Course Outline for Semester VIII (Batch 2024)

In the **8th semester**, students are usually given an option to choose between Honours Track and Research Track

Course Outline for Semester VIII (For Honours Track)

S. No.	Category	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	Major	MTHS450MJ	Computational Mathematics	4	3	0	2	0	5
		MTHS451MJ	Fourier and Laplace Transform	4	2	2	0	0	4
		MTHS458MJ	Financial derivatives	4	4	0	0	0	4
		MTHS453MJ	Advanced Linear Algebra	4	4	0	0	0	4
		MTHS454MJ	Design of Experiments	4	4	0	0	0	4
		MTHS455MJ	Project	4	4	0	0	0	4
2	Minor 8		Students to choose	4					

Note: Students have to choose one elective subject from each basket —

Basket 1

1.	**Fourier or Laplace Transform** (MTHS451MJ)
2.	**Financial derivatives** (MTHS458MJ)

Basket 2.

1.	**Advanced Linear Algebra** (MTHS453MJ)
2.	**Design of Experiments** (MTHS454MJ)

Course Outline for Semester VIII for Research Track

S. No.	Category	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	Major	MTHS456MJ	Research Methodology	4	4	0	0	0	4
		MTHS457MJ	Research Project	12					
2	Minor 8		Students to choose	4					

Course Title: Computational Mathematics	**L**	**T**	**P**	**S**	**Semester: 8th**
Course Code: MTHS450MJ	**3**	**x**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: This programe develops logical skills and basic technical skills so that students should be able to solve basic computing problems. The students should be able to learn the basic of any computer programming language like C, software MATLAB and Scientific documentation using LaTeX.

Course Outcomes:

1. Students will be able to apply computational methods and tools to model and solve real-world problems using programming, numerical and statistical techniques.
2. Implement numerical methods and solution for linear algebra problems such as root finding, numerical integration, and numerical linear algebra.

Prerequisites: 1. Integrated Computational Lab for Simultaneous Theory and Hands-on Practice 2. Calculus, Differential Equations, Numerical Methods and Basic Programming (Python/Matlab/Mathematica)

Unit 1: Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System software's like operating system, compiler, linker, loader; Application programs like editor. Algorithm, specification of algorithm. Flowcharts. Data Types, Identifiers, Variables Constants and Literals. Arithmetic relational logical operators. Basic input/output statements, Control structures: if-else statement, Nested if statement, Switch statement Loops: while loop, do while, for loop, Nested loops. Arrays: Declaration; initialization.

Unit II: Functions; prototype, passing parameters, identifier visibility. Variable scope, lifetime. Multi-file programming, Introduction to macros. Structures and unions: syntax. Pointers: variables, arrarys. Introduction to object oriented programming, Abstraction, Encapsulation, Introduction to classes and objects; Access specifiers, Constructor; destructor; Function overloading; Operator overloading

Unit III: Introduction to MATLAB, Standard MATLAB windows (Command Window, Figure Window, Editor Window, help window), The semicolon (;), The clc command, Using MATLAB as calculator, Display formats, Elementary math built in functions, The zeroes, ones and eye commands, The transpose operators, Using a colon, Adding elements to existing variables, Deleting elements, Creating arrays (one dimensional & two dimensional), Built in functions for handling arrays, Array multiplication, Inverse of a matrix, Solving three linear equations (array division), Element by element operations, Built in function for analysing arrays.

Unit IV: Solving an equation with one variable, Finding a minimum or a maximum of a function, Numerical integration, Ordinary differential equations, Interpolation etc, Symbolic Math: symbolic objects and symbolic expressions, Creating symbolic objects, Creating symbolic expressions, Changing the form of an existing symbolic expression, Integration, Solving an ordinary differential equation, Plotting symbolic expressions, Numerical calculations with symbolic expressions, Examples of MATLAB applications etc.

Textbook/ References

1. E. BALAGURUSWAMI "Programming in ANSI C" Tata McGraw Hill
2. C Programming Absolute Beginner's Guide, Greg Perry ,3rd edition, Que Publishing

3. Bjarne Stroustrup “The C++ programming language” Pearson Education.
4. Steven C Chapra : Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw Hill
5. Amos Gilat: MATLAB-An Introduction and its Application ,Wiley Indian Edition.

Course Title: Fourier And Laplace Transform	**L**	**T**	**P**	**S**	**Semester:** 8^{th}
Course Code: MTHS451MJ	**2**	**2**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives:_ To develop skill in students about Fourier series, Fourier and Laplace transforms as a tool to solve various problems in the field of applied Mathematics and physics and electronics.

Course Outcomes: After the completion of this course, students shall be able to use

1. Analyze periodic functions and construct their Fourier series representation, including half-range expansions for standard waveforms.
2. Extend the concept of frequency domain analysis to aperiodic functions using the Fourier Transform and its properties, and relate it to the Discrete Fourier Transform.
3. Utilize the Laplace Transform and its properties to solve ordinary differential equations and initial value problems, including those with discontinuous forcing functions.
4. Apply the Laplace Transform technique to solve integral equations, boundary value problems, and fundamental partial differential equations arising in engineering and physics. Fourier and Laplace transforms to solve the differential equations and to understand signal processing in frequency and time domain.

Unit-I: Fourier Series: Introduction, Periodic functions: Properties, Even & Odd functions. Special waveforms: Square wave, Sawtooth wave, and Triangular wave. Euler's Formula for Fourier Series, Fourier Series for functions of period 2π, Fourier Series for functions of period 2L, Dirichlet's conditions, Sum of Fourier series. If ( ) is bounded and integrable function on (-π,π) and if _n, _n are its Fourier coefficients, then \sum _n,+ _n converges. Half Range Series for sine and cosine functions, examples. Riemann Lebesque theorem.

Unit-II: The Fourier Transform. Periodic functions, Definition and examples of Fourier seriesDrichlet's conditions, determination of Fourier coefficients, even and odd functions and their Fourier expansion, change of interval, half range series. Fourier transform, inverse Fourier transform, Fourier sine and cosine transforms and their inversion, properties of Fourier transforms Fourier transform of the derivative, convolution theorem, discrete Fourier transform and fast Fourier transform and their properties.

Unit-III: Definition, Laplace transform of elementary functions, Properties of Laplace transforms viz Linearity, translation, Change of Scale property etc. Laplace transform as periodic functions, Dirac-Delta function, Inverse Laplace transform. Laplace transform for derivatives, Laplace transform for integrals, Convolution theorem. Solution of ordinary differential equations with constant coefficients. Applications of partial differential equations.

Unit-IV: Application of Laplace transform to differential equation and integral equation. Application of Laplace transform to boundary value problems. Electrical circuits, dynamics, Beams, Heat conduction equations and wave equations.

TextBooks/ References:

1. Ruel V. Churchill, Fourier Series & Boundary Value Problems, 8th Edition McGraw Hill Education 2011.

2. Davies, Brian, Integral Transforms and Their Applications, Springer, 2002.
3. Erwin, Kreysgiz, Advanced Engineering Mathematics, John Willey & Sons. 10th Edition, 2011.
4. K.S. Rao, Introduction to Partial Differential Equations, K.S. Rao, PHI, India.
5. L. Debnath and D. Bhatta, Integral Transforms and Their Applications, 3rd Edition, CRC Press.

Course Title: Financial derivative	**L**	**T**	**P**	**S**	**Semester: 8th**
Course Code: MTHS458MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: To make the student conversant with Basic of financial derivatives, various types of derivatives, Use of Models for pricing of derivatives, and various investment risk measurement techniques

Course Outcome: On completion of the course the students will be able to

1. Describe how to utilise various financial derivatives
2. Show how to consider binomial model and black-Sholes formula for option pricing
3. Describe how to use stochastic calculus for derivatives.
4. Demonstrate various investment risk measurement techniques.

Unit-I: Different types of derivative contracts and their uses, Types of Options, Option positions, Underlying Assets, Factors affecting option prices, Upper and lower bounds for option prices. Trading strategies involving options, Arbitrage theory.

Unit-II: Binomial model, One-step and two-step models, N-step model. Risk neutral valuation, Option pricing using binomial model, forward contract pricing.

Unit-III: Brownian Motion, Arithmetic and Geometric Brownian motion, , Ito Lemma, Ito integral, Applying Ito Lemma, Stochastic differential equation for geometric Brownian motion , Black-Scholes derivative-pricing model and its application, Validity of the assumptions underlying the Black-Scholes model ,Black-Scholes partial differential equation both in its basic and Garman-Kohlhagen forms, Value options and examples using the Black-Scholes model

Unit-IV: Mean-variance portfolio theory , Expected return, variance and covariance of returns of the individual assets. expected return, variance and covariance of returns of the individual assets of a portfolio, Downside semi-variance of return, Shortfall probabilities , Value at Risk (VaR),Tail VaR.

Textbooks:

1. Hull, John C, “Options, futures and other derivatives” (5th edition), Prentice Hall, 2002.
2. Paul Wilmott, Sam Howison, and Jeff Dewynne “The Mathematics of Financial derivatives” Cambridge University press, 1995.

Course Title: Advanced Linear Algebra	**L**	**T**	**P**	**S**	**Semester: 8th**
Course Code: MTHS453MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: This course aims to develop a deep understanding of special matrices, their eigenvalues, and related theorems. It focuses on concepts of norms, decompositions, and spectral properties essential for advanced linear algebra. Students will learn to apply these theories to matrix analysis, transformations, and computational methods.

Course Outcomes: After studying this course, the student will be able to

1. Analyze eigenvalues, apply diagonalization, and use Schur's and Cayley–Hamilton theorems.
2. Understand norms, inner products, and apply the Gram-Schmidt process in vector spaces.
3. Analyze spectral radius, eigenvalue behavior, and apply SVD and Gersgorin's theorem.
4. Apply matrix decompositions and analyze eigenvalues using Jordan and Courant-Fisher theorems.

Unit-I: Special Matrices and their Eigen values, Characteristic Polynomial, Elementary properties of Eigen values, Similarity, Diagonalization, Relation between eigen values of BA and AB, Unitary matrices, properties of unitary matrices, unitary equivalence, Schur's triangularization theorem, Cayley Hamilton theorem and its application.

Unit-II: Rank and its properties, introduction to norms and Inner products, Gram-Schmidt algorithm, vector norms and their properties, Applications and equivalence of vector norms, Dual norms, Properties and examples of dual norms, matrix norms and its properties, induced norms and examples, Exploring Rank and Norms using Python.

Unit-III: Spectral radius, properties of spectral radius, convergent matrices, Banach lemma, Equivalence of matrix norms and error in inverse of linear systems, errors in inverse of matrices, Eigenvalues: Majorization theorem, Location and perturbance of Eigenvalues, Gersgorin's theorem, singular value definition and singular value decomposition theorem, Exploring spectral radius and singular value decomposition using Python.

Unit-IV: Normal matrices: Definition and fundamental properties, QR decomposition and canonical form, determining the Jordan form of a matrix, properties of the Jordan canonical form, LU decomposition with pivoting, variational characterization of eigenvalues, Courant-Fisher theorem, positive semidefinite matrix, monotonicity theorem and interlacing theorems.

Text Books/ Reference Books:

1. Seymour Lipschutz and Marc Lipson, Schaum's outlines, Linear Algebra, 2017.
2. R. Horn and C. Johnson, Topics in Matrix Analysis, Cambridge University Press, 1991.

3. Richard A. Brualdi, Dragos Cvetkovic, A combinatorial Approach to Matrix Theory and Its Applications, 2008.
4. Carl D. Meyer, Matrix Analysis and Applied Linear Algebra, 2000.
5. Gilbert Strang, Linear Algebra and its applications, Fourth Edition, 2005.

Course Title: Design of Experiments	**L**	**T**	**P**	**S**	**Semester: 8th**
Course Code: MTHS454MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: This course provides the students the ability to understand the design and conduct experiments, as well as to analyze and interpret data.

Course Learning Outcomes: After successful completion of this course, student will be able to:
1. Apply ANOVA for two –way classification, fixed effect models with equal, unequal and proportional number of observations per cell, Random and Mixed effect models with m (>1) observations per cell.

2. Design and analyse incomplete block designs, understand the concepts of orthogonality, connectedness and balance.

3. Identify the effects of different factors and their interactions and analyse factorial experiments.
4. Construct complete and partially confounded factorial designs and perform their analysis and apply Split-plot designs and their analysis in practical situations.

Unit-I: Review of linear estimation and basic designs. Elimination of heterogeneity in two directions. ANOVA: Fixed effect model: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD), Missing plot technique, General theory and applications, Analysis of Co-variance for CRD and RBD.

Unit-II: General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; Confounding: complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot experiments.

Unit-III: Incomplete Block Designs. Concepts of Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design. B.I.B designs with and without recovery of interblock information.

Unit-IV: Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey‘s test for additivity.

Text Books/References:.

1. Alok Dey (1986): Theory of Block Designs, Wiley Eastern.

2. Angela Dean and Daniel Voss (1999): Design and Analysis of Experiment, Springer.

3. Cochran, W.G. and Cox, G.M.: Experimental Design, John Wiley and Sons, Inc., New York.
4. Das, M. and Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.

5. Montgomery, C.D. (1976): Design and Analysis of Experiment, Wiley, New York.

Course Title: Project	**L**	**T**	**P**	**S**	**Semester: 8th**
Course Code: MTHS455MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Title: Research Methodology	**L**	**T**	**P**	**S**	**Semester: 8th**
Course Code: MTHS456MJ	**3**	**x**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective- The objective of this course is to equip students with essential knowledge and skills for conducting high-quality mathematical research. The course covers the fundamentals of research methodology, hypothesis testing, scientific writing, and effective presentation. Additionally, it introduces students to computational tools such as LaTeX, R programming, and simulation techniques, fostering the ability to analyze data, simulate models, and prepare professional research documents and presentations.

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

1. Identify and formulate mathematical research problems through effective topic selection and literature review.
2. Demonstrate skills in scientific writing, presentation, and understanding of the publication and funding process.
3. Apply parametric and non-parametric hypothesis tests to analyze statistical data.
4. Interpret test results and understand the limitations of hypothesis testing and measurement scales in research.
5. Create professional research documents and presentations using LaTeX and MS Word.
6. Perform data analysis and implement statistical models using R programming.
7. Apply simulation techniques and random variable generation methods for mathematical modeling.
8. Implement numerical algorithms for solving equations, integration, and matrix operations using computational tools.

Unit-I: Overview of mathematical research, selection of a research topic and a research problem, literature survey of the topic and problem, writing references and bibliography. Presentations: Importance of effective presentation, how to write good papers, models of the paper writing process, the benefits of targeting good journals, peer review, how to respond to reviewer comments, funding agencies, writing a research grant proposal.

Unit-II: Basic concepts concerning testing of hypotheses, important parametric and non-parametric tests. Hypothesis testing of means, differences between means, comparing two related samples, proportions, difference between proportions, comparing a variance to some hypothesized population variance, variances of two normal populations, correlation coefficients. Limitations of tests of hypotheses. Measurement in research, measurement scales.

Unit-III: Scientific word processing with LaTeX and MS-word: article, thesis report and presentation-power point features, slide preparation. Statistical programming with R: simple manipulations using numbers, vectors, objects & their attributes. Arrays, matrices, lists and data frames. Grouping loops and conditions. User defined functions, probability distributions and statistical models in R.

Unit-IV: Simulation: Concepts and Advantages of Simulation-Event Type Simulation-Random Variable Generation-U (0,1), Exponential, Gamma and Normal Random Variables–Monte Carlo simulation. The MCMC Principle, Algorithms and its Variants. Computer Oriented Numerical Methods-Algorithms for Solving Algebraic Equations-Numerical Integration-Matrix operations.

Text Books/ References:

1. Anderson, J., Durston, B.H., Pooole, M. (1970). Thesis and Assignment Writing, Wiley Eastern. Ltd., New Delhi.

2. Beveridege, B. (1979). The Art of Scientific Investigation, W.E. Norton & Co., New York.

3. Braun, J., Duncan, W. and Murdock, J. (2008). A First Course in Statistical Programming with R, Cambridge University Press, London.

4. Chambers, J. (2008). Software for Data Analysis: Programming with R, Springer, New York.

5. Crewley, M.J. (2007). The R-.Book, John Wiley, New York.

6. Dalgaard, P. (2008). Introductory Statistics with R, Springer Science, New York.

7. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K. R. (1992). Glilmpses of India's Statistical Heritage, Wiley Eastern Limited, New Delhi.

8. Hald, A. (1998). A History of Mathematical Statistics from 1750 to 1930, John Wiley & Sons, New York.

9. Kantiswarup, S., Gupta P.K. and Man Mohan (2008). Operations Research, Sultan Chand & Sons, New Delhi.

10. Kothari, C.R. and Garg, G. (2014). Research Methodology: Methods and Techniques, 3rd Edn., New Age International Publishers.

11. Lamport, L. (1999). LATEX: A Document Preparation System, Addison, Wesley, 2nd edition, New York.

12. Pannerselvan, R. (2006). Research Methodology, Prentice-Hall of India Pvt., New Delhi.

13. Robert, C.P. and Casella, G. (2004). Monte Carlo Statistical Methods, Springer Science, New York.

14. Venkataraman, M.K. (1998). Numerical Methods in Science and Engineering, The National Publishing Company, Chennai.