Darrang College (Autonomous), Tezpur-784001

Syllabus for FYUGP

Sub: STATISTICS

Approved by :

Board of Studies meeting held on 27-12-2025 &
Academic Council vide Resolution no. 2 dated-29-12-2025

DARRANG COLLEGE (AUTONOMOUS)
TEZPUR, ASSAM

FYUGP Structure as per UGC Credit Framework

DEPARTMENT OF STATISTICS

(Courses effective from Academic Year 2025-2026)

SYLLABUS OF COURSES OFFERED

(Major)

AIMS OF FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP) IN STATISTICS:

The aims of Four-Year under Graduate Programme (FYUGP) in Statistics are:

- The UG Programme in Statistics is structured to develop analytical, critical, and logical thinking skills in students.
- It emphasizes the application of mathematical reasoning in solving real-world problems.
- Students are introduced to diverse and practical statistical concepts throughout the course.
- The programme prepares students for roles like data scientist, statistician, strategic banker, researcher, and biostatistician.
- Graduates can pursue careers in industries, government agencies, public sector units, finance, business, and research.
- The curriculum includes both mathematical and applied statistics topics for well-rounded learning.
- Practical training is provided through hands-on sessions in the Computer Lab.
- Students gain experience using statistical software such as MS Excel, C/C++, R, and SPSS.
- Coding skills and software usage are integrated to deepen understanding of statistical methods.
- The programme aims to equip students with the necessary tools for success in research and industry.

Programme Outcome:

By the end of the programme a UG student of Statistics should be able to know about:

- **Statistical Knowledge**: Gain a strong foundation in theoretical and applied statistics to analyze and interpret data effectively.
- **Mathematical Reasoning**: Develop the ability to use mathematical tools and logical thinking for solving real-life and research-oriented problems.

- **Data Handling Skills**: Acquire skills in data collection, cleaning, visualization, and analysis using modern software and statistical techniques.
- **Computational Proficiency**: Learn to use programming languages and statistical software such as R, Python, SPSS, and C/C++ for data analysis and modeling.
- **Critical Thinking**: Enhance the ability to critically evaluate data sources, methods, and interpretations in a wide range of applications.
- **Research Competence**: Build capability to design and conduct statistical investigations and contribute to interdisciplinary research.
- **Problem Solving**: Apply statistical methods to solve practical problems in domains such as business, health, economics, environment, and public policy.
- **Communication Skills**: Develop effective written and verbal communication skills to present statistical findings clearly to both technical and non-technical audiences.
- **Ethics and Responsibility**: Understand the ethical issues in data handling, privacy, and responsible use of statistical results.
- **Career Readiness**: Prepare for careers in data science, analytics, government services, research institutions, finance, and further academic studies.

Teaching Learning Process:

The programme supports the application of multiple pedagogical approaches in both classroom and computer lab environments.

- Focus on learner-centric and outcome-based teaching methods.
- Use of both traditional lectures and digital tools for content delivery.
- Emphasis on conceptual clarity and practical application.
- Interactive sessions including discussions, quizzes, and problem-solving.
- Regular hands-on training using statistical software like R, SPSS, and Excel.
- Continuous internal assessment through tests, assignments, and presentations.
- Integration of project-based learning for real-life data analysis.
- Opportunities for internships and field work for practical exposure.

- Interdisciplinary approach connecting statistics with other domains.
- Inclusion of soft skill development and ethical value-based activities.

Teaching Learning Tools:

- Blackboard and Whiteboard Teaching – For explaining concepts, formulas, and derivations.
- Power Point Presentations – To visually present data, graphs, and theoretical concepts.
- Statistical Softwares – Tools like R, SPSS, Python, Excel for data analysis and practical's.
- ICT Tools – Projectors, Google Classroom
- Graphs and Charts – Manual and digital graph plotting for visualization.
- Problem-Solving Sessions – Interactive numerical sessions to enhance analytical skills.
- Case Studies – Real-life statistical data applications to encourage critical thinking.
- Group Discussions

Assessment/Evaluation Methods:

- A variety of subject-specific assessment procedures will be used to monitor student progress.
- Continuous evaluation will determine the final grade.
- Evaluation includes both In-semester assessment and End semester examination.
- In-semester evaluation methods include:

    - Class tests
    - In-semester Sessional exams
    - Home Assignments
    - Group Discussions
    - Attendance

- Assessment techniques include:

  - Tutorials
  - In-semester assessment
  - Problem-based assignments
  - Lab reports for practicals
  - Individual project reports
  - Oral presentations (including seminars)
  - Viva-voce
  - End Semester examinations (Theory and Practical)

Darrang College (Autonomous), Tezpur, Assam, 784001

FYUGP Structure as per UGC Credit Framework

Year	Semester	Course Code	Title of the Course	Total Credit
1st Year	1st Semester	STA-MJ-01014	Introductory Statistics and Probability	4
		STA-MN-01014	Introductory Statistics and Probability	4
		STA-SEC-01013	Statistical Data Analysis Using Excel	3
		VAC		4
		MDC		3
		AEC		2
	Total			**20**
	2nd Semester	STA-MJ-02014	Intermediate Probability Theory	4
		STA-MN-02014	Intermediate Probability Theory	4
		STA-SEC-02013	Statistical Data Analysis Using SPSS	3
		VAC		4

		MDC		3
		AEC		2
	Total			**20**
2nd Year	**3rd Semester**	STA-MJ-03014	Statistical Inference	4
		STA-MJ-03024	Mathematical Analysis	4
		STA-MN-03014	Basics of Statistical Inference	4
		STA-SEC-01013	Statistical Data Analysis Using R	3
		MDC		3
		AEC		2
	Total			**20**
	4th Semester	STA-MJ-04014	Linear Models & Probability Laws	4
		STA-MJ-04024	Linear Algebra	4
		STA-MJ-04034	Sampling Distributions	4
		STA-MJ-04044	Survey Sampling	4
		STA-MN-04014	Survey Sampling & Design of Experiments	4
		AEC		2
	Total			**22**
3rd Year	**5th Semester**	STA-MJ-05014	Applied Statistics	4
		STA-MJ-05024	Design of Experiments	4
		STA-MJ-05014	Operations Research	4
		STA-INT-05014	Internship	4
		STA-MN-05014	Applied Statistics	4
	Total			**20**

	6th Semester	STA-MJ-06014	Stochastic Process and Queuing Theory	4
		STA-MJ-06024	Multivariate Analysis and Non-Parametric Inference	4
		STA-MJ-06034	Demography and Vital Statistics	4
		STA-MJ-06044	Project	4
		STA-MN-06014	Demography and Vital Statistics	4
	Total			**20**
4th Year	**7th Semester**	STA-MJ-07014	Advanced Mathematical Analysis	4
		STA-MJ-07024	Probability Distributions	4
		STA-MJ-07034	Econometrics	4
		STA-MJ-07044	Research Methodology	4
		STA-MN-07014	Linear Models	4
	Total			**20**
	8th Semester	STA-MJ-08014	Time Series Analysis	4
		STA-MJ-08024	Bayesian and Classical Inference	4
		STA-MJ-08034	Queuing Theory	4
		STA-MJ-08044	Dissertation	4
		STA-MN-08014	Operations Research	4
	Total			**20**

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 1st SEMESTER

Title of the Course	Introductory Statistics and Probability
Course Code	STA-MJ-01014
Nature of Course	Major
Total Credit	4 (Theory - 03 + Practical - 01)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	100-199

Course Objectives: The objective is to give students foundational ideas about the various statistical methods, measures of central tendency and basics of probability. The students are introduced to the methods of collecting data, their representational formats and basic statistical tools.

Learning Outcomes: At the end of the course, students will be able to analyse a data set, represent the data in tabular and diagrammatic form, prepare the frequency distribution, find the summary measures viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.

Course Outcomes:

CO1: Recall and define fundamental concepts in descriptive statistics and probability, such as mean, median, mode, variance, standard deviation and basic rules of probability.

CO2: Interpret and explain the significance of descriptive statistical measures and probability concepts in real-world contexts. Describe the relationship between descriptive statistics and probability and how they are used to analyze and interpret data.

CO3: Apply descriptive statistical techniques to summarize and analyze data sets, including calculating measures of central tendency, dispersion, and constructing frequency distributions.

CO4: Analyze and interpret data using descriptive statistics and probability techniques, identifying patterns, trends, and relationships within datasets.

CO5: Assess the strengths and limitations of descriptive statistics and probability in addressing real life questions and making informed decisions, and propose improvements or alternative approaches when necessary.

Unit	Content	L	T	P	Total hrs
I	**Statistical Data and its representations:** Definition and scope of Statistics, concepts of statistical population and sample. Types of Data: quantitative and qualitative, primary and secondary data, attributes, variables, scales of measurement-nominal, ordinal, interval and ratio. Data visualization. Presentation & Classification of Data: tabular and frequency distribution, Collection and Scrutiny of Data: Primary data-designing a questionnaire and a schedule; Secondary data- their Major sources including some government publications. Idea of National Surveys (ASER, NFHS etc)	05	03	-	08
II	**Descriptive Statistics:** Mathematical measures of central tendency: Arithmetic Mean, Median, Mode, Geometric Mean, Harmonic Mean, Trimmed Mean, Winsorised Mean and their properties and applications. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, Sheppard's corrections, skewness and kurtosis, Partition Values: Fractiles, Quartiles, Deciles, percentiles.	10	05	-	15
III	**Bivariate Data:** Representation of Bivariate Data, scatter diagram, simple, partial and multiple correlation (three variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curve	07	03	-	10
IV	**Introductory Probability**: Introduction, random experiments, sample space, events, algebra of events. Definitions of Probability: classical, statistical and axiomatic. Computational Probability: Conditional	08	04	-	12

	Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications. Idea of Quantum Probability. Idea of probability measure.				
V	**Practical:** **Note**: Students can use calculators / Ms Excel programming as convenient**.** 1. Graphical representation of data. 2. Problems based on measures of central tendency & dispersion. 3. Problems based on measures of location. 4. Problems based on moments, skewness and kurtosis. 5. Karl Pearson correlation coefficient 6. Correlation coefficient for a bivariate frequency distribution 7. Lines of regression, angle between lines and estimated values of variables. 8. Estimation of parameters by Method of Least Square 9. Spearman rank correlation with and without ties. 10. Partial and multiple correlations.	-	-	15	30

SUGGESTED READING:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I &II, 8th Edn. The World Press, Kolkata.

2. Miller, Irwinand Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

3. Mood, A.M. Graybill, F.A.and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co.Ltd.

4. Medhi, J., Statistical Methods (2000): An Introductory text (New Age International (P) Ltd.

5. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics. Sultan Chand & Sons. New Delhi. (12th Edition).

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 2nd SEMESTER

Title of the Course	Introductory Probability and Statistics
Course Code	STA-MJ-02014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	100-199

Course Objective: This course has the objective of providing exposure to random variable and large scale properties of probability distributions. This is a fundamental course on probability theory, random variables and their distributions to make further progress on statistical analysis. This course also introduces the ideas of Statistical Inference and its importance in real world applications

Learning Outcomes: At the end of the course, students shall be able to appreciate the large sample implications of various statistical measures and also learn about a number of statistical distributions. They will be able to determine whether or not moments exist of any given random variable and if so, to determine them. They will also be able to use tools like Probability Generating function and Moment generating functions to study distributions in addition to learning several univariate discrete and continuous distributions and their characterizations.

Course outcomes:

CO1: Define the concepts of two dimensional random variables, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations.

CO3: Define expectation of single and bivariate random variables and its properties, conditional expectations, conditional variance, moments, factorial moments.

CO3: Explain the properties of generating functions. cumulants, cumulant generating function,

characteristic function

CO4: Illustrate the various probability distributions such as Discrete uniform, Bernoulli, Binomial, Poisson, geometric, negative binomial, hyper-geometric, Multinomial, Exponential, Cauchy, Beta and Gamma distributions, Lognormal, their properties and limiting cases and utilize these ideas to solve numerical problems.

Unit	Content	L	T	P	Total hrs
I	**Random variables:** Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, transformation of random variables, Idea of discretisation of continuous random variable.	10	02	-	12
II	**Mathematical Expectation and Generating Functions:** Expectation of single and bivariate random variables and its properties, Computational Expectations of conditional, conditional variance, Theorems on sums and product of expectation of random variables, Inequalities involving expectation. Moment generating function (mgf), cumulants, cumulant generating function (cgf) and characteristic function (cf), probability generating function (pgf) their properties and related problems. Distribution of CDF, Uniqueness and Inversion theorem (without proof) along with applications	09	02	-	11
III	**Discrete Probability Distributions:** Discrete uniform, Bernoulli, Binomial, Poisson, geometric, negative binomial, hyper-geometric, logarithmic distribution along with their properties and limiting/approximation cases	09	01	-	10

IV	**Continuous probability distributions:** Normal, Exponential, Uniform, Beta, Gamma, Cauchy, lognormal and Laplace distributions along with their characteristic properties and limiting/approximation cases.	11	01	-	12
V	**Practical:** **Note**: Students can use calculators / Ms Excel/SPSS programming as convenient**.** 1. Fitting of binomial distributions for n and p = q = ½. 2. Fitting of binomial distributions for given n and p. 3. Fitting of binomial distributions after computing mean and variance. 4. Fitting of Poisson distributions for given value of lambda. 5. Fitting of Poisson distributions after computing mean. 6. Fitting of negative binomial. 7. Fitting of suitable distribution. 8. Application problems based on binomial distribution. 9. Application problems based on Poisson distribution. 10. Application problems based on negative binomial distribution. 11. Problems based on area property of normal distribution. 12. To find the ordinate for a given area for normal distribution. 13. Application based problems using normal distribution. 14. Fitting of normal distribution when parameters are given. 15. Fitting of normal distribution when parameters are not given. 16. Fitting of exponential distribution	-	-	15	30

SUGGESTED READING:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.

2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

4. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics. Sultan Chand & Sons. New Delhi. (12th Edition).

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 3rd SEMESTER

Title of the Course	Statistical Inference
Course Code	STA-MJ-03014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	200-299

Course Objective: This course has the objective of exposing students to concepts of estimation and testing of hypothesis - its types, and desirable properties of an estimator and how to find a good estimate from a sample data.

Learning Outcomes: At the end of the course, students shall be able to apply how to examine the properties of estimators and how to test different types of statistical hypothesis.

Course outcomes:
CO1: Describe the concepts of estimation, unbiasedness, sufficiency, consistency and efficiency, non-parametric tests and distribution free procedures.
CO2: Discuss factorization theorem. minimum variance unbiased estimator (MVUE). Cramer-Rao inequality and MVB estimators, testing of hypothesis problems based on the traditional approach and p-value approach.
CO3: Discuss the different methods of estimation such as method of moments, method of maximum likelihood.
CO4: Illustrate different non-parametric tests such as Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one sample, Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test**.**
CO5: Learn the idea categorical data, tests related to categorical data and their applications.
CO5: Utilize the above learnt concepts to solve numerical problems.

Unit	Content	L	T	P	Total hrs
I	**Point Estimation & Interval estimation:** Definitions of random sample, parameter and statistic, Concepts of Estimation, Unbiasedness, Sufficiency, Consistency and Efficiency. Factorization theorem, Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators. Idea of Interval estimation, confidence level, construction of shortest expected length confidence interval, uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses.	10	05	-	15
II	**Methods of Estimation:** Method of moments, method of maximum likelihood estimation, method of minimum Chi-Square, method of least squares, basic idea of Bayes estimators.	07	03	-	10
III	**Hypothesis Testing:** Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, idea of p value, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof)	08	04	-	12
IV	**Categorical data analysis:** Tests of proportions, tests of association for contingency table and goodness-of-fit using Chi- square test, Yates' correction.	05	03	-	08
V	**Practical:** **Note**: Students can use calculators / Ms Excel/SPSS programming as convenient**.**	-	-	15	30

	Based on Unit II, III & IV				

SUGGESTED READING:

1. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics. Sultan Chand & Sons. New Delhi. (12th Edition).
2. Goon A.M., Gupta M.K.: Das Gupta.B. (2005): Fundamentals of Statistics, Vol. I, World Press, Calcutta.
3. Mood A.M, Graybill F.A. and Boes D.C: Introduction to the Theory of Statistics, McGraw Hill.
4. Rohatgi V. K. and Saleh, A.K. Md. E. (2015): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
5. Casella, George, and Roger Berger. *Statistical inference*. Chapman and Hall/CRC, 2024.
6. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 3rd SEMESTER

Title of the Course	Mathematical Analysis
Course Code	STA-MJ-03024
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	200-299

Course Objective: This course has the objective of providing student with the necessary mathematical basics of Calculus, Algebra and Finite difference in so far as they are used in the study of Statistics.

Learning Outcomes: At the end of the course, students shall be able to use the mathematical results of Calculus, Algebra and Finite difference to develop better understanding of some statistical theories like Distribution theory and Multivariate analysis.

Course Outcomes:

CO1: Relate Calculus as a preliminary tool to understand Distribution theory and other concepts in Statistics.

CO2: Solve problems on constrained optimizations, functions of several variables and to understand the concepts of different series expansions using Taylor's series.

CO3: Apply various tests to investigate the convergence of infinite series and relate the application of infinite series in discrete distributions.

CO4: Interpolate or extrapolate a numerical series and solve transcendental equations by

numerical methods.

CO5: Illustrate some real-life applications of calculus and numerical analysis specially in the domain of Statistics.

Unit	Content	L	T	P	Total hrs
I	**Real Analysis:** Sets, Bounded and unbounded sets, neighbourhoods and limit points, Supremum and infimum, open and closed sets, sequences and their convergence and Cauchy's general principle of convergence, monotonic sequences. Infinite series, positive termed series and their convergence; Comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test, Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Cauchy's condensation test, Conditional convergence.	09	05	-	14
II	**Calculus:** Pre-requisite (Limits of function, continuous functions, properties of continuous functions, Idea of integration and some standard function integration), Rolle's theorem and Mean Value Theorem, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Maxima and minima (global and local) of functions of one and two variables, constrained optimization techniques (with Lagrange's multiplier) along with some problems, 1st order and 2nd order ordinary differential equation, Beta and Gamma functions: properties and relationship between them. Taylor's and Maclaurin's series expansions of $in(x)$, $cos(x)$, e^x, $(1+x)^n$, $log(1+x)$, $log(1-x)$.	08	04	-	12

III	**Finite Difference:** Operators, E, Δ and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae.	06	03	-	09
IV	**Numerical Integration:** Idea of Numerical Differentiation, Numerical integration: Trapezoidal rule, Simpson's one-third rule, three-eighth rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of Transcendental equations: Bisection method, Regula-Falsi method, Newton Raphson method.	07	03	-	10
V	**Practical:** **Note**: Students can use calculators / Ms Excel/R programming as convenient**.** Based on Unit III & IV	-	-	15	30

SUGGESTED READING:

1. Malik, S.C. and Arora, S. (1994): Mathematical Analysis, 2nd Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
2. Bartle, Robert G., and Donald R. Sherbert. *Introduction to real analysis*. Vol. 2. New York: Wiley, 2000.
3. Apostol T.M. (1987): Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi.
4. Shanti Narayan (1987): A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
5. Gupta PP, Malik GS and Chauhan JP (Revised edition): Calculus of Finite Differences & Numerical Analysis, Krishna Publications.
6. Mukherjee, K.K. (1990): Numerical Analysis, New Central Book Agency.
7. Saxena, H.C. (2010): Finite Differences & Numerical Analysis, S Chand, New Delhi.
8. Scarborough, J.B. (2017): Numerical Mathematical Analysis, 6th Edition, Oxford & IBH Publishing Co Pvt. Ltd, London.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 4th SEMESTER

Title of the Course	Probability Laws and Linear Models
Course Code	STA-MJ-04014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	200-299

Course Objective:

The objective of the course is to give exposure to various probability laws, analysis of simple and multiple linear regression models.

Learning outcome:

Upon completion of the course, students will be able to apply simple and multiple regression analysis to analyse relationships between multiple variables, interpret regression coefficients, assess model fit, and make predictions based on the developed regression models.

Course outcomes:

CO1: Applications of various probability limit laws and central limit theorem in real life scenarios.

CO2: Define multiple linear regression and its key components. Explain the assumptions underlying multiple linear regression, such as linearity, independence of errors, and homoscedasticity.

CO3: Identify the steps involved in building a linear regression model, from data preprocessing to model evaluation.

CO4: Explain the concept of multicollinearity, autocorrelation and their implications for simple and multiple linear regression models.

Unit	Content	L	T	P	Total hrs
I	**Probability Laws:** Chebyshev's inequality, Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their interrelations, Khinchin's law of large numbers, Weak law of large numbers, Strong law of large numbers, and their applications. Central Limit Theorem, De-Moivre Laplace theorem, Lindeberg Levy Central Limit Theorem and Liapunoff Theorem (without proof), Applications of Central Limit Theorem.	08	06		14
II	**Gauss-Markov set-up:** Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance. **Simple Regression Model:** Assumptions of simple linear regression, Estimation of parameters and hypothesis testing in case of simple regression models, Concept of model matrix and its use in estimation.	10	05	-	15
III	**Multiple regression model:** Estimation of model parameters, Hypothesis Testing in multiple linear regression, Regression with and without intercept terms, standardized regression coefficients and interpretations, use of R^2 & adjusted R^2. Prediction from a fitted model	07	02	-	09
IV	**Analysis of Variance:** Definitions of fixed, random and mixed effect models, analysis of variance in one-way classified data for fixed effect models, analysis of variance in two-way classified data with one observation per cell for fixed effect models.	05	03		08
V	**Practical:** **Note**: Students can use calculators / Ms Excel/SPSS programming as convenient**.** Based on II & III	-	-	15	30

SUGGESTED READING:

1. Gupta, S.C. and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics. Sultan Chand & Sons. New Delhi. (12th Edition).
2. Weisberg, S. (2005). Applied Linear Regression (Third edition).Wiley.
3. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
4. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
5. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). *Introduction to linear regression analysis*. John Wiley & Sons.
6. Goon, A.M. and Gupta, M.K. and Dasgupta, B.(1991): An Outline of Statistical Theory, World Press Private Limited

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 4th SEMESTER

Title of the Course	Linear Algebra
Course Code	STA-MJ-04024
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	200-299

Course objectives: This course in linear algebra will provide the students the mathematical foundation for many Statistical methods and models. Since multidimensional data can be represented in a matrix form and data are the most important ingredients of Statistics, this course in matrix algebra will be beneficial to the students to better understand certain domains of Statistics like Multivariate analysis, Regression analysis, Designs of Experiments and others.

Learning Outcomes: At the end of this course, the student will be able to work with an orthogonal basis, find a linear transformation from its matrix, apply the various concepts of Eigenvalues and vectors and those of quadratic forms to solve certain mathematical problems depicting some practical situations.

Course Outcomes:

CO1: Explain the concept of rank and calculate the rank of the sum and the product of two matrices.

CO2: Compute Characteristic roots and vectors of a matrix and apply some of their properties to solve simple problems in Statistics.

CO3: Discuss Cayley Hamilton theorem and its applications, Classify different Quadratic forms and indicate methods to diagonalize them.

CO4: Define vector spaces, vector subspaces, differentiate between linear dependent and independent vectors and assess whether a set of vectors constitutes a basis or not and to identify the dimension of a vector space.

CO5: Compute the determinant and inverse of a matrix by various methods and solve a system of linear equations with illustration on some of its applications.

CO6: Describe the basic concepts of basis and dimension for a linear space and recall the various operations on matrix theory.

CO7: Demonstrate the construction of an 2x2 and 3x3 determinant and illustrate various numerical problems on calculation of value of a matrix.

Unit	Content	L	T	P	Total hrs
I	**Introductory concepts:** Idea of Group, Ring and Field, Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem (statement only).	05	03	-	08
II	**Determinants:** Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations (Cramer's rule), row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations, linear independence, Applications of linear equations, inverse	08	04		12

	of a matrix.				
III	**Algebra of Matrices:** A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices (theorems without proof), singular and non-singular matrices and their properties. Trace of a matrix, theorems on trace of matrix (without proof), unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties.	07	04	-	11
IV	**Rank and Eigenvalues:** Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Basic idea of quadratic forms, Linear orthogonal transformation and their diagonalization, Spectral decomposition of a symmetrical matrix (Full rank and non-full rank cases), Example of spectral decomposition, Spectral decomposition of asymmetric matrix.	10	05	-	15
V	**Practical:** **Note**: Students can use calculators / Ms Excel/R programming as convenient**.** **Based on Unit II, III & IV**	-	-	15	30

SUGGESTED READING:

1. Schaum's Outlines. (2006). Linear Algebra, 3rd Edition. Tata McGraw-Hill Edition.
2. Vasishtha, A. R. (1982). Matrices, 9th Edition. Krishna Prakashan Mandir.
3. Gupta, S. C. (2008). An Introduction to Matrices, Reprint. Sultan Chand & Sons.
4. Biswas, S. (1997). A Textbook of Matrix Algebra. New Age International.
5. Hohn, F. E. (2002). *Elementary matrix algebra*. Courier Corporation.
6. Rao, A. R., & Bhimasankaram, P. (2000). *Linear algebra* (Vol. 19). Springer.
7. Gallian, J. (2021). *Contemporary abstract algebra*. Chapman and Hall/CRC.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 4th SEMESTER

Title of the Course	Sampling Distributions
Course Code	STA-MJ-04034
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	200-299

Course Objective: This course will enable students to infer about the population characteristics, based on the corresponding sample analogues. Since the sample quantities are random, it is required to find their exact or asymptotic probability distributions.

Learning Outcomes: At the end of the course, students shall be able to understand the concepts of variability in sample measures and their distributions.

Course Outcome:

CO1: Define random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion.

CO2: Discuss exact sampling distributions viz: chi square, t and F and its application in real life scenario.

CO3: Illustrate the concept of large sample tests, testing single proportion, difference of two proportions, single mean, difference of two means.

CO4: Discuss the distributions of different order statistics.

Unit	Content	L	T	P	Total hrs
I	**Large Sample Theory:** Essence of sampling distribution, Test statistic, Sampling distribution of test statistic and standard errors. Large sample tests, testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches, difference between standard error and standard deviation.	10	03	-	13
II	**Chi Square Distribution:** Definition and derivation of p.d.f. of $\chi 2$ with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, reproductive property and limiting form of χ^2 distribution. Tests of significance and confidence intervals based on distribution.	08	04	-	12
III	**Exact Sampling Distributions:** Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Test of significance and confidence Intervals based on t distribution. Snedecor's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of $\frac{1}{F(n_1,n_2)}$. Relationship between t, F and χ^2distributions. Test of significance and confidence Intervals based on t and F distributions.	08	04	-	12
IV	**Order Statistics:** Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics (without derivation), distribution of sample median and sample range.	04	04	-	08

V	**Practical:** **Note**: Students can use calculators / Ms Excel/R Based on Unit I, II & III	-	-	15	30

SUGGESTED READING:

1.Goon, A.M., Gupta, M.K., and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edition. World Press, Kolkata.

2.Goon, A.M., Gupta, M.K., and Dasgupta, B. (2019): Fundamentals of Statistics, Vol. I & II, 9th Edition. The World Press, Kolkata.

3.Gupta, S.C., and Kapoor, V.K. (2020): Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand & Sons.

4.Hogg, R.V., and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.

5.Johnson, R.A., and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edition. John Wiley and Sons.

6.Mood, A.M., Graybill, F.A., and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition (Reprint). Tata McGraw-Hill Pub. Co. Ltd.

7.Mukhopadhyay, P. (2011): Applied Statistics, 2nd Edition Revised Reprint. Books and Allied (P) Ltd.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 4th SEMESTER

Title of the Course	Survey Sampling
Course Code	STA-MJ-04044
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	200-299

Course Objectives: The main objective of this course is to provide the basic knowledge of various probabilistic and non probabilistic sampling procedures to draw a random sample from a population.

Learning Outcomes: At the end of this course, the student will be able to determine the sample size, draw a random sample using various sampling techniques. They will also learn unequal sampling procedures and their estimators which are commonly used in large scale survey.

Course Outcomes:

CO1: Learn the concept of population and sample, importance of sampling, principle underlying sampling and designing of large-scale survey; comparison between census and sample survey; SRSWR and SRSWOR.

CO2: Discuss the estimation procedure of sample size with different types of allocation, Construction of strata, determination of optimum number of strata, method of collapsed strata and post stratification in case of stratified random sampling. Also Illustrate some other scheme of probability sampling like cluster (Equal and unequal size), two stage (Equal and unequal first stage unit) and multi stage sampling.

CO3: Discuss the probability sampling procedures viz. PPSWR and PPSWOR,

CO4: Apply the technique of systematic sampling in population with linear trend, periodic trend. Comparison between Systematic sampling, stratified, SRSWR and SRSWOR. basic knowledge in quota sampling, distance sampling, snowball sampling, importance sampling, network sampling etc.

CO5: Distinguish between the concept of ratio method of estimation and regression method

of estimation.

Unit	Content	L	T	P	Total hrs
I	**Introduction:** Role and importance of surveys in statistical analysis., Key terminologies used in sample survey, Sampling Frame, Sampling vs Complete enumeration- advantages and limitations, Principles of sample survey, sampling and non-sampling errors- factors and remedial measures, Types of sampling: Probability and non-probability sampling, Importance of sample size determination	08	02	-	10
II	**Simple Random Sampling:** Simple Random Sampling with and without Replacement, Definition and Procedure for Selecting a Sample, Use of random number tables, Estimates of Population Mean, Total and its variances, Variances of these estimates, Sample Size Determination, Simple Random Sampling of Proportions;	09	03	-	12
III	**Stratified Random Sampling:** Stratification, Allocation and Sampling from Strata, Estimation of population, mean, total, and its variances. Estimates of the variances of these estimates, estimation of gain in precision. **Systematic Sampling:** Concept and Procedure of Systematic Sampling- Linear and circular systematic sampling, Linear systematic sampling: estimates of population mean, variances of the estimates. Comparison between SRS, Stratified and Systematic Sampling in terms of efficiency.	07	05	-	12
IV	**Cluster sampling** (equal clusters only) estimation of population mean and its variance, Concept of sub sampling. Idea of cluster sampling with unequal clusters. Idea of Probability Proportional to Size Sampling, Need for unequal probability sampling.	06	05	-	11

	Idea of Double Sampling, Multi-Stage Sampling **Ratio and Regression** methods of estimation, applications.				
V	**Practical:** **Note**: Students can use calculators / Ms Excel/R Based on Unit II, III & IV	-	-	15	30

SUGGESTED READING:

1. Chaudhari, A. and Stenger, H. (2005): Survey Sampling Theory and Methods, 2nd Edition, Chapman and Hall.

2. Chaudhari, A. and Vos, J.W.E. (1988): Unified Theory and Strategies of Survey Sampling, North –Holland, Amsterdam.

3. Cochran, W.G. (1977): Sampling Techniques, John Wiley & Sons, New York.

4. Levy, P.S. and Lemeshow, S. (2008): Sampling of Populations-Methods and Applications, Wiley.

5. Mukhopadhyay, P. (2009): Theory and Methods of Survey Sampling, 2nd Edition, Prentice Hall of India, New Delhi.

6. Murthy, M.N. (1967): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.

7. Raj, D. and Chandhok, P. (1998): Sample Survey Theory. Narosa Publishing House.

8. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.

9.Thompson, S. K. (2002): Sampling, John Wiley and Sons, New York.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 5th SEMESTER

Title of the Course	Applied Statistics
Course Code	STA-MJ-05014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	300-399

Course Objective: This course has the objective of exposing students to the different domains of applied statistics.

Learning Outcomes: At the end of the course, students shall be able to understand how statistics is directly applied in economic analysis, govt. and society.

Course outcomes:

CO1: Define and construct index numbers of prices and quantities (Laspeyres' , Paasche's, Fisher's and Marshal-Edgeworth's).

CO2: Outline the organisations involved in official data collection in India along with major publications on such official statistics in India.

CO3: Explain the importance of statistical methods in industrial research and practice, how tolerance limits are determined, chance and assignable causes of variations in quality, various methods of fertility, mortality and reproduction, construction of life tables, concepts related to demand analysis and measures of inequality (Lorenz curve, Gini coefficient).

CO4: Prepare various control charts for process and product control.

CO5: Use various methods like method of free-hand curve, moving average method, method of semi-averages and method of least squares to measure trend and method of ratio to trend to measure seasonal variations.

Unit	Content	L	T	P	Total hrs
I	**Time Series:** Components of time series, Decomposition of time series: Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, moving average method, method of semi-averages and method of least squares (linear, quadratic and modified exponential), Detrending, Measurement of seasonal variations by method of ratio to trend. Measurement of cyclical fluctuations.	10	03	-	13
II	**Index Numbers:** Definition, Uses and limitations of index numbers, idea of inflation and deflation, Criteria/tests for a good index number, different types of index numbers- price, quantity, value, Problems of index number, Wholesale price index number, Index of Industrial Production. Construction of index numbers of prices and quantities – Laspeyres', Paasche's, Fisher's and Marshal-Edgeworth's Index numbers. Consumer price index number. Base shifting, splicing, and deflating of index numbers.	05	04	-	09
III	**Statistical Quality Control:** Importance of statistical methods in industrial research and practice. Rational subgroup., Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for variables: X bar, R-charts and sigma chart, idea of 3 sigma limit, Control charts for attributes: np charts, p charts, c charts and u-charts. Comparison between control charts for variables and control charts for attributes. Product control – basic ideas of Single sampling and double sampling plans.	07	04	-	11

IV	**Demand Analysis:** Theory of consumption and demand, demand function, elasticity of demand, determination of elasticity of demand by family budget method, Lorentz curve and Gini's coefficient, Engel's law and Engel's curve, Pareto's (80-20) law of income distribution.	08	04	-	12
V	**Practical:** Based on Unit I, II, III & IV			15	30

SUGGESTED READING:

1. Mukhopadhyay,P.(1999): Applied Statistics, New Central Book Agency, Calcutta.

2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II,9th Edition World Press, Kolkata.

3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons.

4. Montogomery, D.C.(2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

5. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied(P)Ltd.

6. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.

7. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 5th SEMESTER

Title of the Course	Design of Experiments
Course Code	STA-MJ-05024
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	300-399

Course Objective: This course has the objective of providing student the knowledge of art of analysis of field experiments.

Learning Outcomes: At the end of the course, students shall be able to understand the different types of commonly used field experimental techniques.

Course Outcome:

CO1: Learn fixed, random and mixed effect models, analysis of variance (one way and two way), principles of design of experiments, basic designs: CRD, RBD.

CO2: Discuss analysis of covariance, RBD with more than one observation per cell, Latin Square Design (LSD), analysis with missing observations, Split Plot Design, Strip Plot Design.

CO3: Discuss 2^n and 3^n factorial experiments

CO4: Explain confounding technique to reduce block size in factorial experiment.

CO5: Discuss Split Plot Design, Strip Plot Design, Incomplete Block Designs, and balanced Incomplete Block Design (BIBD).

Unit	Content	L	T	P	Total hrs
I	**Introduction:** Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with one and two missing observations, Idea of Orthogonal Latin Square, Graeco Latin Square Design.	13	03		16
II	**Factorial experiments:** advantages, notations and concepts, 2^2, $2^3 \ldots 2^n$ and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$), idea of 3^2 experiment.	09	04	-	13
III	**Analysis of Covariance**: one-way and two-way classified data with one concomitant variable. Variance Component Analysis: Introduction, analysis in a two-way classification.	04	04	-	08
IV	Split Plot Design, Strip Plot Design, Incomplete Block Designs, Introduction to Balanced Incomplete Block Design (BIBD).	04	04	-	08
V	**Practical/Lab** Based on Unit I, II, III & IV			15	30

SUGGESTED READING:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.

2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn.

World Press, Kolkata.

4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.

5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

6. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 5th SEMESTER

Title of the Course	Operations Research
Course Code	STA-MJ-05034
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	300-399

Course Objective: This course has the objective of inculcating the skills of Operations Research.

Learning Outcomes: At the end of the course, students shall be able to use techniques of operations research to obtain optimization in field level problems.

Course Outcome:

CO1: Discuss optimization techniques using OR tools VIZ. LPP, Transportation problem, Replacement problem, Inventory Control and Network.

CO2: Distinguish use of different methods to various kinds of LPP on the basis of type of constraints and number of variables in real life problems.

CO3: Solve transportation problem using North West corner rule, Least cost method ad Vogel Approximation method..

CO4: Solve assignment problem using Hungarian method.

CO5: Determine different types of floats and slacks, determination of critical path in network problem.

Unit	Content	L	T	P	Total hrs
I	**Operations Research**: Introduction to Operations Research, Linear Programming Problem, Mathematical formulation of the L.P.P, basic geometry involving LPP, graphical solutions of a L.P.P. Simplex method for solving L.P.P, the artificial variable techniques - Charne's Big M-technique. Idea of Duality in linear programming, symmetric and asymmetric duals.	10	03	-	13
II	**Transportation Problem:** Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, Idea of loop, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.	07	04	-	11
III	**Game theory:** Introduction, Two person Zero sum game, Dominance rule, The Minimax-Maximin Principle; saddle points; Game without saddle point; Pure and Mixed strategies; Solution procedure of 2x2 game; Graphical solution procedure; Equivalence of Rectangular game and linear programming.	08	04	-	12
IV	**Replacement model & Network Analysis:** Replacement problem, Different time estimates related to any project under CPM and PERT, Probability distribution associated with PERT, Probability of achieving completion date of project, Resource allocation – Resource Smoothing and Resource Levelling.	05	04	-	09

V	**Practical/Lab** **List of Practical** Based on Unit I, II, III & IV			15	30

SUGGESTED READING:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.

2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.

3. Hadley, G: (2002) : Linear Programming, Narosa Publications

4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 6th SEMESTER

Title of the Course	Stochastic Process and Queueing theory
Course Code	STA-MJ-06014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	300-399

Course Objective: Students have to move from univariate to higher dimensional analysis. Moreover, this course will enable students to understand the transition from fundamental probability theory to stochastic process. It covers the structure of discrete time and continuous time stochastic processes. This course will also expose students to elements of programming logic.

Learning Outcomes: On completion of the course, students will be able to understand the basics of stochastic process, Markov models, Poisson process and its applications.

Course Outcomes:

CO1: Understand and apply the basic concept and classification of stochastic processes and stationary processes.

CO2: Understand and analyse the theory of Markov chains, Markov process and Poisson process.

CO3: Application of these theories in real life problems, classification of states and chains.

CO4: Understand the general concept of queuing system, Markovian models with finite and infinite system capacity.

Unit	Content	L	T	P	Total hrs
I	**Introduction to Stochastic Processes:** Generating functions, Bivariate probability generating function. Classification of Stochastic Processes: Introduction to Stationary Process, Evolutionary Process, Idea of Martingale.	07	02	-	09
II	**Markov Chains**: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, Stability of Markov System, Graph theoretic approach, Markov chain with denumerable number of states.	10	04	-	14
III	**Poisson Process:** Postulates of Poisson process, properties of Poisson process, Time dependent Poisson Process, Arrival, Inter arrival and Conditional Arrival Distributions.	08	04	-	12
IV	**Queuing System**: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).	05	05	-	10
V	**Practical/Lab** Based on Unit II, III & IV			15	30

SUGGESTED READING:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.

2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.

3. Bhat, B.R.(2000): Stochastic Models: Analysis and Applications, New Age International Publishers.

4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.

5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.

6. J. K Sarma, Operations Research: Theory and Applicatios (9th Edition)

7. S. S Sharma, Operations Research: Theory, Methods and Techniques.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 6th SEMESTER

Title of the Course	Multivariate Analysis and Nonparametric Methods
Course Code	STA-MJ-06024
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	300-399

Course Objective: Students have to move from univariate to higher dimensional analysis.

Learning Outcomes:

CO1: Demonstrate bivariate normal distribution.

CO2: Determine marginal and conditional distributions of BVN.

CO3: Demonstrate multivariate normal distribution.

CO4: Determine marginal and conditional distributions of multivariate normal distribution, basic idea of principal component analysis, Hotelling T^2 statistics and its applications.

CO5: Illustrate different non-parametric tests such as Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one sample, Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

CO5: Utilize the above learnt concepts to solve numerical problems.

Unit	Content	L	T	P	Total hrs
I	**Bivariate and Multivariate Distributions:** Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.	07	04	-	11
II	**Multivariate Data:** Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.	05	02	-	07
III	**Multivariate Normal Distributions:** Definition and derivation Multivariate Normal distribution and its properties, Idea of multivariate symmetry, concept of spherical distribution, Quadratic forms, Sampling distribution for mean vector and variance- covariance matrix, Cochran theorem (without proof), Concept of Wishart distribution (without proof) and its properties, Mahalanobis Distance D^2 and its applications, Hotelling T^2 – concept and applications (one sample and two sample).	08	04	-	12
IV	**Nonparametric Tests:** Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogorov Smirnov test for one and two samples, Sign tests- one sample and two samples, Wilcoxon signed rank test, Wilcoxon Matched pair signed rank test, Mann-Whitney test, Kruskal-Wallis test.	10	05		15
V	Practical: Based on Unit I, III & IV			15	30

SUGGESTED READING:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.

3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1stEdn. Marcel Dekker.

4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall.

5. Mukhopadhyay, P. : Mathematical Statistics.

6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 6th SEMESTER

Title of the Course	Demography and Vital Statistics
Course Code	STA-MJ-06034
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	300-399

Course Objective: Students will learn to collect valid Demographic data using different methods and to learn basic measures of Mortality, Fertility and Population Growth.

Learning Outcomes:

CO1: Make distinction between Vital Statistics and Demography.

CO2: Identify the source and errors in demographic data.

CO3: Demonstrate multivariate normal distribution.

CO4: Make distinction between Rate and Ratio.

CO5: Calculate basic measures of Mortality, Fertility, and population growth.

CO6: Understand the concept of Life Tables, their construction and uses.

Unit	Content	L	T	P	Total hrs
I	**Introduction to demography:** Introduction and sources of collecting data on vital statistics, Coverage and content errors in demographic data, use of balancing equations, Measurement of population, rate, proportion and ratio of vital events. Population composition, dependency ratio, Demographic transition theory, Age-sex pyramid, population projection.	07	02	-	09
II	**Morbidity and Mortality:** Concept of Morbidity and Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. Incidence, Prevalence rate and Specificity.	10	04	-	14
III	**Life Table:** Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) tables: Assumption, description. Types of life table, Complete and Abridged Life Tables: Concept and construction.	07	04	-	11
IV	**Measurements of Fertility:** Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).	06	05		11
V	**PRACTICAL/LAB. WORK:** Based on Unit I, II, III & IV			15	30

SUGGESTED READING:

1. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.

2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9 th

3. Edition, World Press.

4. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.

5. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.

6. Keyfitz N., Beckman John A.: Demography through Problems S-Verlag New York.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 6th SEMESTER

Title of the Course	Project
Course Code	STA-MJ-06044
Nature of Course	Major
Total Credit	4 (Project)
Contact Hours	120
Distribution of Marks	End Semester (100)
Course Level	300-399

Unit	Content	L	T	P	Total hrs
I	**Objective:** The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts.				120

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 7th SEMESTER

Title of the Course	Advanced Mathematical Analysis
Course Code	STA-MJ-07014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	400-499

Course Objective: Students will learn to study basics of one variable calculus, multivariable variables calculus and will study properties of analytic functions, complex integration and series expansions of complex valued functions and matrix representation of a linear operator and basic matrix theory.

Course Outcomes:

CO1: Understand the convergence of sequence of real numbers and sequence of functions.

CO2: Realize the speciality of uniform convergence, find multiple integrals on different domains.

CO3: Understand the concept of analytic functions, find complex integration over curves and contours, relate analytic functions and their integration over closed contour and understand definite integrals, Taylor's and Laurent's series.

CO4: Use different factorization techniques for matrices, Apply the techniques of matrix theory to other branch of mathematics and practical problems.

Unit	Content	L	T	P	Total hrs
I	**Real Analysis:** Cauchy's criterion and Weirstrass's M-test, uniform convergence and its relation to continuity, differentiability and integration, Convergence of Improper Integrals. Double integral over rectangle, Double integral over region, Concept of Multiple integrals simple examples involving change of variables in multiple integrals, Dirichlet integral and Liouville's extension.	10	04	-	14
II	**Complex Analysis:** Properties of complex numbers. Region in complex plane. Analytic function. Contour integration: Cauchy's theorem (without proof), Cauchy integral formula (without proof). Liouville's theorem. Power series and radius of convergence. Taylor's and Laurent's series. Cauchy residue theorem (without proof). Singular points and their types. Residue at singular point and residue at infinity. Evaluation of real integrals involving sine and cosine using residue.	07	04	-	11
III	**Linear Algebra:** Linear Transformations, Kernel and Image of a linear transformation, Rank and Nullity, Change of Basis, Similarity, Inner product spaces with examples, Orthogonality, Orthonormal sets and Bases, Gram Schmidt Orthogonalization Process.	09	03	-	12
IV	**Integral Transforms:** Laplace, Fourier, Mellin and Z transformations and their statistical applications**.**	04	04		08

SUGGESTED READING:

1. Graybill, F.A. (1983). Matrices with applications in statistics, 2nd Ed. Wadsworth.

2. Dass, H. K. (2010). *Mathematical physics*. S. Chand Publishing.

3. Searle, S.R. (1982). Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.

4. Rajput, BS : *Mathematical physics*. S. Chand Publishing.

5. Bartle, R. G., & Sherbert, D. R. (2000). *Introduction to real analysis* (Vol. 2). New York: Wiley.

6. Hohn, F. E. (2002). *Elementary matrix algebra*. Courier Corporation.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 7th SEMESTER

Title of the Course	Probability Distributions
Course Code	STA-MJ-07024
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	400-499

Course Objective: Students will learn the idea about various advanced probability distributions, their corresponding truncated, weighted, mixture and modified forms, understand the concept of non - central distributions and their applications in statistical inference and gain knowledge about sequential probability ratio test.

Course Outcomes:

After completing this course, students should develop a clear understanding of:

CO1: Various theoretical probability distributions along with their properties and applications.

CO2: Transforming of random variables.

CO3: Definitions, applications and properties of extreme valued distributions, symmetric distributions, truncated distributions, mixture distributions, weighted distributions and modified distributions.

CO4: Generalized power series distributions, Exponential family of distributions, concept of generalised family of distributions.

CO5: Non – central chi-square, t and F distributions and their applications.

CO6: Introduction to Sequential probability ratio test (SPRT) and the theory and applicability Operating Characteristic (OC) function, Average Sample Number (ASN) function.

Unit	Content	L	T	P	Total hrs
I	Logarithmic, positive and negative multinomial, distributions of extremes: Gumbel, Freichet, Weibull and their properties. Symmetric distributions, generalized power series distributions, Exponential family of distributions, Systems of Pearsonian distributions.	07	05	-	12
II	**Truncated and Weighted distributions:** Truncated Binomial, Poisson, Logarithmic, Normal and Cauchy distributions. **Mixture distributions:** Definition, finite mixtures, Zero modified and inflated distributions with examples, Mixed Poisson distributions and its properties and examples of Poisson mixtures, Mixtures of Binomial distributions with examples.	12	04	-	16
III	**Sampling Distributions:** Non-central chi-square, t, and F distributions, their properties and the related distributions.	06	03	-	09
IV	**Sequential Analysis:** Introduction to Sequential probability ratio test (SPRT), Operating Characteristic (OC) function, Average Sample Number (ASN) function, applications of SPRT.	05	04		09
V	PRACTICAL / LAB WORK Based on Unit II, III & IV			15	30

SUGGESTED READING:

1. Rao, C. R. (1965). *Linear statistical inference and is applications*. John Wiley & Sons, Incorporated.

2. Johnson, N. L., Kemp, A. W., & Kotz, S. (2005). *Univariate discrete distributions*. John Wiley & Sons.
3. Johnson, N. L., Kotz, S., & Balakrishnan, N. (1995). *Continuous univariate distributions, volume 2* (Vol. 2). John wiley & sons.
4. Johnson, N. L., Kotz, S., & Balakrishnan, N. (1972). *Continuous multivariate distributions* (Vol. 7). New York: Wiley.

5. Kotz, S., & Nadarajah, S. (2000). *Extreme value distributions: theory and applications*.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 7th SEMESTER

Title of the Course	Econometrics
Course Code	STA-MJ-07034
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	400-499

Course Objective: This course aims at making economic research in a mathematically simple way in applied econometric research

Course Outcomes:

After completing this course, students should develop a clear understanding of:

CO1: Simple linear regression model and multiple linear regression model in matrix notation.

CO2: Violations of various assumptions under regression analysis viz. multicollinearity, heteroscedasticity, and autocorrelation.

CO3: lagged variables and distributed lag models.

CO4: Models of simultaneous relationships between various economic factors.

CO5: full information maximum likelihood, limited information maximum likelihood methods.

Unit	Content	L	T	P	Total hrs
I	**Introduction:** Nature of econometrics. The Classical Linear Normal Regression Model (Matrix Approach): Estimation, test and their properties. Heteroscedasticity, Autocorrelation: implications and consequences, test and solutions and Multicollinearity: implications and consequences and solutions. Theil BLUS procedure Estimation and prediction.	06	04		10
II	**Generalized linear model:** Generalized linear model**,** Heteroscedastic and autocorrelated structure. Aitken's Theorem of GLS-Feasible GLS and its properties. Logit and Probit model	04	03		09
III	**Distributed lag models:** Koyck Model, Polynomial lag models, Almon's lag model, Determination of degree of polynomial and lag length. Adaptive expectation model, Partial adjustment model, Compound Geometric lag model. Methods of estimation. Idea of Vector Auto Regression (VAR), The Granger Causality Test.	10	05	-	15
IV	**Simultaneous-equation models:** Identification problems. Restrictions on structural parameters – Rank and Order Condition for identification. Restrictions on variances and covariance. Recursive Models- Methods of Estimation. 2 SLS Estimators. Limited information estimators, 3SLS estimation. Full information maximum likelihood (FIML) Methods.	10	03	-	13
V	**Practical/Lab** Based on Unit I, II, III & IV			15	30

SUGGESTED READING:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.

2. Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.

3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited,

4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.

5. Madnani, G. M. K., & Madnani, G. M. K. (2015). *Introduction to Econometrics: Principles and Applications*. Oxford and IBH Publishing.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 7th SEMESTER

Title of the Course	Research Methodology
Course Code	STA-MJ-07044
Nature of Course	Major
Total Credit	4
Contact Hours	120
Distribution of Marks	End Semester (100)
Course Level	400-499

Unit	Content	L	T	P	Total hrs
I	Importance of research methodology in statistical research: Motivation, objectives and purpose of research. Data collection, information extraction and knowledge discovery as statistical methodology.	06	04		10
II	Types of statistical research: empirical, field experiments, laboratory experiments, and secondary sources of data. Types of research design: Exploratory, Explanatory, Descriptive and confirmatory research. Non-response and methods of recovering the missing response.	04	03		07
III	Sampling of non-standard populations: Sampling designs when the population is contiguous or non-stationary or when sampling units are not distinguishable, are not enumerated, are affected by the process of making	10	05	-	15

	observation or are evasive. Simulation methods: Monte Carlo methods, techniques to handle missing data				
IV	Research Report: Research report and its structure, journal articles – Components of journal article. Explanation of various components. Structure of an abstract and keywords. components of thesis and dissertations. Referencing styles and bibliography, Writing of Research proposal. Ethics in Research - Plagiarism - Definition, different forms, consequences	10	03	-	16

1. Kothari, C.K. [2004], 2.e, Research Methodology – Methods and Technique3s [New Age International, New Delhi]
2. Gruijter, J., de Brus, Bierkens, M. F. P. amd Knotters, M. (2006): Sampling for natural resource monitoring. Springer.
3. Thompson, S. K. (2002): Sampling, 2nd Edition. Wiley.
4. Hastie, T., Tibshirani, R. and Friedman, J. (2009): Elements of statistical learning, 2nd Edition. Springer.
5. Myers, R. H., Montgomery, D. C., and Anderson-Cook, C. M. (2009): Response surface methodology, 3rd Edition. Wiley

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 8th SEMESTER

Title of the Course	Time Series Analysis
Course Code	STA-MJ-08014
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	400-499

Course Learning Objectives: The objective of this course is to study intermediate and advanced topics in time series namely, Moving Averages (MA), Autoregressive (AR), ARMA, ARIMA Models, ARCH, GARCH, Spatial Temporal Analysis, Co-integration Longitudinal and Panel Data analysis.

Course Outcomes:

After completing this course, students should develop a clear understanding of:

CO1: Acquire knowledge of various advanced time series models, estimation methods and related theories.

CO2: Eliminate Seasonal and Cyclical components of Time Series and conduct Periodogram and correlogram analysis.

CO3: Understand and apply statistical techniques pertaining to Auto-correlation, Autoregressive process, Moving Average, ARMA, ARIMA and seasonal ARIMA models, Box-Jenkins methodologies, Spectral analysis.

CO4: Conduct exponential and moving average smoothing, Holt winters smoothing, Forecasting based on smoothing.

CO5: Understand and apply statistical techniques pertaining to ARCH, GARCH, Spatio Temporal Analysis, Cointegration, Longitudinal and Panel Data Analysis.

Unit	Content	L	T	P	Total hrs
I	**Basic Time Series:** Introduction to Stationary processes, Autocovariance, Auto-correlation and Auto-regressive process, Properties of Auto-covariance function, Concept of Weak Stationarity, Autoregressive (AR), Moving Average (MA), Linear processes, White Noise.	05	02	-	07
II	**ARMA Models:** ARMA (p,q) processes, The auto-correlation function and partial auto-correlation function of an ARMA (p,q) process, Partial auto-correlation function, Forecasting ARMA processes.	09	05	-	14
III	**Spectral Analysis:** Spectral densities of MA, AR, ARMA, Time-invariant linear filters, The spectral density of an ARMA.	09	04	-	13
IV	**Nonstationary and seasonal time series models:** Auto-regressive integrated moving average (ARIMA (p,d,q)) models for nonstationary time series, Identification techniques, Forecasting ARIMA models, seasonal ARIMA models. ARCH, GARCH, Cointegration, Longitudinal , Cross-Sectional and Panel Data Analysis, Idea of Spatial Temporal Analysis.	07	04		11
	Practical Based on Unit II, III & IV			15	30

SUGGESTED READING:

1. Anderson, T.W. (1971): Statistical Analysis of Time Series, Wiley, NY

2. Box, G.E.P and Jenkins, G.M.(1976): Time series Analysis-Forecasting and Control, Holden-day, San Francisco.

3. Brockwell, P.J. and Davis, R.A.(1996): Introduction to Time Series and Forecasting, Springer, New York.

4. Enders, W.,(2008): Applied Econometric Time Series, 2nd Edition, Wiley

5. Medhi, J. (2009): Stochastic Processes, 3rd Ed., New Age International Publishers, New Delhi, India.

6. The analysis of Time Series: An Introduction, Chris Chatefield

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 8th SEMESTER

Title of the Course	Bayesian and Classical Inference
Course Code	STA-MJ-08024
Nature of Course	Major
Total Credit	4 (Theory – 3)+(Practical-1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	400-499

Course Learning Objectives: The learning objectives include:

- The knowledge of non-parametric statistical inference.
- The knowledge of the Elements of Decision Theory and Bayesian Inference.
- The knowledge of UMPU tests and likelihood ratio test.

Course Outcomes:

After completing this course, students should develop a clear understanding of:

CO1: The basic concepts of the elements of decision theory with decision rules, loss functions, point estimation, interval estimation, and testing of hypotheses as decision problems.

CO2: The development of Bayesian inference- prior and posterior distributions and their construction.

CO3: Concept of Bayesian point and interval estimation and testing of Hypothesis.

CO4: The Bayesian Computation using Analytic approach, E-M algorithm, MCMC, Gibbs Sampling.

CO5: Construction of UMPU tests, Type A and Type A1 critical regions, Optimum Regions and similar regions.

Unit	Content	L	T	P	Total hrs
I	**Elements of Decision Theory:** Introduction, Basic Concepts, Bayes and Minimax Decision rules. Different types of loss function, Bayes risk. Estimation of Parameters: Bayes estimate and Minimax estimate. Point estimation, Interval estimation and Testing of Hypothesis as Decision Problem.	07	04	-	11
II	**Bayesian Prior distributions:** Subjective and Frequentist Probability, Advantages, Bayes theorem, Subjective prior distribution of a parameter, Computation of posterior distribution, Natural Conjugate family of priors for a model, Hyper parameters of a prior form conjugate family, Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension, Non informative, improper and invariant priors, Jeffrey's invariant prior,	10	04	-	14
III	**Bayesian estimation and Hypothesis Testing:** as a prediction problem from posterior distribution, Bayes estimators for (i) absolute error loss, (ii) squared error loss, and (iii) 0-1 loss. Bayesian interval estimation: Credible intervals, High posterior density regions; Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem; Bayesian Computation: Analytic approach, E-M algorithm, MCMC, Gibbs sampling.	07	04	-	11
IV	**Classical Parametric Estimation:** Frechet- Cramer- Rao lower bound for multi parameter case, Bhattacharyya bound and Chapman- Robins-Kiefer lower bound. Introduction to BAN and CAN estimators and related theorems. UMPU-tests, Type A and Type A_1 critical regions, Optimum	06	03		09

	Region, Similar Regions. Likelihood Ratio Tests, Asymptotic distribution of Likelihood ratio. Randomised test: Test function, Monotone Likelihood Ratio.				

SUGGESTED READING:

1. An outline of Statistical Theory Vol.II: AM Gun, MK Gupta, B Dasgupta. World Press.

2. Mathematical Statistics: Parimal Mukhopadhyay: New Central Book Agency

3. Statistical Decision Theory and Bayesian Analysis: JO Berger, Springer Verlag

4. Bayesian Parametirc Inference. A K Bansal. Narosa Publishing House

5. An Introduction to Bayesian Analysis Theory and Methods. J K Ghosh, M Delampady and T. Samanta

6. Bayesian Statistics: An Introduction. Peter Lee. Arnold, London.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 8th SEMESTER

Title of the Course	Queuing Theory
Course Code	STA-MJ-08034
Nature of Course	Major
Total Credit	4 (Theory - 3 + Practical - 1)
Contact Hours	45 (Theory) + 30 (Practical)
Distribution of Marks	End Semester (45) + In Semester (30) + End sem Practical (25)
Course Level	400-499

Course Learning Objectives: The learning objectives include:

- To define, design, model and analyse random processes.
- To identify the real life applications of stochastic processes.
- To understand Branching process and renewal theory.

Course Outcomes:

After completing this course, the students have gained knowledge:

CO1: To explain and describe characteristic features of a queuing system.

CO2: To categorize and describe queuing models.

CO3: To derive and numerically calculate quantitative metrics of performance of queuing systems.

CO4: To analyse queues with Poisson arrivals, single server and multi server exponential service requirements together with non Poisson Queues.

CO5: To obtain derivation of associated probability distributions and to apply and extend queuing models to analyse real world problems.

CO6: Branching Process and related theorems.

Unit	Content	L	T	P	Total hrs
I	General concept: Basic Characteristics of a Queue, Notations, Transient and Steady state, Little's formula (without proof), idea of PASTA. M/M/1 model: Steady state distribution, waiting time distribution, Steady state Distribution of M/M/1/k. M/M/c model: Steady state distribution, distribution of waiting time. Steady state distribution of the following models : M/M/c/c, M/M/c//m (m>c).	07	03	-	10
II	**Bulk Queues:** Steady State Distribution and Waiting Time Distribution of M/M(1,b)/1, M/G(1,b)/1 models; Steady State Distribution of M/G(1 , b)/1 and M/G(a , b)/1 models.	09	04	-	13
III	M/G/1 model: Pollaczek Khinchin and Pollaczek Khinchin Transform Formulae; Steady state distribution and distribution of waiting time of GI/M/1 model; Steady State Distribution of M/D/1 and M/D/c model.	09	05	-	14
IV	**Reliability Theory**: Parallel system, Series system, k out of n, Stress and strength and applications in communication and system engineering.	05	03	-	08
V	Practical based on Unit I, II, III, IV			15	30

SUGGESTED READING:

1. Medhi, J, Stochastic Models in Queuing Theory, Academic Press.

2. Gross, D and Harris, C. M. Fundamental of Queuing Theory, Wiley

3. Kashyap, B. R.K and Chaudhry, M. L. An Introduction to Queuing Theory.

4. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.

2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.

B.A./B.Sc. IN STATISTICS PROGRAMME (FYUGP)

DETAILED SYLLABUS OF FYUGP 8th SEMESTER

Title of the Course	Dissertation
Course Code	STA-MJ-08044
Nature of Course	Major
Total Credit	4
Contact Hours	120
Distribution of Marks	End Semester (100)
Course Level	400-499

Unit	Content	L	T	P	Total hrs
I	**Dissertation**				120