Gujarat University

Department of Applied Mathematical Science, Actuarial Science and Analytics

M.Sc. Applied Mathematical Science

Semester - II

Course Code	Course Name	Course Credits
AMS407	Design of Experiments and Regression Analysis	4
AMS408	Advanced Operations Research	4
AMS409	Mathematical Modelling	4
AMS410	Mathematical Methods	4
AMS411	(Practical-III) Programming with Python-II	4
AMS412	(Practical-IV) Programming with R-II	4
	Total	**24**

AMS407

Design of Experiments and Regression Analysis

Unit 1: Design of Experiments and Non-Parametric Test

Analysis of Variance (One Way & Two Way), Design of Experiment: Completely Randomized Design, Multiple Comparison Procedures, Randomized Block Design, LSD
Normality test: Kolmogorov-Smirnov (K-S) test, Anderson-Darling test
Runs Test, Sign Test, Wilcoxon Signed-Rank Test, Mann-Whitney- Wilcoxon Test, Kruskal-Wallis Test, Friedman Test, Spearman's Rank Correlation

Unit 2: Linear Regression

Regression equation, Estimation of regression equation, Standard error of the estimate, Coefficient of Determination, assumptions of the regression model, Using Residuals to test the assumption of the regression model
Test for significance for the slope of the regression model and testing the overall model, Estimation: Confidence intervals to estimate the mean and Prediction intervals to estimate an individual value, using regression to develop a forecasting trend line, Case study-based examples through computer output

Unit 3: Multiple and Logistic Regression

Model equation, least Square Method, Multiple coefficients of determination, Model assumption, Test for significance, Estimation and Prediction, Categorical independent variables, Residual analysis, Logistic Regression, Case study-based examples
Durbin-Watson test for testing autocorrelation
Test heteroscedasticity: Bartlett Test, Breusch Pagan test
Identification for Multi Collinearity on the basis of Multiple Correlation Coefficient

Unit 4: Time Series and Forecasting

Components of Time Series, Forecast Accuracy, Moving Average and Exponential Smoothing, Trend Analysis and Projection, Seasonality and Trend, Time Series Decomposition

Reference Books:

1. Probability and Statistics in Engineering by Hines, Montgomery, Goldsman and Borror (Wiley 4th edition)
2. Fundamentals of Mathematical Statistics, S. C. Gupta & V. K. Kapoor, Sultan Chand & Sons (11 edition)
3. Statistics for Business and Economics by Anderson, Sweeney, Williams (Cengage Publishers 12th edition)
4. Applied Business Statistics by Black (Wiley 7th edition)
5. Statistics for Management by Levin, Rubin, Pearson (8th edition)

6. Introduction to Linear Regression Analysis, Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Wiley (3rd edition)
7. All of Statistics by Larry Wasserman, Springer
8. Regression Analysis by Example, Samprit Chatterjee, Ali S. Hadi, Wiley (5th edition)
9. Applied Statistics in Business and Economics by David P. Doane, Lori E. Seward, McGraw-Hill (3rd Addition)

AMS408

Advanced Operations Research

Unit 1: Decision Analysis and Game Theory

Decision Analysis: Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwicz criterion, Decision tree, Calculation of posterior probabilities by Bayes Rule and calculation of EPPI, EVPI and EVSI

Game Theory: Characteristics of Game Theory, Maxmin and Minmax principle, Two-person Zero-sum games with saddle point, Game problems without saddle point, Pure strategy and mixed strategy, Solution of a 2×2 game problem without saddle point, Graphical method of solution for n×2 and 2×n game problem, Reduction rule of a game problem (Dominance rule), Algebraic method of solution of game problem without saddle point, Reduction of a game problem to linear programming problem

Unit 2: Non-Linear Programming

Non-Linear Programming, Lagrangian Method, Kuhn-Tucker conditions, Quadratic Programming, Wolfe's method, Separable Programming

Unit 3: Goal Programming and Multicriteria Decision Making

Goal programming: Difference between linear programming and Goal programming approach, Goal programming model formulation, Graphical solution method of goal programming. Modified simplex method of goal programming, alternative simplex method for Goal programming

Multicriteria decision: Multicriteria decision making models, Determination of set of feasible alternatives, Solution Techniques, Multicriteria simplex method

Unit 4: Dynamic Programming

Dynamic programming: Characteristics of dynamic programming, Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stagecoach/Shortest Path, cargo loading and Reliability problems

Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality

Bellman's principle of optimality and recursive relationship of dynamic programming for various optimization problems

Reference Books:

1. Nita H. Shah, Ravi M. Gor, Hardik Soni, "Operations Research", Prentice-Hall India (2007)
2. Hiller and Liberman, "Introduction to Operations Research", 9th edition, Tata McGraw-Hill

3. Hamdy A. Taha, “Operations Research: An Introduction”, 8th edition, Prentice-Hall India (2007)
4. Wayne L. Winston, “Operations Research: Applications and Algorithms”, 4th edition, Thomson
5. Anderson, Sweeney, Williams, “An Introduction to Management Science: Quantitative Approaches to Decision Making”, 13th edition, South-Western College Publishing

AMS409

Mathematical Modelling

Prerequisites:

Mathematical Modeling: Need, Techniques, Classifications and Simple illustration
What is Mathematical Modeling, History of Mathematical Modeling, Importance of Mathematical Modeling, Latest Developments in Mathematical Modeling, Classification of Mathematical models, Mathematical Modeling through Algebra and Calculus, Limitations of Mathematical Modeling

Unit 1: Basic Models based on Difference Equations

Introduction to Discreate models, Linear Models: Growth models, Decay models, Newton's Law of cooling, Bank Account problem, Drug Delivery problem, Economic Model (Harrod Model), Arms Race model, Linear Prey-Predator problem, Non-linear Models: Density dependent growth models, the learning model

Unit 2: Introduction to Continuous Models

Formation of various continuous models: Carbon dating, Drug distribution in the body, Growth and Decay of current in an L-R circuit, Rectilinear motion under variable force, Mechanical oscillations: Horizontal oscillations, Vertical oscillations, Damped Force Oscillation, Dynamics of Rowing, Arms Race models, Mathematical model of influenza infection, Epidemic models (SI, SIR, SIRS, SIC), Steady state solutions, Linearization and local stability Analysis, Phase plane diagrams of linear systems, Bifurcations

Unit 3: Spatial Models using Partial Differential Equations

Different Mathematical Models using Diffusion: Fluid flow through a Porous Medium, Heat flow through a small thin rod (One dimension), Wave equation, Vibrating string, Traffic flow, Theory of car-following, Crime Model, Linear stability Analysis: One species with Diffusion, Two species with Diffusion

Unit 4: Modeling with Delay Differential Equations

Different Mathematical Models using Delay Differential Equations: Delayed Protein Degradation, Football Team Performance Model, Breathing Model, Housefly Model, Shower Problem, Two- Neutron System, Linear Stability Analysis: Linear Stability Criteria

Reference Books:

1. Banerjee, S., "Mathematical Modeling: Models, Analysis and Applications", CRC Press, 2019
2. Kapur, J.N., "Mathematical Modeling", New Age International, 2005
3. Marotto, F.R., "Introduction to Mathematical Modeling using Discrete Dynamical Systems", Thomson Brooks/Cole
4. Klamkin, M.S., "Mathematical Modeling: Classroom Notes in Applied Mathematics", Siam,1987

AMS410

Mathematical Methods

Unit 1: Numerical methods for Differential Equations

Initial value problem: Methods of first-order Differential Equations: Euler's method (Euler-Cauchy method), Modified Euler's method (Heun's Method), Runge-Kutta methods (First, Second, Third and Fourth order), Multistep methods and stability, Predictor-Corrector methods Numerical Integration: Trapezoidal and Simpson's rules, Gaussian Quadrature formula, Newton-Cotes Quadrature formula, Flow charts, Algorithms and computer programs to implement the above techniques

Unit 2: Laplace Transformation

Laplace Transform, Properties of Laplace Transforms, Inverse transform, linearity, shifting, Transforms of Derivatives and Integrals, Differential equations, unit step function, second shifting theorem, Dirac's Delta function, Differentiation and Integration of Transforms, Convolution, Integral Equations, Partial fractions, Differential equations, Laplace transform: General formulas

Unit 3: Fourier series, Integrals and Transforms

Periodic functions, Trigonometric series, Fourier series, Dirichlet's conditions, Advantages of Fourier series, functions of any period $p = 2L$, Even and odd functions, Half-Range expansions, Forced oscillations, Approximation by trigonometric polynomials, Fourier Integrals, Fourier sine and cosine transforms, Fourier inverse transform

Unit 4: Complex Numbers and Functions, Conformal mapping

Analytic functions, Cauchy-Riemann conditions, mapping by elementary functions, conformal mapping and Mobius transformation, complex integration: Cauchy's Integral formula, Taylor's and Laurent series, singularities, zeros and poles, isolated singularities and residues, Cauchy residue theorem, use of conformal mapping

Reference Books:

1. Mollah, S.A., "Numerical Analysis and Computational Procedures", Books and Allied (P) Ltd., 3rd Edition – 2001
2. Balagurusamy, E., "Numerical Methods", McGraw- Hill, 2005
3. Kreyszig, E., "Advanced Engineering Mathematics", Wiley, 10th edition, 2017
4. O'Neil, P.V., "Advanced Engineering Mathematics", Cengage Learning, 7th Edition
5. Widder, D.V., "Advanced Calculus", Prentice-Hall, 2nd Edition
6. Churchill, R.V., Brown J.W., "Complex Variables and Applications", McGraw-Hill, 8th Edition
7. S. Ponnusamy, "Foundations of Complex analysis", Narosa Publication

AMS411

(Practical-III) Programming with Python-II

Unit 1: Data Structure and Algorithm

Introduction of Data Structure and algorithm, Built -in and User defined Data Structure, Linear and Non-Linear Data Structure

Sorting and Searching Algorithm: Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort, Counting Sort, Radix Sort, Bucket Sort, Heap Sort, Shell Sort, Linear Search, Binary Search

Greedy Algorithm & Dynamic Programming: Ford-Fulkerson Algorithm, Dijkstra's Algorithm, Prims Algorithm, Huffman Code, Floyd-Warshall Algorithm, Longest Common Subsequence

Unit 2: Graphical User Interface

Definition of a Graphical User Interface, Import tkinter module, Create the container/main window, Working with Containers, Fonts and Colors, Introduction to tkinter Widgets, tkinter standard attributes, Canvas, Frame, Widget, Arranging widget in the frame, Label Widgets, Massage widgets, Text Widgets, Scrollbar Widgets, Checkbutton Widgets, Radiobutton Widgets, Entry Widgets, Spinbox Widgets, Listbox Widgets, Menu Widgets, Creating Tables, Geometry manager classes

Unit 3: Python Database Connectivity

DBMS, Advantage of DBMS over Files, Working with MySQL Database, Retrieving all Rows from a Table, Inserting rows into a Table, Deleting Rows from a Table, Updating Row in a Table, Creating Database table through python, Installation of Oracle, Verifying oracle installation in windows operating system, Working with Oracle Database in Python

Unit 4: Libraries for Machine Learning and Deep Learning

SciKit Learn: Introducing SciKit Learn, Loading Data Set, Cleaning Data Set, Visualizing Data Set, Normalizing Data Set for Training, Splitting Data Set into Training and Testing, Model Selection, Training and Testing Model, Different performance metrics for evaluating model performance

Tensorflow Keras API: Introduction to Tensorflow, What is Tensor, How to create different types of Tensors, Shape, Rank, Size and Dimension of Tensor, Indexing of Tensor, Tensorflow Variable and Constant, Manipulation of Shapes, Broadcasting, Ragged Tensor, String Tensor, Sparse Tensor, Various Tensor Operations, Casting Tensor to NumPy, Gradient Tape, How to create Layers, Training and Evaluating Models, Saving and Loading Models

Reference Books:

1. Mark Summerfield, “Rapid GUI Programming with Python and Qt: The Definitive Guide to PyQt Programming” Pearson; 1st edition (2015)
2. Brad Miller and David Ranum, “Problem Solving with Algorithms and Data Structures using Python”, Luther College, 2nd edition
3. Albert Lukaszewski, “MySQL for Python”, Packt (2010)
4. Michael T Goodrich and Roberto Tamassia and Michael H Goldwsasser, “Data Structures and Algorithms in Python++”, John Wiley (2013)
5. Sebastian Raschka, Vahid Mirjalili, “Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow”, Packt, 3rd edition
6. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems”, O’Reilly, 2nd edition
7. Chris Albon, “Machine Learning with Python Cookbook: Practical Solutions from Preprocessing to Deep Learning”, O’Reilly, 1st edition (2018)
8. U Dinesh Kumar and Manaranjan Pradhan, “Machine Learning using Python”, Wiley, 1st edition (2020)
9. https://www.tensorflow.org/tutorials/quickstart/beginner

AMS412

(Practical-IV) Programming with R-II

Unit 1:

Inference about Population variance: Interval Estimation, Hypothesis Testing for Variance, Inference about Two Population Variance
Goodness of Fit Tests: Multinomial Population, Test of Independence, Distribution Fitting (Normal and Poisson Distribution)
Non-Parametric Tests: Sign Test, Wilcoxon Signed Rank Test, Mann-Whitney-Wilcoxon Test, Kruskal-Wallis Test

Unit 2:

Analysis of Variance: Completely Randomized Design, Randomized Block Design, Factorial Design
Simple Linear Regression Model: Estimated Simple Linear Regression Equation, Coefficient of Determination, Testing for Significance, Confidence Interval, Prediction Interval, Residual Plots, Correlation

Unit 3:

Multiple Regression Model: Estimated Multiple Regression Model, Coefficient of Determination, Testing for Significance, Confidence Interval, Prediction Interval, Residual Analysis, Plotting multivariate data
Time Series and Forecasting: Plotting Time Series, Smoothing Methods: Moving Average, Weighted Moving Average, Exponential Smoothing

Unit 4: Package 'deSolve' for differential equations

Ordinary Differential Equations (ODE): Initial Value Problems, Runga-Kutta Method, Euler Method, Model Diagnostics, Plotting
Differential Algebraic Equations (DAE): DAE solver in R, A Simple DAE (up to 3), Nonlinear Implicit ODE, Plotting
Partial Differential Equations (PDE): Methods for solving PDE, Heat Equation, Wave Equation, Laplace's Equation, Plotting
Delay Differential Equations (DeDE): DeDE solver in R, Events & Roots, Difference Equation, Plotting

Reference Books:

1. Peter Dalgaard “Statistics and computing: Introductory Statistics with R”, Springer (2002)
2. Tilman M. Davies “The Book of R: A First Course in Programming and Statistics”, no starch press, San Francisco (2016)
3. Karline Soetaert, Jeff Cash, Francesca Mazzia “Solving Differential Equation in R” Springer (2012)
4. Dr. Marcel Dettling “Applied Time Series Analysis” Institute for Data Analysis and Process Design, Zurich University of Applied Sciences.
5. Jonathan D. Cryer and Kung-Sik Chan “Time Series Analysis with Application in R” 2nd Edition Springer (2008)
6. Jared P. Lander, “R for Everyone”, 2nd edition, Addison Wesley Data & Analytics Series (2017)
7. Maindonald J. and Braum, J., “Data Analysis and Graphics Using R: An example-based approach”, 3rd edition, Cambridge Series in Statistical and Probabilistic Mathematics (2010)
8. Hey-Jahans, C., “An R Companion to Linear Statistical Models”, CRC Press (2012)