TECHNO INDIA UNIVERSITY
WEST BENGAL

DEPARTMENT OF MATHEMATICS

SYLLABUS STRUCTURE AND COURSE DETAILS
w.e.f 2024-25

M.Sc. Mathematics - 1^{ST} Semester

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Real analysis and Measure Theory	**Subject Code:** TIU-PMA-T103
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:
1. This course enables the students to understand the approach towards the generalizations of Riemann integration theory.

2. to demonstrate their understanding of the comparison between the cardinalities of different sets.

COURSE OUTCOME:

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

CO-1:	Interpret the concepts of bounded variation and absolutely continuous functions with several applications.	K4
CO-2:	Point out Riemann Stieltjes Integrals and fundamental properties.	K4
CO-3:	Illustrate concept of cardinal numbers and cardinal arithmetic.	K4
CO-4:	Interpret the basic concept and properties of measure theory, Outer measure and Lebesgue measure.	K4
CO-5:	Identify measurable functions and their properties.	K4
CO-6:	Identify the theories of measure towards the generalization of integration.	K4

COURSE CONTENT:

MODULE 1:	**Bounded Variation and Absolutely continuous functions**	**10 Hours**
Functions of Bounded Variation and their properties, Differentiation of a function of bounded variation, Absolutely Continuous Function, Equicontinuity, Luzin (N) property of an absolutely continuous function.		
MODULE 2:	**Cardinal numbers and cardinal arithmetic**	**15 Hours**
Cardinal Number: Concepts of cardinal number of an infinite set, Cantor's theorem, Schroder-Bernstein theorem. arithmetic of cardinal numbers, order relation of cardinal numbers Riemann Stieltjes Integrals and fundamental properties.		
MODULE 3:	**Measure Theory**	**20 Hours**

Measure: Lebesgue Outer Measure and Measurable Sets, Borel sets, Non-measurable set, Measurable functions, Approximation of Lebesgue measurable functions by continuous functions. Simple and Step Functions, Lebesgue integral of step functions, Upper Functions, Lebesgue integral of upper functions, Lebesgue Integrable functions, Fatou's Lemma, Dominated Convergence Theorem, Monotone Convergence Theorem, Riemann integral as a Lebesgue integral, Lebesgue-Vitali Theorem.	
TOTAL LECTURES	**45 Hours**

Books:

1. A. M. Bruckner, J. Bruckner & B. Thomson: Real Analysis
2. R. R. Goldberg: Methods of Real Analysis
3. G.De Barra: Measure Theory and Integration
4. H.L Royden: Real Analysis
5. I.P.Natanson: Theory of functions of a real variable vol-I,II

Program: MSc Mathematics	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Linear Algebra	**Subject Code:** TIU-PMA-T105
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. become familiar with theoretical aspects of linear algebra with a thorough understanding of the theory of matrices, theory of vector spaces and the theory of linear maps.
2. equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced levels of mathematics and applications that they would find useful in their disciplines.
3. understand algebraic and geometric representations of linear algebra.

COURSE OUTCOME:

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

CO-1:	develop a deep understanding of vector spaces.	K4
CO-2:	develop the concepts of linear transformation, its properties and connection with matrix transformation.	K4
CO-3:	explain the existence of the eigenvalues for a given operator; learn to use eigenvectors and eigenspaces to determine the diagonalizability of a linear transformation.	K4
CO-4:	understand the idea of Jordan blocks, Jordan matrices, and construct the Jordan form of a matrix;	K4
CO-5:	Interpret the notions of inner product space, Gram-Schmidt method, adjoint of an operator, unitary and orthogonal operator.	K4
CO-6:	define and find the bilinear form, quadratic form etc.	K3

COURSE CONTENT:

MODULE 1:	**VECTOR SPACES AND LINEAR TRANSFORMATIONS**	**14 Hours**
Vector spaces, subspaces, Linear transformation on a finite dimensional vector space, Matrix representation, Rank, Nullity, Echelon form of a matrix, Row and column space. Linear functional and dual spaces. Inner product space, Orthogonal vectors, Construction of orthogonal polynomials, Grammian, Nonsingular matrix, inverse of a matrix.		
MODULE 2:	**DIAGONALIZATION**	**6 Hours**
Eigenvalues and Eigenvectors, Characteristic equation, Algebraic and geometric multiplicities, Diagonalization, Cayley Hamilton Theorem		
MODULE 3:	**CANONICAL FORMS**	**10 Hours**
Invariant subspaces, Jordan canonical form, rational canonical form., Minimal polynomial, Unitary and normal transformation.		

MODULE 4:	**BILINEAR AND QUADRATIC FORMS**	**15 Hours**
Real quadratic form, Hermitian matrices, Lagrange's reduction, Sylvester's law of inertia, Positive definite forms, Simultaneous diagonalizability. Multilinear forms, Multilinear algebra.		
TOTAL LECTURES		**45 Hours**

Books:

1. Elementary Linear Algebra: A Matrix Approach, 2nd Edition, L. Spence, A. Insel, S. Friedberg.
2. Linear Algebra, K. Hoffmann and R Kunze, Prentice Hall of India.
3. Introduction to linear algebra, 5th Edition, Gilbert Strang.
4. Linear Algebra and Its Applications 2nd Edition, Peter D Lax.

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: Complex Analysis	**Subject Code:** TIU-PMA-T107
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

Enable the student to:

1. understand the theories of functions of a complex variable
2. analyze the behavior of the function according to analyticity and integrability along a contour
3. find the series development of a function and identify the singularities

COURSE OUTCOME:

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

CO-1:	interpret geometrically the numbers in the complex plane and identify curves and regions given by functions	K5
CO-2:	decide analyticity of a complex function and identity harmonic functions and itsconjugates	K5
CO-3:	construct series representation for a function	K5
CO-4:	explain the basic properties of complex integration and evaluate such integrals	K5
CO-5:	decide types of singularities; find residues and evaluate complex integrals using residue theorem	K5
CO-6:	explain the behavior of certain types of functions and the conformal mapping	K5

COURSE CONTENT:

MODULE 1:	**INTRODUCTION TO COMPLEX PLANE**	**3 Hours**
Complex plane - lines and half planes in the complex plane - extended plane and its spherical representation - stereographic projection.		
MODULE 2:	**DIFFERENTIABILITY AND ANALYTICITY OF A FUNCTION**	**8 Hours**
Derivative of a complex function - comparison between differentiability in the real and complex senses - Cauchy-Riemann equations: necessary and sufficient criterion for complex differentiability - analytic functions - entire functions - harmonic functions and harmonic conjugates		
MODULE 3:	**ELEMENTARY FUNCTIONS AND MAPS**	**7 Hours**
Polynomial functions - rational functions - power series – exponential - logarithmic, trigonometric and hyperbolic functions - branch of a logarithm - analytic functions as mappings - conformal maps - Möbius transformations		
MODULE 4:	**INTEGRAL OF A COMPLEX FUNCTION**	**12 Hours**
Complex integral over a real variable - Index of a closed curve – contour - index of a contour - contour integrals - Cauchy-Goursat's theorem - simply connected domains - Cauchy's theorem for simply connected domains - Cauchy's integral formula - Morera's theorem - Liouville's theorem - fundamental theorem of algebra - Schwarz's lemma, Maximum modulus principle and its applications		
MODULE 5:	**SERIES REPRESENTATION OF A COMPLEX FUNCTION**	**4 Hours**

Power series representation of analytic functions - Laurent series		
MODULE 6:	**RESIDUES AND POLES**	**11 Hours**
Definitions and classification of singularities of complex functions - isolated singularities - Residue theorem and its applications to contour integrals - zeros of analytic functions – poles - Casorati-Weierstrass theorem - meromorphic functions - argument principle - Rouche's theorem		
TOTAL LECTURES		**45 Hours**

Books:

1. JB Conway, "Functions of one Complex Variable
2. S Ponnuswamy, "Foundations of Complex Analysis"
3. JW Brown, RV Churchill, "Complex Variables and Applications"

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: General Mechanics	**Subject Code:** TIU-PMA-T111
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand the drawbacks of Newtonian approach and the necessity of alternate approaches to solve advanced problems involving the dynamic motion of classical mechanical systems
2. introducethe students to the idea of generalized coordinates, configuration space and phase space
3. represent equations of motion for mechanical systems using the Lagrangian and Hamiltonian formulations
4. develop an in-depth understanding of canonical transformations

COURSE OUTCOME:

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

CO-1:	Define and understand basic mechanical concepts related to the dynamic motion of classical mechanical systems.	K4
CO-2:	Apply the concept of Virtual Work and D'Alembert's Principle to solve simple physical problems.	K4
CO-3:	Use the concept of Lagrangian formalism to describe the motion of a mechanical system and derive its equations of motion.	K4
CO-4:	Understand the basic concepts in variational principle and principle of least actions and apply the concept of Hamiltonian mechanics to describe the motion of a mechanical system and derive its equations of motion.	K4
CO-5:	Derive generating functions for canonical transformations.	K4
CO-6:	Have an in depth understanding of Poisson and Lagrange brackets and their relation to canonical transformations.	K4

COURSE CONTENT:

MODULE 1:	**Constraints, Virtual Work, D'Alembert's Principle**	**8 Hours**
Concept of generalized coordinates in mechanics, Holonomic and Non-holonomic systems, Scleronomic and Rheonomic systems, Virtual displacement and virtual work, Statement and application of D'Alembert's Principle.		
MODULE 2:	**Lagrangian and Hamiltonian Mechanics**	**12 Hours**

Lagrange's equations of first and second kind, Energy equation for conservative fields, Cyclic coordinates, Routh's equations, Phase Space, Hamilton's principle, Principle of least action, Hamilton canonical equation, Canonical variables, Liouville's Theorem.		
MODULE 3:	**Canonical Transformations**	**12 Hours**
Canonical transformations and generating functions, Infinitesimal Canonical Transformations.		
MODULE 4:	**Brackets**	**8 Hours**
Poisson and Lagrange Brackets, Invariance of Lagrange brackets and Poisson brackets under canonical transformations.		
MODULE 5:	**Rigid Body Motion**	**5 Hours**
Rotating coordinate system, Euler angles, Motion related to rotating earth, Foucalt's pendulum and torque free motion of a rigid body about a fixed point, Motion of a symmetrical top and theory of small vibrations.		
TOTAL LECTURES		**45 Hours**

Books:

1. Classical Mechanics by H Goldstein, Poole and Safko, Pearson Education, 3rd edition
2. Classical Mechanics by Rana and Joag, McGraw Hill Education (India) Private Limited
3. Classical Mechanics by JC Upadhyay, Himalaya Publishing House
4. Mechanics, L. D. Landau and E. M. Lifshitz, Pergamon.
5. Classical Mechanics, R. Douglas Gregory, Cambridge University Press.
6. Solved Problems in Classical Mechanics, Delange and Pierrus, Oxford Press.

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: ODE AND SPECIAL FUNCTIONS	**Subject Code:** TIU-PMA-T117
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. study the existence and uniqueness of solutions of initial value problems.
2. solve solutions of homogeneous and non-homogeneous second order differential equations.
3. discuss series solutions of second order linear equations.

COURSE OUTCOME:

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

CO-1:	understand the existence and uniqueness of solutions of initial value problems.	K2
CO-2:	analyze second order homogeneous differential equations.	K4
CO-3:	analyze non-homogeneous second order differential equations and Green's function.	K4
CO-4:	construct Sturm-Liouville boundary value problems.	K5
CO-5:	evaluate series solutions of Legendre and Bessel equations.	K5
CO-6:	calculate the eigenvalue-eigenvector for solving systems of differential equations.	K4

COURSE CONTENT:

MODULE 1:	**Existence-Uniqueness for systems**	**11 Hours**
Application of fixed-point theorem to show the existence and uniqueness, The method of successive approximations, Convergence of successive approximations, Picard’s theorem, Non-local existence of solutions, Existence and uniqueness of solutions to systems, Equations of order n.		
MODULE 2:	**Second Order Equations**	**12 Hours**
General solution of homogeneous equations, Non-homogeneous equations, Wronskian, Method of variation of parameters, Sturm comparison theorem, Sturm separation theorem, Boundary value problems, Green's functions, Sturm-Liouville problems.		
MODULE 3:	**Series Solution of Second Order Linear Equations**	**14 Hours**
ordinary points, regular singular points, Legendre polynomials and properties, Bessel functions and properties.		
MODULE 3:	**Systems of Differential Equations**	**8 Hours**
Algebraic properties of solutions of linear systems, The eigenvalue-eigenvector method of finding solutions, Complex eigenvalues, Equal eigenvalues, Fundamental matrix solutions, Matrix exponential.		
TOTAL LECTURES		**45 Hours**

Books:

1. Ordinary Differential Equations by EL Ince
2. Differential Equations by Shepley Ross
3. Theory of ordinary differential equation by JC Burkhill
4. E.A. Coddington, An Introduction to Ordinary Differential Equations, PHI Learning 1999.
5. R.P. Agarwal and R.C.Gupta, Essentials of Ordinary Differential Equations, McGraw-Hill, 1993.
6. R.P. Agarwal and D. O'Regan, An Introduction to Ordinary Differential Equations, Springer-Verlag, 2008.

Program: MSc in Mathematics	**Year, Semester:** 1st Yr., 1st Sem.
Course Title: CAREER ADVANCEMENT & SKILL DEVELOPMENT - I	**Subject Code:** TIU-PMA-S197
Contact Hours/Week: 0–0–6 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE :

Enable the student to:

1. Introduce scientific computing tools in Python and fundamental programming concepts.
2. Develop numerical computing, data visualization, and scientific computation skills.
3. Apply symbolic computation techniques for solving mathematical problems.

COURSE OUTCOME :

On completion of the course, the student will be able:

CO-1	Identify and explain essential tools and libraries for scientific computing in Python, including NumPy, SciPy, Matplotlib, and SymPy.	K2
CO-2	Implement Python programming concepts, including data structures, control flow, functions, and file handling, to develop computational solutions.	K3
CO-3	Apply NumPy for numerical computations, including array operations, linear algebra, and function vectorization.	K3
CO-4	Develop data visualizations using Matplotlib, customizing plots for effective data representation.	K3
CO-5	Examine and utilize scientific computing techniques using SciPy for optimization, statistical analysis, interpolation, and differential equations.	K4
CO-6	Formulate and solve symbolic mathematical problems using SymPy, including differentiation, integration, equation solving, and expression manipulation.	K4

COURSE CONTENT:

MODULE 1:	**FOUNDATIONS OF SCIENTIFIC COMPUTING IN PYTHON**	**10 Hours**
Introduction to the SciPy ecosystem: IPython, Jupyter Notebook, NumPy, SciPy, Matplotlib, and SymPy; overview of Python’s role in mathematical and scientific computing.		
MODULE 2:	**PYTHON PROGRAMMING ESSENTIALS**	**20 Hours**
Core Python concepts: data types (numbers, strings, lists, tuples, dictionaries, sets), indexing and slicing, string formatting; control structures (conditionals, loops, list comprehensions); functions, modules, exception handling, and file I/O.		
MODULE 3:	**NUMERICAL COMPUTING WITH NUMPY**	**15 Hours**
Multi-dimensional arrays, advanced indexing and slicing, typecasting, array manipulation (sorting, reshaping, broadcasting), linear algebra operations, function vectorization, and universal functions.		
MODULE 4:	**DATA VISUALIZATION WITH MATPLOTLIB**	**15 Hours**
2D and 3D plotting techniques: line plots, histograms, polar plots, contour plots, surface plots; customization and styling for effective visualization.		
MODULE 5:	**SCIENTIFIC COMPUTING WITH SCIPY**	**15 Hours**

Computational methods: root finding, interpolation, descriptive statistics, probability distributions, curve fitting, hypothesis testing, optimization, numerical integration, solving ordinary differential equations (ODEs), and signal processing.		
MODULE 6:	**SYMBOLIC COMPUTATIONS WITH SYMPY**	**15 Hours**
Introduction to symbolic mathematics, symbolic calculus (differentiation, integration), integral transforms (Laplace, Fourier), solving algebraic and differential equations (ODEs, basics of PDEs), expression manipulation (simplification, factorization, expansion, Taylor series), and applications in physics and engineering.		
TOTAL LECTURES		**90 Hours**

Books:

1. Learning Scientific Programming with Python, Christian Hill, Cambridge University Press
2. Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib, Robert Johansson, APRESS

M.Sc. Mathematics– 2ND Semester

Program:MSc Mathematics	**Year, Semester:** 1nd Yr., 2nd Sem.
Course Title: General Topology	**Subject Code:** TIU-PMA-T104
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand the notion of topological spaces and analyze the structures associated with them
2. demonstrate the understanding of metric spaces and its extension to topological spaces

COURSE OUTCOME:

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

CO-1:	Explain the structure of topological space.	K5
CO-2:	Construct maps between topological spaces and compare structures of topologicalspaces	K5
CO-3:	Develop an understanding of the concepts of connectedness and compactness	K5
CO-4:	Explain the concept of convergence in metric spaces and in general topologicalspaces	K5
CO-5:	Interpret the relation between general topological spaces and metric spaces inparticular	K5
CO-6:	Explain the axioms of countability and separation on topological spaces.	K5

COURSE CONTENT:

MODULE 1:	**STRUCTURE OF TOPOLOGICAL SPACES**	**21 Hours**
Definition and examples of topological spaces - open sets – basis – subbasis - product topology - subspace topology - closed sets – neighbourhoods, limit points, closures, interiors - Hausdorff spaces - nets and filters and their convergence - continuous functions – homeomorphisms - product topology on arbitrary collection of topological spaces - box topology - metric topology - order topology - quotient topology: construction of cylinder, cone, Mobius band, torus, etc		
MODULE 2:	**CONNECTEDNESS AND COMPACTNESS**	**10 Hours**
Connected spaces - connected subspaces of the real line - components and local connectedness - compact spaces - Heine-Borel Theorem - local–compactness,		
MODULE 3:	**COUNTABILITY AXIOMS**	**6 Hours**
First countable and second countable spaces - separability		
MODULE 4:	**SEPARATION AXIOMS**	**8 Hours**
Regularity - complete regularity – normality - Urysohn Lemma		
TOTAL LECTURES		**45 Hours**

Books:

1. GF Simmons, “Introduction to Topology and Modern Analysis”
2. JR Munkres, “Topology: A First Course”

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Algebra-I	**Subject Code:**TIU-PMA-T106
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:
1. Have a detailed introduction of Abstract algebra (Groups and rings) and their fundamental properties and structures.

2. To provide the basis for any advanced mathematical theory.

COURSE OUTCOME:

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

CO-1:	Interpret Groups, subgroups, permutation groups, cyclic groups.	K4
CO-2:	Calculate Normal subgroups, Quotient groups, Homomorphism of groups, Isomorphism theorems.	K4
CO-3:	Identify the classification of finite groups.	K4
CO-4:	Interpret Group action: Cauchy's theorem, Sylow's theorem, Cayley's theorem, Nilpotent and Solvable groups.	K4
CO-5:	Identify Ideals, homomorphisms of rings, Polynomial and power series rings.	K4
CO-6:	Calculate divisibility theory of an abstract commutative ring, ED, PID, UFD and irreducibility of polynomials.	K4

COURSE CONTENT:

MODULE 1:	**Basic concepts**	**15 Hours**
Subgroups, Direct product of groups, Symmetric, Alternating, Quaternion and Dihedral groups, Normal Subgroups, Quotient Groups, Homomorphism of groups and Isomorphism Theorems.		
MODULE 2:	**Group action and Sylow theorems**	**15 Hours**
Group Action: Cauchy's Theorem, Sylow Theorems and their applications, Cayley's Theorem, finitely generated abelian groups and classification of finite groups up to isomorphism. Solvable Groups and Nilpotent Groups, Jordan-Hölder Theorem and its applications		
MODULE 3:	**Rings**	**15 Hours**
Ideals and Homomorphisms, Prime, Maximal and Primary Ideals, Polynomial and Power Series Rings, Quotient Field of an Integral Domain, Divisibility Theory: Euclidean Domain, Principal Ideal Domain, Unique Factorization Domain. Irreducibility of polynomials, Eisenstein's criterion.		
TOTAL LECTURES		**45 Hours**

Books:

1. Hungerford, T.W., Algebra, Springer.
2. Topics in Abstract Algebra by Herstein.
3. Jacobson, N., Basic Algebra, I & II, Hindusthan Publishing Corporation, India.
4. Abstract Algebra by DS Dummit and RM Foote.
5. Fundamentals of Abstract Algebra by Malik, Mordersen and Sen.

Program: MSc Mathematics	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Functional Analysis	**Subject Code:** TIU-PMA-T108
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. become familiar with the concepts of Normed Linear Space, Banach Space, bounded linear operators and linear functionals in Banach Spaces.
2. equip with standard concepts of Inner Product Spaces, Hilbert spaces, orthogonalization and bounded linear functionals and operators in Hilbert spaces.
3. be familiar with the spectral decomposition of operators.

COURSE OUTCOME:

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

CO-1:	Understand the concepts of norms on a vector space, equivalence of two norms and completeness of a normed linear space.	K4
CO-2:	Find norms of bounded linear transformation, functionals, characterize dual space and linear spaces of bounded linear transformations.	K3
CO-3:	Demonstrate open mapping theorem, closed graph theorem and uniform boundedness principle and apply them to characterize bounded linear operators	K4
CO-4:	Understand the idea of Hahn-Banach Theorem and apply the result in various problems related to linear functionals	K4
CO-5:	Develop a knowledge of Hilbert Space, bounded linear functionals on Hilbert Space, adjoint operators and characterize linear operators using adjoint operators	K3
CO-6:	Get the idea of Spectral decomposition of operators on finite dimensional spaces and to evaluate them.	K4

COURSE CONTENT:

MODULE 1:	**NORMED LINEAR SPACES**	**8 Hours**
Normed linear space, Banach space with examples, equivalence of two norms, finite dimensional normed linear spaces and its completeness, quotient space of normed linear space.		
MODULE 2:	**BOUNDED OPERATORS**	**8 Hours**
Bounded linear transformation, normed linear spaces of bounded linear transformations, Dual spaces and examples, bounded linear functionals.		
MODULE 3:	**THEOREMS ON BOUNDED OPERATORS**	**10 Hours**
Hahn-Banach theorem and its consequences, separability, reflexivity, Open mapping theorem, closed graph theorem and uniform boundedness principle and some applications.		
MODULE 4:	**HILBERT SPACES**	**10 Hours**

Hilbert Spaces, Orthogonal complement, Riesz representation theorem, Adjoint of an operator on a Hilbert Space, reflexivity of Hilbert Space, Self-adjoint Operators, Projection Operators, Normal Operators, Unitary operators.		
MODULE 5:	**SPECTRAL DECOMPOSITION**	**9 Hours**
Introduction to Spectral Properties of Bounded Linear Operators, Spectral Theorem for Normal Operators for finite dimensional spaces.		
TOTAL LECTURES		**45 Hours**

Books:

1. Introduction to Topology and Modern Analysis by G. F. Simmons
2. Introductory Functional Analysis with Applications by E. Kreyszig.
3. Notes on Functional Analysis by Rajendra Bhatia
4. Introduction to Functional Analysis by A. E. Taylor
5. Functional Analysis by Bachman and Narici

Program: MSc Mathematics	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Integral Transforms	**Subject Code:** TIU-PMA-T114
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. provide ideas about different transformations such as Laplace, Fourier transform
2. apply these transformations on solving differential equations such as initial value problem, boundary value problem
3. learn the concept of Fourier series.

COURSE OUTCOME:

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

CO-1:	evaluate Laplace transform, inverse Laplace transform of a function.	K4
CO-2:	apply Laplace and Fourier transform in solving initial and boundary value problems, respectively.	K3
CO-3:	interpret Fourier series representation of a function, sine and cosine series representation.	K4
CO-4:	deduce the value of an integral with the help of Fourier integral theorem.	K4
CO-5:	determine Fourier transform, Fourier sine and cosine transform of a function.	K4
CO-6:	apply Fourier transform in determining value of various integral and learn other type of integral transforms	K3

COURSE CONTENT:

MODULE 1:	**Fourier Series**	**11 Hours**
Introduction, Dirichlet conditions, Fourier Sine and Cosine Series, Parseval's Identity.		
MODULE 2:	**Fourier Transform**	**13 Hours**
Fourier Integral Theorem, Fourier Transform, Fourier transforms of some useful functions, Fourier transform of the derivative and integral, Fourier cosine and sine transforms, Inverse Fourier transform, Convolution, Applications.		
MODULE 3:	**Laplace Transforms**	**21 Hours**
Definition and properties, Sufficient conditions for the existence of Laplace transform, Laplace transform of some elementary functions, Laplace transform of the derivatives, Inverse Laplace transform, Convolution theorem, Applications.		
TOTAL LECTURES		**45 Hours**

Books:

1. Fourier Series and Boundary Value Problems by Brown and Churchill

2. Advanced Differential Equations by MD Raisinghania
3. Davies, Brian, Integral Transforms and Their Applications. (Third Edition), Springer-Verlag New York.
4. Lokenath Debnath, Dambaru Bhatta, Integral Transforms and Their Applications. (Second Edition), Chapman & Hall/CRC (Taylor & Francis)

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title: Probability and Statistics	**Subject Code:** TIU-PMA-T116
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. have an in depth understanding of the foundations of probabilistic and statistical analysis
2. apply probability and statistics in varied applications in engineering and science like disease modelling, climate prediction and computer networks etc.

COURSE OUTCOME:

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

CO-1:	review the basic probability and describe characteristic properties of various discrete and continuous distributions.	K2
CO-2:	apply different discrete and continuous distributions to solve various problems in fields of engineering, science and social sciences.	K3
CO-3:	determine mathematical expectation and moment generating functions for various distributions	K4
CO-4:	apply some probability inequalities, law of large numbers, Central Limit Theorem etc.	K3
CO-5:	analyze various population characteristics using different estimating procedures	K4
CO-6:	establish test procedures for simple and composite hypotheses under parametric and non-parametric methods.	K4

COURSE CONTENT:

MODULE 1:	**Probability**	**28 Hours**
Revision of basic probability and random variables, Special Distributions - binomial, geometric, negative binomial, hypergeometric, Poisson; uniform, exponential, gamma, normal, beta, lognormal, Weibull.		
Mathematical expectation, moments, moment generating function, Chebyshev's inequality		
Law of large numbers, Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions.		
MODULE 2:	**Statistics**	**17 Hours**
The method of moments and the method of maximum likelihood estimation, properties of best estimates, confidence intervals for the mean(s) and variance(s)		

of normal populations.	
TOTAL LECTURES	**45 Hours**

Books:

1. A First Course in Probability by Sheldon Ross
2. Probability and Statistics for Engineering and the Sciences by JL Devore

Program:MSc Mathematics	**Year, Semester:** 1st Yr., 2nd Sem.
Course Title:CAREER ADVANCEMENT SKILL DEVELOPMENT – II	**Subject Code:**TIU-PMA-S198
Contact Hours/Week: 0–0–6 (L–T–P)	**Credit:**3

COURSE OBJECTIVE:

Enable the student to:

1. apply numerical techniques to find the solution of a system of equations, find eigen values, approximate functions and solve IVPs.
2. use computational tools to implement the numerical methods

COURSE OUTCOME:

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

CO-1:	find the exact solution of a system of linear equations through direct methods.	K4
CO-2:	approximate the solution of a system of linear equations through indirect methods.	K4
CO-3:	find the numerically largest eigen value of a matrix	K4
CO-4:	apply numerical methods to find the quadratic approximation of a function.	K4
CO-5:	apply spline interpolation to approximate a function.	K4
CO-6:	solve initial value problems.	K4

COURSE CONTENT:

MODULE 1:	**Solution of System of Linear Equations**	**48 Hours**
Direct Methods – Gauss Elimination, Gauss Jordan, LU Decomposition, Matrix Inversion. Iterative Methods – Gauss - Jacobi, Gauss – Seidel Relaxation method – S.O.R. and S.U.R. methods.		
MODULE 2:	**Eigen value problem**	**6 Hours**
Determination of Largest eigen value by Power method		
MODULE 3:	**Interpolation**	**12 Hours**
Quadratic Approximation, Cubic Spline Interpolation		
MODULE 4:	**Numerical solution of initial value problems**	**24 Hours**
Euler, Modified Euler, Runge-Kutta 2^{nd} and 4^{th} order, Predictor-Corrector method		
TOTAL LAB HOURS		**90 Hours**

Books:

1. Balagurusamy, E. (2017). Numerical Methods (1st ed.). McGraw-Hill Education.
2. Veerarajan, T., & Ramachandran, T. (2006). Numerical Methods with Programs in C and C++ (1st ed.). Tata McGraw-Hill.
3. Chapra, S. C. (2018). Applied Numerical Methods with MATLAB for Engineers and Scientists (4th ed.). McGraw-Hill Education.

4. Pradeep, N., & Govindarajan, G. (2008). Numerical Methods and Computer Programming (1st ed.). New Age International Publishers.
5. Grewal, B. S. (2019). Numerical Methods in Engineering and Science with Programs in C and C++ (10th ed.). Khanna Publishers.
6. Rajaraman, V. (2012). Computer Oriented Numerical Methods (3rd ed.). PHI Learning Pvt. Ltd.

M.Sc. Mathematics– 3rd Semester

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Optimization Techniques	**Subject Code:** TIU-PMA-T205
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. familiar with various optimization related programming problems
2. solve those problems by using various techniques.

COURSE OUTCOME:

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

CO-1:	apply the theory of optimization methods and algorithms for solving various non-linear programming problems	K3
CO-2:	solve integer programming problems using advanced techniques	K3
CO-3:	apply dynamic programming for optimization problems	K3
CO-4:	solve stochastic programming problems with uncertainty	K3
CO-5:	analyze different metaheuristic approach	K4
CO-6:	develop and evaluate optimization models for real-world applications	K4

COURSE CONTENT:

MODULE 1:	**Nonlinear programming**	**12 Hours**
Lagrangian function, NLPP with equality constraint, NLPP with inequality constraint, Kuhn-Tucker (KT) conditions, Quadratic programming, Convex Programming, Separable Programming.		
MODULE 2:	**Integer Programming**	**12 Hours**
Branch and bound algorithm, cutting plane methods for pure and mixed Integer programming problems, Knap-sack problem, travelling salesman problem.		
MODULE 3:	**Dynamic Programming**	**6 Hours**
Bellman's principle of optimality and recursive relationship of dynamic programming for various optimization problems.		

MODULE 4:	Stochastic Programming	
Stochastic programming with one objective function. Stochastic linear programming. Two stage programming technique. Chance constrained programming technique		**8 Hours**
MODULE 5:	**Metaheuristic Algorithms**	**7 Hours**
Genetic algorithms, Ant colony optimizations, Particle swarm optimization		
TOTAL LECTURES		**45 Hours**

Books:

1. Optimization for Engineering Design: Algorithms and Examples by K Deb
2. An algorithm to Genetic Algorithm by Melanie Mitchell
3. Operations research, Theory and Applications, J.K.Sharma, Mcmillan India
4. Harvey M. Wagner, *Principles of Operations Research*, Englewood Cliffs, Prentice-Hall, 1969
5. S D Sharma and Himansu Sharma, Operations Research: Theory, Methods and Applications, 15 Edition, Kedarnath Ramnath & Co

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: INTEGRAL EQUATION AND VARIATIONAL METHODS	**Subject Code:** TIU-PMA-T209
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. to understand the concept of linear functional and integral equations
2. to learn techniques for solving integral equations and to apply these techniques to solve integral equations encountered in natural sciences, physical sciences and engineering.

COURSE OUTCOME:

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

CO-1:	have a conceptual understanding of functionals and apply Euler – Lagrange equation to solve linear functionals	K4
CO-2:	describe and solve brachistochrone problem, geodesics and special types of functionals	K4
CO-3:	find the solution to moving boundary problems and isoperimetric problems	K4
CO-4:	identify, classify and solve Volterra's integral equation	K4
CO-5:	identify, classify and solve Fredholm's integral equation	K4
CO-6:	have an understanding of the occurrence of singular integral equations and solve Abel's equation	K4

COURSE CONTENT:

MODULE 1:	**CALCULUS OF VARIATIONS**	**20 Hours**
Introduction to Functionals, Euler – Lagrange equations; Brachistochrone Problem, Geodesics; Variable end – points and transversality conditions; functional with several dependent variables, functional dependent on higher order derivatives, functional dependent on several independent variables, conditional extremum; Isoperimetric problems.		
MODULE 2:	**INTEGRAL EQUATIONS**	**25 Hours**
Basic concepts, Volterra integral equations, relationship between initial value problems and Volterra equations;		

resolvent kernel, method of successive approximations; Fredholm integral equations, Fredholm equations of the second kind, the method of Fredholm determinants, iterated kernels, integral equations with degenerate kernels, eigen values and eigen functions of a Fredholm alternative Existence and uniqueness of continuous solutions of Fredholm and Volterra's integral equation of second kind. Abel's integral equation.	
TOTAL LECTURES	**45 Hours**

Books:

1. Calculus of Variations with Applications by AS Gupta
2. Integral Equations by FG Tricomi
3. Integral Equations and Boundary Value Problems by MD Raisinghania

Program: MSc Mathematics	**Year, Semester:** 2^{ND} Yr., 3^{RD} Sem.
Course Title: Algebra-II	**Subject Code:** TIU-PMA-T215
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:
1. bringing together ideas from group theory, ring theory and linear algebra.

2. to solve classical geometric problems such as whether there is a construction for trisecting angles, using ruler and compasses.

3. It can also be used to analyze the question of —solubility by radicals, i.e. the question of whether there are formulae (like the quadratic formula) for the solution of equations of higher degree than 2. 4. 4. Galois theory gives the license to study many advanced mathematical theories.

COURSE OUTCOME:
On completion of the course, the student will be able to:

CO-1:	Identify Field Extensions: Finite, Algebraic and Transcendental Extensions, Algebraically Closed Field.	K4
CO-2:	Calculate Splitting Field of a polynomial, Multiple roots, Normal Extension, Separable and inseparable Extension.	K4
CO-3:	Calculate Galois Group of polynomials and Galois Theory (Fundamental Theorem).	K4
CO-4:	Interpret Galois theory: Impossibility of some constructions by straightedge and compass, Solvability by radicals	K4
CO-5:	Calculate Finite Fields and their properties	K4
CO-6:	Identify Cyclic and Cyclotomic extension.	K4

COURSE CONTENT:

MODULE 1:	**Basic concepts**	**15 Hours**
Field Extensions: Finite, Algebraic and Transcendental Extensions, Algebraically Closed Field. Splitting Field of a polynomial, Multiple roots, Algebraic Closure of a field, Isomorphism extension theorem.		
MODULE 2:	**Galois theory**	**15 Hours**
Normal Extension, Separable and inseparable Extension, Dedekind's Lemma, Artin's Lemma, Galois Group of polynomials and Galois Theory (Fundamental Theorem).		
MODULE 3:	**Applications of Galois Theory**	**15 Hours**
Impossibility of some constructions by straightedge and compass, Finite Fields and their properties, Solvability by radicals, cyclic and cyclotomic extension.		
TOTAL LECTURES		**45 Hours**

Books:

1. Field and Galois theory by Patrick Morandi.
2. Galois theory by Ian Stewart.
3. Hungerford, T.W., Algebra, Springer.
4. Galois theory by David A. Cox
5. Abstract Algebra by DS Dummit and RM Foote
6. Fundamentals of Abstract Algebra by Malik, Mordersen and Sen

Program:MSc Mathematics	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Graph Theory	**Subject Code:** TIU-PMA-T217
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand the fundamental concepts of graph theory
2. construct graphs from given real life problems and solve the problems accordingly.

COURSE OUTCOME:

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

CO-1:	Explain the basic concepts of graphs and directed graphs.	K2
CO-2:	Analyze the properties of bipartite graphs, particularly the graphs in the form of trees.	K4
CO-3:	Demonstrate an understanding of the notion of connectivity in graphs.	K3
CO-4:	Understand and develop the theory of colouring a graph.	K4
CO-5:	Develop the concept of planar graphs.	K4
CO-6:	Design and formulate real life problems using graphs.	K4

COURSE CONTENT:

MODULE 1:	**INTRODUCTION**	**8 Hours**
The concept of a graph, Paths in graphs, Graphs and graph models, Graph terminology and special types of graphs, Bipartite graphs, Complete graphs, External graphs, Intersection graphs, Operations on graph, Graph Isomorphism. Blocks: Cutpoints, bridges and blocks. Block graphs and cutpoint graphs.		
MODULE 2:	**TREES**	**10 Hours**
Introduction to trees and characterizations, Applications of Trees, Spanning Trees, Minimum Spanning Trees, Trees in computer science, Centers and centroids, Block-cutpoint trees, independent cycles and cocycles, Matroids.		
MODULE 3:	**GRAPH CONNECTIVITY**	**10 Hours**
Connectivity and line-connectivity, Graphical version of Menger’s theorem,Eulerian Graphs, Hamiltonian Graphs. Coverings and independence, Critical points and lines, Matching, Maximum Matching Problem, Minimum covering problems. Type of Connectedness, Covers and Bases, Distance concepts and matrices, Acyclic digraphs, Cycles and traversability, Orientations and Tournaments.		
MODULE 4:	**MATRIX REPRESENTATION AND PLANARITY**	**6 Hours**
Adjacency matrix, Incidence matrix, Cycle matrix. Plane and planar graphs, Outerplanar graphs, Kuratowski’s theorem, other characterizations of planar graphs.		
MODULE 5:	**GRAPH COLORING**	**5 Hours**
Vertex coloring, Chromatic number, Edge coloring, Five color theorem, Unique colourable graphs.		
MODULE 6:	**NETWORK**	**6 Hours**

Network Flows: Max Flow – Min Cut Theorem, Menger's Theorem.	
TOTAL LECTURES	**45 Hours**

Books:

1. F. Harary - Graph Theory.
2. John Clark and Derek Allan Holton - A First Look at Graph Theory.
3. Combinatorial Mathematics, D.B. West.
4. Graph theory, Diestel, Springer.

Program:MSc Mathematics	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Elective I (Fuzzy Set Theory)	**Subject Code:** TIU-PMA-T219
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand the fundamental concepts of fuzzy sets theory
2. understand about fuzzy logic, measure.
3. apply above concept in given real life problems and solve the problems accordingly.

COURSE OUTCOME:

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

CO-1:	explain fuzzy sets, fuzzy logic, and membership functions	K2
CO-2:	demonstrate basic operations on fuzzy sets	K3
CO-3:	apply operations on fuzzy relations	K3
CO-4:	calculate and interpret different measures of uncertainty	K4
CO-5:	employ fuzzy logic and fuzzy decision-making techniques; explore recent developments and future trends in decision-making	K3
CO-6:	apply fuzzy logic to areas in computer science and systems science	K3

COURSE CONTENT:

Module 1:	**Introduction to Fuzzy Set Theory**	**5 hours**
Basic concepts of fuzzy sets, fuzzy logic		
Module 2:	**Operations on Fuzzy Sets, Relations and ordering**	**15 hours**
operations on fuzzy sets, fuzzy relations, equivalence and similarity relations, ordering, morphisms, fuzzy relation equations		
Module 3:	**Measures**	**15 hours**
fuzzy measures, probability measures, possibility and necessity measures, measures of uncertainty, dissonance, confusion and non-specificity, principles of uncertainty and information		
Module 4:	**Applications**	**10 hours**
Applications of fuzzy sets in management, decision making, computer science and systems science.		
TOTAL LECTURES		**45 Hours**

Books:

1. Fuzzy Set Theory—and Its Applications by H.-J. Zimmermann, *Springer*
2. Fuzzy Set Theory Fuzzy Logic and Their Applications by AK Bhargava, *S Chand & Company*
3. Fuzzy Sets and Fuzzy Logic: Theory and Applications by George J. Klir and Bo Yuan, *Pearson Education India*

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: Elective I (Advanced Algebra-I)	**Subject Code:** TIU-PMA-T219A
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:
1. Have a detailed introduction of Module theory and their fundamental properties and structures.
2. Have a detailed introduction of Commutative ring theory and structures.
3. To provide the basis for any advanced mathematical theory.

COURSE OUTCOME:

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

CO-1:	Interpret Modules, submodules, cyclic modules, Free modules.	K5
CO-2:	Interpret Operations of modules such as Tensor product.	K5
CO-3:	Identify Injective, Projective and Free modules with their structures.	K4
CO-4:	Interpret basic concepts of Commutative rings and structure of ideals.	K5
CO-5:	Evaluate localization of rings.	K4
CO-6:	Calculate structure of Artinian and Noetherian rings.	K4

COURSE CONTENT:

MODULE 1:	**Basic concepts**	**15 Hours**
Left and Right Modules over a ring with identity, Cyclic Modules, Fundamental Structure Theorem for finitely generated modules over a PID and its applications to finitely generated abelian groups, Modules and Module Homomorphisms, Submodules and Quotient Modules.		
MODULE 2:	**Structure theory of Modules**	**15 Hours**
Operations on submodules, Direct Sum and Product, Finitely Generated Modules, Free Modules. Tensor Products of modules, Universal Property of the tensor product, Restriction and Extension of Scalars, Algebras. Exact Sequences, Projective and Injective Modules, Five Lemma, Projective Modules and $\mathrm{Hom}_R(M,-)$, injective modules and $\mathrm{Hom}_R(-,M)$.		
MODULE 3:	**Commutative Rings Theory**	**15 Hours**
Rings and Ring Homomorphisms, Ideals, Quotient Rings, Zero-divisors, Nilpotent elements, Units, Prime and Maximal ideals, Nil-radical and Jacobson radical, Nakayama's Lemma, Operations on Ideals, Prime Avoidance, Chinese Remainder Theorem, Extension and Contraction of ideals. Rings and Modules of Fractions, Local Properties, Extended and contracted ideals in rings of fractions. Noetherian Rings, Artinian Rings, Primary Decomposition in Noetherian Rings.		
TOTAL LECTURES		**45 Hours**

Books:

1. Hungerford, T.W., Algebra, Springer.
2. Abstract Algebra by DS Dummit and RM Foote.
3. Introduction to commutative Algebra by Atiyah, M. F., Macdonald, I.G.
4. Commutative Algebra by Matsumara, H.
5. Fundamentals of Abstract Algebra by Malik, Mordersen and Sen.

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 3rdSem.
Course Title: RINGS OF CONTINUOUS FUNCTIONS- I	**Subject Code:** TIU-PMA-T219B
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:
Enable the student to:
1. Aims to study the ring of real-valued continuous functions on a topological space.

2. Exploring its algebraic properties and the interplay between these properties and the topology of the space.

COURSE OUTCOME:
On completion of the course, the student will be able to:

CO-1:	Identify Ring C(X) and C_(X) for a topological space X	K4
CO-2:	Investigate algebraic concepts like ideals, maximal ideals, Zero sets and their relationship with the topology of the space.	K4
CO-3:	Analyze how topological properties of the space X influence the algebraic properties of the ring C(X).	K4
CO-4:	Apply Uryshon's Theorem to extend Ring of continuous functions to a bigger space.	K4
CO-5:	Identify Tychonoff spaces and M. H. Stone Theorem, Structure space of C(X), Banach-Stone Theorem.	K4
CO-6:	Explain Stone-Cech compactification βX of a Tychonoff space X.	K4

COURSE CONTENT:

MODULE1:	**Preliminaries**	**10 Hours**
Rings C(X) and C_(X) for a topological space X, Zero sets Z(f) and their properties.Ideals.		
MODULE2:	**Functions in a Topological Space**	**15 Hours**
C-embedded and C*-embedded subsets of X. Uryshon's Extension Theorem, z-ideals of C(X) and z-filters on X and their relations.		
MODULE3:	**Tychonoff spaces**	**20 Hours**
Tychonoff spaces and M. H. Stone Theorem, Structure space of C(X) and Banach-Stone Theorem, Stone-Cech compactification βX of a Tychonoff space X.		
TOTAL LECTURES		**45 Hours**

Books:
1. Gillman and Jerison; Rings of continuous functions; Springer-verlag, N.Y. Heidelberg, Berlin, 1976.
2. Charles E. Aull; Rings of continuous functions; Marcel Dekker. Inc. 1985.
3. J. Dugundji; Topology; Boston, allyn and Bacon, 1966.
4. Gillman and Kohls; Convex and pseudo-prime ideals in rings of continuous functions; Math-zeitschr, 72, 399-409, 1960.

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 3rdSem.
Course Title:FLUID MECHANICS - I	**Subject Code:** TIU-PMA-T219C
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. Understand fundamental fluid mechanics concepts
2. Apply the conservation of mass to fluid systems, derive the continuity equation in both Lagrangian and Eulerian forms.
3. solve kinematic problems such as finding particle paths and stream lines
4. study 3D hydrodynamical singularities (sources, sinks, doublets)

COURSE OUTCOME:

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

CO-1:	Develop an understanding on the fundamental ideas of fluid mechanics, identify the numerous fluid flow issues that can arise in real-world situations, able to differentiate between ideal fluids and real fluids and comprehend the fundamental characteristics of fluids.	K4
CO-2:	Develop an understanding of the flow lines, role of the material derivative in transforming between Lagrangian and Eulerian descriptions, velocity potential functions, translation, deformation and rotation of fluid elements, distinguish between rotational and irrotational regions of flow based on the flow of vorticity property.	K4
CO-3:	apply the conservation of mass equation to balance the incoming and outgoing flow rates in a flow system, to express the equation of continuity in Lagrangian and Eulerian method and their equivalency	K4
CO-4:	Develop an understanding of the boundary condition during flow of the fluid, work with energy equation, circulation, vorticity, vorticity equation, permanence of irrotations, axially symmetric flows and Kelvin Circulation theorem.	K4
CO-5:	formulate the motion of a sphere through the liquid at rest at infinity and to calculate the pressure distribution and drag force on sphere.	K4
CO-6:	formulate Lagrange's stream function, understand three-dimensional hydrodynamical singularities: source, sinks and doublets in three-dimensions their images in infinite plane and spherical surface and derive the velocity potential functions for these singularities.	K4

COURSE CONTENT:

MODULE 1:	**Kinematics**	
Introduction, Lagrangian and Eulerian method in fluid motion, acceleration, equation of continuity, equation of continuity in the Lagrangian method, acceleration in polar and cylindrical coordinates, the boundary surface, Stream lines, Velocity potential, Irrotational and rotational motion.		
MODULE 2:	**Equations of motion**	

Euler's dynamical equations, Bernoulli's theorem, equations of motion by flux method, Lagrange's equation, equations of spin (moving axes), impulsive action, stream function.		
MODULE 3:	**Irrotational motion**	
Irrotational motion in two-dimension, general displacement of a fluid element, flow and circulation, Stoke's theorem, Kelvin's circulation theorem, Vorticity equation(Helmholtz theorem), energy equation, Green's theorem, Kelvin's minimum energy theorem, kinetic energy of an infinite mass.		
MODULE 4:	**Motion of sphere**	
Motion of sphere, motion of a sphere through a liquid at rest at infinity, liquid streaming past a fixed sphere, pressure distribution and drag force on a sphere.		
MODULE 5:	**Stoke's stream function**	
Complex potential and velocity, Sources sinks and doublets, velocity potential due to a simple source of strength m, Stoke's stream function and application.		
TOTAL LECTURES		**45 Hours**

Books:

1. Milne-Thompson, "Theoretical Hydrodynamics" (1955), Macmillan London
2. S. Ramsay, "Hydromechanics part II" (1935), G. Bell &Sons London
3. Bansi Lal," Theoretical Hydrodynamics" A vectorial Treatment, (1967), Atma Ram & Sons, New Delhi.

NOTE: Choose any 1 from Elective I

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 3rd Sem.
Course Title: CAREER ADVANCEMENT & SKILL DEVELOPMENT - III	**Subject Code:** TIU-PMA-S203
Contact Hours/Week: 0–0–6 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. familiarize themselves with LATEX and its features
2. create various types of documents with LATEX
3. prepare presentations using BEAMER

COURSE OUTCOME:

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

CO-1:	understand the basic structure and syntax of latex	K1
CO-2:	create equations, equation arrays, matrices, tables, lists etc.	K6
CO-3:	install packages as needed to create custom documents	K2
CO-4:	create customized page layouts	K5
CO-5:	have an overview of different document classes and create different kinds of documents	K6
CO-6:	prepare presentations	K6

COURSE CONTENT:

MODULE 1:	**Introduction to Latex**	**20 Hours**
Installation of the software Latex, Understanding Latex compilation – basic syntax, writing equations, matrices, tables, lists		
MODULE 2:	**Page Layout**	**10 Hours**
Title, abstract, chapters, sections, references, equation references, citation, table of contents		
MODULE 3:	**Packages**	**10 Hours**
how to install packages, popular packages viz., geometry, amsmath, amssymb, color, natbib		
MODULE 4:	**Document classes**	**20 Hours**
article, report, book, thesis, beamer; using documentclass template		
MODULE 5:	**Applications**	**30 hours**
writing articles, resume, reports; creating presentations based on beamer		
TOTAL LAB HOURS		**90 Hours**

ONLINE RESOURCE:

1. https://www.latex-project.org/
2. https://latex-tutorial.com/

M.Sc. Mathematics– 4th Semester

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Elective II (Advanced OR)	**Subject Code:** TIU-PMA-E204
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. understand the need of inventory management
2. choose the appropriate queuing model for a given practical application.
3. know how project management techniques help in planning and scheduling a project
4. get ideas about job sequencing and replacement models.

COURSE OUTCOME:

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

CO-1:	apply job sequencing and optimization techniques	K3
CO-2:	construct network diagrams and analyze PERT, CPM	K4
CO-3:	design various models for timely replacement	K4
CO-4:	solve inventory management problems using EOQ and EPQ models	K3
CO-5:	analyze queuing systems using queuing theory	K4
CO-6:	use advanced optimization techniques for real-world applications	K3

COURSE CONTENT:

MODULE 1:	**Job Sequencing**	**11 Hours**
Sequencing problems, Solution of sequencing problems, Processing *n* jobs through two machines, Processing *n* jobs through three machines, Optimal solutions, Processing of two jobs through *m* machines, Graphical method, Processing *n* jobs through *m* machines.		
MODULE 2:	**Project Scheduling and Network Analysis**	**12 Hours**
Project scheduling by PERT and CPM, Construction of a network, Critical path analysis, Forward and backward pass methods, Floats of an activity, Project costs by CPM, crashing of an activity, Crash-cost slope, Time-cost trade, Solution of network problems using Simplex technique. Time estimates for PERT, Probability of completion of a project within a scheduled time.		
MODULE 3:	**Replacement Models**	**10 Hours**

Replacement problem, Types of replacement problems, Replacement of capital equipment that varies with time, Replacement policy for items where maintenance cost increases with time and money value is not considered, Money value, Present worth factor (pwf), Discount rate, Replacement policy for item whose maintenance cost increases with time and money value changes at a constant rate, Choice of best machine, Replacement of low cost items, Individual replacement policy, Mortality theorem, Group replacement policy.		
MODULE 4:	**Inventory and Queuing Models**	**12 Hours**
Inventory models: EOQ and EPQ models and their applications, Basic review systems and single period model and their applications Queuing models: M/M/1 Queues and applications, M/M/c and M/M/c/k Queues and their applications, Introduction, Queueing system, Queue disciplines FIFO, FIFS, LIFO, SIRO, FILO etc. The Poisson process (Pure birth process), Arrival distribution theorem, Properties of Poisson process, Distribution of inter arrival times (exponential process), Pure death process (Distribution of departures), Derivation of waiting time distribution, Kendals notations, M/M/1 Queues and applications, M/M/c and M/M/c/k Queues and their applications		
TOTAL LECTURES		**45 Hours**

Books:

1. Operations research, Theory and Applications, J.K.Sharma, Macmillan India
2. Harvey M. Wagner, *Principles of Operations Research*, Englewood Cliffs, Prentice-Hall, 1969
3. Operations Research: An Introduction by Hamdy A. Taha
4. Operations Research by S D Sharma
5. Operations Research by Kanti Swarup

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: Advanced Algebra-II	**Subject Code:** TIU-PMA-E204A
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. Have an introduction of Multilinear Algebra.
2. Have a detailed introduction of ring theory and structures
3. To provide an introduction to Representation Theory

COURSE OUTCOME:

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

CO-1:	Interpret Tensor Algebras, Symmetric Algebras, Exterior Algebras.	K5
CO-2:	Evaluate Radicals of rings and algebras.	K4
CO-3:	Identify Artinian and non-commutative Noetherian rings.	K4
CO-4:	Interpret Structure of non-commutative ring Theory, Wedderburn - Artin theorem.	K5
CO-5:	Identify basic concepts of Representation theory.	K4
CO-6:	Interpret Detailed theorems and structures of Representation Theory.	K5

COURSE CONTENT:

MODULE 1:	**Multilinear Algebra**	**10 Hours**
Determinants, Tensor Algebras, Symmetric Algebras, Exterior Algebras, Homomorphisms of Tensor Algebras, Symmetric and Alternating Tensors.		
MODULE 2:	**Structure of Rings**	**20 Hours**
Artinian rings, Simple rings, Primitive rings, Jacobson density theorem, Wedderburn - Artin theorem on simple (left)Artinian rings. The Jacobson radical, Jacobson semisimple rings, subdirect product of rings, Jacobson semisimple rings as subdirect products of primitive rings, Wedderburn - Artin theorem on Jacobson semisimple (left)Artinian rings. Simple and Semisimple modules, Semisimple rings, Equivalence of semisimple rings with Jacobson semisimple (left)Artinian rings, Properties of semisimple rings, Characterizations of semisimple rings in terms of modules.		
MODULE 3:	**Group Representations**	**15 Hours**
Representations, Group-Rings, Maschke's Theorem, Character of a Representation, Regular Representations, Orthogonality Relations, Burnside Two-Prime Theorem.		
TOTAL LECTURES		**45 Hours**

Books:

1. A first course in non-commutative rings by Lam, T.Y.
2. Noncommutative Rings by Herstein, I. N.
3. Introduction to Lie Algebra and Representation Theory, Humphreys, James, E.
4. Hungerford, T.W., Algebra, Springer.

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4thSem.
Course Title:RINGS OF CONTINUOUS FUNCTIONS- II	**Subject Code:** TIU-PMA-E204B
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:
1. Explore the algebraic properties and the interplay between these properties and the topology of the space.

2. Understand concepts like, βX (The Stone-Čech Compactification of X) for Various Spaces X and Their Cardinalities, Real Compact Spaces and Hewitt Real Compactification (υX), P-Spaces, F-Spaces and Their Characterizations in Terms of C(X) etc.

COURSE OUTCOME:

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

CO-1:	Identify βX for various spaces X and their cardinalities.	K4
CO-2:	Explain Gelfand-Kolmogoroff Theorem and to understand Isomorphism Between Commutative C-Algebras and Continuous Function Algebras	K4
CO-3:	Interpret Real compact spaces and Hewitt real compactification υX of X and their relations with βX	K4
CO-4:	Explain the concepts of Zero-dimensional spaces, Extremally disconnected spaces, basically disconnected spaces.	K4
CO-5:	Identify and analyzeP-spaces to understand how Gδ-sets are open in these spaces and to classify P-spaces and explore their algebraic and topological properties.	K4
CO-6:	Analyze F-spaces X and their characterizations in terms of C(X).	K4

COURSE CONTENT:

MODULE 1:	**βX (The Stone-Čech Compactification of X) for Various Spaces X and Their Cardinalities**	**10 Hours**
βX for various spaces X and their cardinalities; Gelfand-Kolmogoroff Theorem.		
MODULE 2:	**Hewitt Real Compactification (υX)**	**15 Hours**
Realcompact spaces and Hewitt realcompactificationυX of X andtheir relations with βX.		
MODULE 3:	**Additional Concepts**	**20 Hours**
Zero-dimensional spaces, Extremally disconnectedspaces, basically disconnected spaces, P spaces, F-spaces X and their characterizations in terms of C(X). Some interesting Problems.		
TOTAL LECTURES		**45 Hours**

Books:

1. Gillman and Jerison; Rings of continuous functions; Springer-verlag, N.Y. Heidelberg, Berlin, 1976.
2. Charles E. Aull; Rings of continuous functions; Marcel Dekker. Inc. 1985.
3. J. Dugundji; Topology; Boston, allyn and Bacon, 1966.
4. Gillman and Kohls; Convex and pseudo-prime ideals in rings of continuous functions; Math-zeitschr, 72, 399-409, 1960.

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4thSem.
Course Title:FLUID MECHANICS - II	**Subject Code:** TIU-PMA-E204C
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. Apply complex potential theory to construct and visualize conformal transformations between planes, and analyze their applications in fluid mechanics.
2. Analyze rotational or vortex motion.
3. Generalize wave motion as an energy transmission mechanism.
4. Examine fluid viscosity's role in resisting shearing stress.

COURSE OUTCOME:

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

CO-1:	construct the transformation from one-plane to another plane and particularly conformal transformation, visualize the images using complex potential theory, know the application to fluid mechanics,	K4
CO-2:	derive Blasius theorem, Milne-Thomson Circle Theorem, understand Joukovski transformation and aerofoils.	K4
CO-3:	Develop an understanding of rotational or vortex motion, deduce the Kelvin's proof of permanence using stoke's theorem, understand the vortex pair and rectilinear vortices	K4
CO-4:	Generalize the wave motion as a principal mode of transmission of energy, represent the wave motion mathematically, calculate the energy of stationary wave and long wave and progressive wave,	K4
CO-5:	Develop an understanding of sound transmission by waves, formulate the general equation of propagation of sound waves,	K4
CO-6:	To develop an understanding of the viscosity of a fluid to offer resistance to sheering stress, calculate the energy dissipation due to viscosity, calculate the Reynolds number.	K4

COURSE CONTENT:

MODULE 1:	**Conformal transformation**	
Conformal transformation and its application to fluid mechanics, image of a line source and line doublet in a plane, Milne-Thomson Circle Theorem, Blasius Theorem, The Joukowski Transformation, Aerofoil, Kutta-Joukowski Theorem.		
MODULE 2:	**Vortex motion**	
Definitions and elementary properties of vortex, Kelvin's proof of permanence, Rectilinear or columnar Vortex Filament, vortex pairs, Complex Potential for Circulation about a Circular Cylinder, Complex Potential for Rectilinear Vortex		
MODULE 3:	**Waves**	

Modes of transmission of energy, the oscillatory nature of wave motion, standing or stationary wave, long wave, energy of a long wave and stationary wave, surface waves on deep water, wave length and wave velocity, group velocity, transmission of energy, capillary waves, ripples, wave due to local disturbance on the surface of water		
MODULE 4:	**Sound waves**	
General equations and velocity of sound, plane waves and energy of plane waves, intensity of sound, forced vibration in tube, reflection and refraction of plane waves, harmonic waves diverging from a source, doublets		
MODULE 5:	**Viscosity**	
Definition and measurement of viscosity, stress in a fluid in motion, equation of motion in cylindrical and polar coordinates in viscous fluid, dissipation of energy, the Reynolds number, Connection between stresses and gradients of velocity. Navier-Stoke's equations of motion. Plane Poiseuille and Couette flows between two parallel plates, Prandtl's boundary layer.		
TOTAL LECTURES		**45 Hours**

Books:

4. Milne-Thompson, "Theoretical Hydrodynamics" (1955), Macmillan London
5. S. Ramsay, "Hydromechanics part II" (1935), G. Bell &Sons London
6. Bansi Lal," Theoretical Hydrodynamics" A vectorial Treatment, (1967), Atma Ram & Sons, New Delhi.

NOTE: Choose any 1 from Elective II

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4^{TH} Sem.
Course Title: PARTIAL DIFFERENTIAL EQUATIONS	**Subject Code:** TIU-PMA-T204
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. study first and second order partial differential equations.
2. solve linear Partial Differential equations with different methods.
3. derive heat and wave equations in one dimension and Laplace equations both in cartesian and polar coordinates.
4. find the solutions of partial differential equations determined by conditions at the boundary of the spatial domain and initial conditions at time zero.

COURSE OUTCOME:

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

CO-1:	construct classification of partial differential equations and transform into canonical form.	K5
CO-2:	analyze the existence and uniqueness of the solutions to the initial value problem for the wave equation.	K4
CO-3:	evaluate the fundamental solution of Laplace equation in 1D and also both in Cartesian and polar coordinates.	K5
CO-4:	develop the fundamental solution of Laplace equation in 2D and also both in Cartesian and polar coordinates.	K5
CO-5:	determine the heat equation in all possible domains.	K4
CO-6:	analyze Maxima-Minima principle for both heat equation and Laplace equation.	K4

COURSE CONTENT:

MODULE 1:	**Introduction to PDE**	**8 Hours**
Introduction, Cauchy-Kowalewski's theorem (statement only) classification of second order PDE. Reduction of linear and quasilinear equations in two independent variables to their canonical forms, characteristic curves. Well-posed and ill-posed problems.		
MODULE 2:	**Hyperbolic Equations**	**15 Hours**
Hyperbolic Equations: The vibration of a string. Formulation of mixed initial and boundary value problem. Existence, uniqueness and continuous dependence of the solution to the initial conditions. D'Alembert's formula for the vibration of an infinite string. Method of separation of variables. Investigation of the conditions under which the infinite series solution convergence and represents the solution. Riemann method of solution, Problems. Rectangular and circular membranes problems.		
MODULE 3:	**Elliptic equations**	**14 Hours**
Elliptic equations: Occurrence of Laplace's equation. Fundamental solutions of laplace's equation in two independent variables. Laplace equation in polar, spherical polar and in cylindrical polar coordinates, Minimum – Maximum theorem and its		

consequences. Boundary value problems, Dirichlets and Neumann's interior and exterior problems, uniqueness and continuous dependence of the solution on the boundary conditions. Method for the solution of Laplace's equations in two dimensions, interior and exterior Dirichlet's problem for a circle, and a semi-circle, Green's function for the Laplace equation in two dimensions.		
MODULE 3:	**Parabolic equation**	**8 Hours**
Parabolic equation: Conduction of heat in a bounded strip, First boundary value problem, Maximum-Minimum theorem and its consequences, uniqueness, continuous dependence of the solution and existence of the solution.		
TOTAL LECTURES		**45 Hours**

Books:

1. Elements of Partial Differential Equations by IN Sneddon

2. Advanced Differential Equations by MD Raisinghania

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: DISCRETE MATHEMATICS	**Subject Code:** TIU-PMA-T210
Contact Hours/Week: 3–1–0 (L–T–P)	**Credit:** 4

COURSE OBJECTIVE:

Enable the student to:

1. develop an understanding of the fundamental concepts of logic and its applications,
2. build and analyze arguments and grasp the different methods of proofs
3. learn the concepts of combinatorics and its various applications
4. construct and solve recurrence relations and the use of generating functions.

COURSE OUTCOME:

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

CO-1:	Develop formal logical reasoning techniques and demonstrate the application of logic to analysing and writing proofs	K4
CO-2:	Build and analyze logical arguments and make suitable conclusions therefrom	K5
CO-3:	Apply the rules of counting and its applications	K4
CO-4:	Solve problems on permutation and combination	K4
CO-5:	Apply the concept of generalized permutation and combination to real problems	K4
CO-6:	Construct recurrence relations to represent real problems and solve them	K5

COURSE CONTENT:

MODULE 1:	**Introduction to Logic and Proof methods**	**15 Hours**
Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs, Proof methods and strategy.		
MODULE 2:	**Combinatorics**	**30 Hours**
Rules of counting, Pigeonhole Principle, Permutation and Combination (with and without repetition), identical objects, Pascal's Identity and Pascal's triangle, Binomial, Negative Binomial and Extended Binomial theorems and its relation to Generalized Combination, Principle of inclusion - exclusion. Recurrence Relation – construction of linear and non-linear recurrence relations (homogeneous and non-homogeneous types), solution of linear recurrence relations, generating functions, applications.		
TOTAL LECTURES		**45 Hours**

Text Books:

1. Discrete Mathematics and Its Applications, K.H. Rosen.
2. Discrete Mathematics: An Open Introduction, O. Levin.

Program: MSc Mathematics	**Year, Semester:** 2nd Yr., 4^{th}Sem
Course Title: CAREER ADVANCEMENT & SKILL DEVELOPMENT - IV	**Subject Code:** TIU-PMA-S200
Contact Hours/Week: 0–0–6 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. Present research findings through a structured technical report/dissertation

COURSE OUTCOME:

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

CO-1:	Write a technical report, book chapter or research article in WORD or LATEX	K6
CO-2:	Use WORD or LATEX templates to create research articles, technical reports, book chapters etc.	K3
CO-3:	Create bibliography as per prescribed format	K3
CO-4:	Create a dissertation presenting the research findings of the project	K6

COURSE CONTENT:

MODULE:	**Preparation of dissertation**	
Creating the final hard copy of the dissertation based on the research project carried out.		

Program:MSc in Mathematics	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title:PROJECT & VIVA VOCE	**Subject Code:**TIU-PMA-P296
Contact Hours/Week: 0–0–10 (L–T–P)	**Credit:** 5

COURSE OBJECTIVE:

Enable the student to:

1. Identify and analyze research problems through a structured literature review.
2. Assess theoretical and experimental gaps to formulate research objectives.
3. Implement mathematical models or synthesis techniques to investigate the research problem.
4. Utilize appropriate analytical methods to interpret results.

COURSE OUTCOME:

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

CO-1:	Identify a relevant research problem through idea conceptualization.	K2
CO-2:	Analyze existing literature to refine objectives and research gaps.	K5
CO-3:	Analyze existing literature to identify theoretical or experimental gaps and define research objectives.	K5
CO-4:	Develop a mathematical model or theoretical framework for the problem.	K6
CO-5:	Draw conclusions from the research findings.	K6
CO-6:	Provide some insight into future research based on the findings.	K6

COURSE CONTENT:

MODULE 1:	RESEARCH PROBLEM IDENTIFICATION	
Introduction to research methodology and scientific inquiry, identifying research gaps and formulating a problem statement, Understanding ethical considerations in research.		
MODULE 2:	**LITERATURE REVIEW**	
Planning and conducting a literature survey, Tools for literature search: Journals, databases (Scopus, IEEE, Web of Science), Reviewing relevant theories, experiments, and models.		
MODULE 3:	**IDENTIFYING RESEARCH GAPS & DEFINING OBJECTIVES**	
Evaluating key findings, limitations, and contradictions. Gap Identification: Recognizing theoretical or experimental gaps in existing research. Research Objectives: Defining precise research questions and justifying their relevance.		
MODULE 4:	**MATHEMATICAL MODELING / THEORETICAL FRAMEWORK**	
Developing a mathematical model or theoretical framework; selecting appropriate methods for data collection and analysis, if statistical in nature.		
MODULE 6:	**CONCLUSIONS AND FUTURE SCOPE**	
Drawing some conclusions from the research findings and defining some scope for future research.		

Program: MSc in Mathematics	**Year, Semester:** 2nd Yr., 4th Sem.
Course Title: GRAND VIVA VOCE	**Subject Code:** TIU-PMA-G298
Contact Hours/Week: 0–3–0 (L–T–P)	**Credit:** 3

COURSE OBJECTIVE:

Enable the student to:

1. Develop confidence in appearing before a selection committee/panel
2. Assess the questions asked based on the courses taught under the program and respond appropriately
3. Enhance communication skills

COURSE OUTCOME:

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

CO-1:	be prepared to appear before a selection committee/panel of experts for future job prospects and/or research opportunities	K6
CO-2:	showcase their knowledge and understanding of the courses taught under the program	K6
CO-3:	enhance their communication skill	K6
CO-4:	demonstrate their ability to think laterally and respond to questions suitably	K6

COURSE CONTENT:

MODULE:	**MOCK SESSIONS**	
Mock QnA sessions to practice responses to course-based questions, develop technical communication skills.		