FYUGP Mathematical Sciences Course Outline for Semester IV (Batch 2024)

S. No.	Category	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	Major	MTHS254MJ	R Programming for Data Analytics	4	2	0	4	0	6
		MTHS251MJ	Differential Equations	4	4	0	0	0	4
		MTHS255MJ	Probability Theory	4	4	0	0	0	4
		MTHS253MJ	Operations Research	4	4	0	0	0	4
2	Minor 4		Students to choose	4					

Course Title: R Programming for Data Analytics	**L**	**T**	**P**	**S**	**Semester:** 4^{th}
Course Code: MTHS254MJ	**2**	**x**	**4**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The objective of this course is to provide students with practical knowledge and skills in R programming for data analysis and statistical computing. It aims to develop the ability to write R scripts, manipulate data, perform descriptive and inferential statistical analyses, and create effective data visualizations. By the end of the course, students will be capable of using R for real-world data analysis and research applications.

Course Outcomes: After completing this course, students will be able to:

1. Understand the R environment and basic R syntax for statistical computing and data management.
2. Work with various data structures in R such as vectors, matrices, lists, and data frames, and perform data import/export operations.
3. Apply descriptive statistical methods and data manipulation techniques using built-in R functions and apply-family functions.
4. Develop reusable R scripts and functions for solving practical data analysis problems.

Unit I: Fundamentals of R programming; overview of R and RStudio environment; using R as a calculator, assignment operator, object name rules, basic operations on objects; vectors and data frames, subsetting vectors and data frames using indices, logical conditions, names, and other subset functions; applying basic mathematical functions on data frames for summarization and transformation.

Unit II: Working with matrices, arrays, and lists, indexing, and operations, subsetting using indices and logical conditions; applying basic functions for summarization and transformation; setting and managing the working directory; importing data from various file formats such as CSV and Excel; exporting processed data to external files; exploring and analyzing default datasets available in R for practice and demonstration.

Unit III: Writing and calling functions in R; creating basic graphics using base plotting system; descriptive statistics-mean, median, variance, standard deviation, frequency tables, cross-tabulations, proportion tables, correlation and simple linear regression analysis using R.

Unit IV: Data manipulation using apply(), lapply(), sapply(), and tapply(), random number generation from different distributions, data cleaning and transformation, checking normality, handling outliers, preparing data for statistical modeling and visualization, swirl() package for interactive learning.=

Text Books and Reference Books:

1. Matloff, N. (2016). The art of R programming: A tour of statistical software design. No Starch Press.
2. Gardener, M. (2017). Beginning R: The statistical programming language, Wiley.
3. Cotton, R., Learning R: a step by step function guide to data analysis. 1st edition. O'reilly Media Inc.
4. Lawrence, M., & Verzani, J. (2016). Programming Graphical User Interfaces in R. CRC press. (ebook

Course Title: Differential Equations	**L**	**T**	**P**	**S**	**Semester:** 4^{th}
Course Code: MTHS251MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: To acquaint students with various methods for solving differential equations and to develop an understanding of their qualitative applications through mathematical models.

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

(i) Solve ordinary and partial differential equations using appropriate analytical methods.
(ii) Apply differential equations to model and analyze real-life dynamical systems.
(iii) Classify and interpret the behavior of linear and non-linear differential systems.

Unit-I: Review of differential equations, first order first degree differential equations and methods of solving(variable separable, homogeneous, equations reducible to homogeneous, and Bernoulli's form), equations of first order but of higher degree and methods of solving(solvable for p, solvable for y, solvable for x, and clairaut's form), singular solution, p-discriminant, c-discriminant.

Unit-II: Higher-order differential equations, basic theory of linear differential equations, linear homogeneous and non-homogeneous differential equations with constant coefficients, homogeneous linear equations with variable coefficients, fundamental set of solutions, linear dependence and independence of solutions, wronskian.

Unit-III: Simultaneous differential equations, system of linear differential equations with constant coefficients, total differential equations $Pdx + Qdy + Rdz = 0$, ordinary and singular points, series solution of differential equations near an ordinary point.

Unit-IV: Introduction to partial differential equations-PDEs(linear, non-linear, quasi-linear and semi linear PDEs), Formation of PDE by elimination of arbitrary constants and functions, complete, general and singular solution of PDE, Lagrange's and Charpit's methods for the solution of linear and non-linear PDEs.

Text Books / References

1. W.E. Boyce and R.C. DiPrima, Elementary Differential Equations and Boundary Value Problems, John Wiley and Sons, 11^{th} Edition, 2021.
2. Zafar Ahsan, Differential Equations and their Applications, PHI, Pvt. Ltd. New Delhi-Second edition, 2004.
3. S. L. Ross, Differential Equations, 3^{rd} Edition, John Wiley and Sons, India, 2004.
4. C. H. Edwards and D.E. Penny, Differential Equations and Boundary Value Problems Computing and Modeling, Pearson Education India, 2005.
5. K.S. Rao, Introduction to Partial Differential Equations, PHI, New Delhi, Pvt. Ltd., 2011.

Course Title: Probability Theory	**L**	**T**	**P**	**S**	**Semester:** 4^{th}
Course Code: MTHS255MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The main objective of this course is to introduce the notion of probability, random variable, expectation, Law of Large Numbers and the Central Limit Theorem with their applications based on which statistical theory and tools have been developed.

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

1. Recall concept of probability and related terminology.
2. Differentiate discrete and continuous random variables and their distributions.
3. Understand probability mass function, density function and distribution function.
4. Compute expectations of random variables and their generating functions
5. Learn the concepts of weak and strong laws of large numbers and central limit theorem.

Unit I: Probability: Introduction**,** random experiments, sample space and algebra of events. Counting principle: permutations and combinations etc. Definitions of Probability-classical, statistical and axiomatic. Conditional probability, laws of addition and multiplication, independence of events, Theorem of total probability, Bayes theorem and its applications.

Unit II: Random Variables: discrete and continuous random variables. Cumulative distribution function (c.d.f.), Probability mass function (p.m.f.) & Probability density function (p.d.f.) - definition and properties. Expectation of a random variable, expectation of a function of a random variable, simple properties, moments and cumulants. Some Special Distributions and their applications: Uniform (discrete and continuous), Bernoulli, Binomial, Poisson, Exponential, Normal.

Unit III: Two-dimensional random variables, Joint distribution for two random variables (continuous and discrete case); independence, marginal and conditional distributions. Expectation of sums of random variable, covariance, variance of sums, correlations. Conditional expectation and conditional variance.

Unit IV: Moment generating function, probability generating function and characteristics function; cumulant generating function, derivation for various distributions; sums of independent random variables. Markov and Chebyshev's inequalities, normal approximation to binomial; strong and weak law of large numbers; central limit theorem with proof (using Levy's Continuity Theorem).

Text Books / References

1. Mood A. M. , Grabyll R. A. and Boes D. C., *Introduction to the theory of Statistics*, Tata McGraw Hill

2. Miller, I. and Miller, M., *John E. Freund's Mathematical Statistics with applications*, Pearson Education, Asia.

3. Ross Sheldon M., *A first Course in Probability*, Pearson.
4. Goon A.M., Gupta M.K. and DasGupta B., *Fundamentals of Statistics*, Volume-I, The World Press, Kolkata.
5. Rohtagi, V.K. and Md. Ehsanes Saleh A. K., *An Introduction to Probability and Statistics*, John Wiley & Sons.

Course Title: Operations Research	**L**	**T**	**P**	**S**	**Semester:** 4^{th}
Course Code: MTHS253MJ	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The aim of the course is to give knowledge to students to use quantitive methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Course Outcomes:

1. Student will be able to Identify and develop operational research models from the verbal description of the real system.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Solve various linear programming, transportation, assignment, queuing, inventory and game problems related to real life.

Unit-I: Linear programming; concept and uses of linear programming, formulation of linear programming problem. Solution of LP problem- graphical method, slacl and surplus variable, simplex method, unbounded and infeasible solution. Duality in Linear Programming, Properties of the primal-dual pair, Fundamental theorem of duality, dual simplex Method.

Unit II: Transportation and Assignment problems: Formulation of transportation and assignment problems as linear programs. Methods of obtaining the initial basic feasible solution to a transportation problem. Solution of the Transportation problem by MODI Method. Unbalanced transportation problems and their solutions. Degeneracy in Transportation problem and its resolution. Solution of Assignment Problem by Hungarian Method. Traveling salesman problem as an assignment problem (Formulation only).

Unit III: Sequencing problems- problems with n jobs and 2 machines, problems with n jobs and k machines. Games and Strategies: Two person zero-sum games, Maximin-Minimax Principle, Mixed Strategies, Solution of 2×2 and $m\times n$ games.

Unit-IV: Concept of PERT/CPM networks, estimating the activity time, determination of earliest expected and latest allowable times, determination of critical path Drawing network diagram, probability consideration in PERT networks PERT/CPM- cost analysis, applications of PERT/CPM. Simulation: meaning & uses; Monte Carlo method, random number generation, waiting line simulation model.

Books Recommended:

1. Gass, S.I.: Linear Programming-Methods & Applications.
2. Taha, H.A.: Operations Research-An introduction, Pentice Hall of India Pvt. Ltd. New Delhi. (7th Edition-2003)
3. Swaroop K, Gupta, P.K. & Mohan, M.: Operations Research, Sultan Chand & Sons, New Delhi.
4. Vohra, N D: 'Quantitative Techniques in Management' Tata McGraw Hill
5. Sharma S.D.: 'Operational Research', Kedar Nath Ram Nath and Co., Meerut