis** Discussing the steps involved in time series analysis, including data preparation, model selection, and forecasting. Explaining the importance of stationarity and differencing in time series analysis. Providing examples of time series analysis in real-world scenarios.
Lecture 34	**Forecasting with Time Series Models** Discussing the importance of forecasting in business and economics Explaining how to use time series models for forecasting. Providing examples of forecasting with time series models.

Lesson Plan
Subject: Mathematics (Major)

Lecture 35	**Time Series Models in Finance** Discussing the application of time series models in finance, including stock price forecasting and risk analysis. Explaining how to use time series models to analyze financial data. Providing examples of time series models in finance.
Lecture 36	**Time Series Models in Economics** Discuss the application of time series models in economics. Explaining how to use time series models to analyze economic data. Providing examples of time series models in economics.
Lecture 37	**Introduction to Simulation Models** Introducing the concept of simulation models and their applications Discussing the importance of simulation models in evaluating performance, risk analysis, and decision support. Providing examples of simulation models in real-world scenarios.
Lecture 38	**Monte Carlo Simulation Model** Explaining the concept of Monte Carlo simulation and its applications Discussing how to use Monte Carlo simulation to model uncertainty Providing examples of Monte Carlo simulation.
Lecture 39	**Simulating Deterministic Features** Discussing how to simulate deterministic features, including area under a curve and volume under a surface Explaining the importance of simulating deterministic features in modeling real-world systems. Providing examples of simulating deterministic features.
Lecture 40	**Simulation Models in Operations Research** Discussing the application of simulation models in operations research, including inventory management and supply chain optimization Explaining how to use simulation models to analyze and optimize complex systems. Providing examples of simulation models in operations research.
Lecture 41	**Simulation Models in Finance** Discussing the application of simulation models in finance, including risk analysis and portfolio optimization. Explaining how to use simulation models to analyze and optimize financial systems. Providing examples of simulation models in finance.
Lecture 42	**Advanced Topics in Simulation Models** Discussing advanced topics in simulation models, including stochastic processes and Markov chains. Explaining how to use advanced simulation techniques to model complex systems. Providing examples of advanced simulation models.
Lecture 43	**Simulation Model in Supply Chain Optimization** Presenting a case study of a simulation model used in supply chain optimization. Discussing the application of simulation models in optimizing complex systems. Providing examples of simulation models in supply chain optimization.
Lecture 44	**Simulation Model in Financial Risk Analysis** Presenting a case study of a simulation model used in financial risk analysis. Discussing the application of simulation models in analyzing and optimizing financial systems. Providing examples of simulation models in financial risk analysis.
Lecture 45	**Reviewing the key concepts of mathematical modeling.**