Appendix B

Department of Statistics

Chaudhary Charan Singh University, Meerut

CHAUDHARY CHARAN SINGH UNIVERSITY, MEERUT

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यत्र सत्यस्य परमं निधानम्

NAAC A++

Syllabus of

Four Year B.Sc. Honours in Statistics Programme

(With and Without Research)

(as per guidelines of National Education Policy-2020)

w.e.f. the session 2026-2027

25/7/26 25/7/26 25/7/26

Subject Prerequisites:

To study this subject, a student must have passed 12th class with Mathematics.

Programme Outcomes (POs):

Students having Degree in B.Sc. Honours (Statistics) should have knowledge of different concepts and fundamentals of Statistics and ability to apply this knowledge in various fields of industry. They may pursue their future career in the field of Statistics and Research.

Programme Specific Outcomes (PSOs):

After completing B.Sc. Honours (Statistics) the student should have

- Knowledge of different concepts, principles, methodologies and tools (skills) of Statistics.
- Ability to collect, tabulate, represent graphically, analyze and interpret data/information by using appropriate statistical tools.
- Ability to identify and solve a wide range of problems in real life/industry related to Statistics.
- Familiarity with computational techniques and statistical software including programming language (e.g. C, Excel, R, and SPSS) for mathematical and statistical computations.
- Capability to use appropriate statistical skills in interdisciplinary areas such as finance, health, agriculture, government, business, industry, telecommunication and bio-statistics.
- Ability to compete with industrial/private sector demand in the field of data analysis, marketing survey, etc. in professional manner and pursue their future career in the field of Statistics.
- Ability to develop original thinking for formulating new problems and providing their solutions. As a result, they will be able to pursue higher studies or research in the field of Statistics

Members of the Board of Studies

S. No.	Name	Designation	College/ University	Signature
1.	Prof. Hare Krishna	Dean, Faculty of Science	C.C.S. University, Meerut	
2.	Prof. Bhupendra Singh	Convener-I	Department of Statistics, C.C.S. University, Meerut	
3.	Prof. Seema Raj	Convener-II	M.M. College, Modinagar	
4.	Dr. Shiv Kumar	Member	Janta Vedic College, Baraut	
5.	Sh. Rajeev Kumar	Member	Janta Vedic College, Baraut	
6.	Prof. Sanjeev Kumar Tomar	External Subject Expert	Department of Statistics, B.H.U., Varanasi	
7.	Prof. Athar Ali Khan	External Subject Expert	Department of Statistics and Operations Research, A.M.U., Aligarh	
8.	Prof. D.K. Garg	External Subject Expert	Department of Statistics, Punjabi University, Patiala	
9.	Prof. Pawan Kumar	External Subject Expert	Department of Statistics, University of Jammu	
10.	Dr. Abha Chandra	Retd. Principal	Meerut College, Meerut	
11.	Dr. Anil Kumar	ADG (Coordination)	ICAR, Krishi Bhawan, New Delhi	

Semester-wise Titles of the Papers in B.Sc. Honours (Statistics)

Four year programme

Major: Statistics, Minor: Mathematics

Year	Sem.	Course Code	Major/ Minor	Paper Title	Theory/ Practical	Credits	MM Int + Ext
I	I	1.	MJDSCC	Univariate Descriptive Statistics	Theory	03	25 + 75
		2.	MJDSCC	Introduction to Probability Theory	Theory	03	25 + 75
		3.	MJDSCC	Basic Probability Distributions	Theory	03	25 + 75
		4.	MJDSCC	Data Analysis Lab using MS Excel	Practical	03	100
		5.	MNGEC	Computer fundamentals and Programming in C Language	Theory	04	25 + 75
		6.	AEC	Pool of Courses	-	02	25+75
		7.	SEC	Pool of Courses	-	02	40+60
		8.	VAC	Indian Official Statistical System	-	02	100
		Total Credit				**22**	
	II	9.	MJDSCC	Bivariate Descriptive Statistics	Theory	03	25 + 75
		10.	MJDSCC	Advanced Probability Distributions	Theory	03	25 + 75
		11.	MJDSCC	Introduction to R Software	Theory	03	25 + 75
		12.	MJDSCC	Data Analysis Lab using R	Practical	03	100
		13.	MNGEC	Matrix Theory	Theory	04	25 + 75
		14.	AEC	Pool of Courses	-	02	25+75
		15.	SEC	Pool of Courses	-	02	40+60
		16.	VAC	Pool of Courses	-	02	100
		Total Credit				**22**	

Year	Sem.	Course Code	Major/ Minor	Paper Title	Theory/ Practical	Credits	MM Int + Ext
II	III	17.	MJDSCC	Theory of Point and Interval Estimation	Theory	03	25 + 75
		18.	MJDSCC	Testing of Hypothesis and Non-Parametric Inference	Theory	03	25 + 75
		19.	MJDSCC	Designs of Sample Survey	Theory	03	25 + 75
		20.	MJDSCC	Sampling & Inference Lab using MS Excel and R	Practical	03	100
		21.	MNGEC	Real Analysis and Laplace Transform	Theory	04	25 + 75
		22.	AEC	Pool of Courses	-	02	25+75
		23.	SEC	Pool of Courses	-	02	40+60
		Total Credit				**20**	
	IV	24.	MJDSCC	Linear Models and Regression Analysis	Theory	03	25 + 75
		25.	MJDSCC	Time Series and Index Numbers	Theory	03	25 + 75
		26.	MJDSCC	Sampling Distributions and Test of Significance	Theory	03	25 + 75
		27.	MJDSCC	Applied Statistics Lab	Practical	03	100
		28.	MNGEC	Numerical Methods	Theory	04	25 + 75
		29.	AEC	Pool of Courses		02	25+75
		30.	SEC	Pool of Courses		02	40+60
		31.	VAC	Pool of Courses		02	100
		Total Credit				**22**	

Year	Sem.	Course Code	Major/ Minor	Paper Title	Theory/ Practical	Credits	MM Int + Ext
III	V	32.	MJDSCC	Introduction to ANOVA & Design of Experiments	Theory	04	25 + 75
		33.	MJDSCC	Econometrics	Theory	04	25 + 75
		34.	MJDSCC	Practical	Practical	04	100
		35.	MJDSEC	(i) Demography and Vital Statistics	Theory	04	25 + 75
				(ii) Statistical Simulation and Optimization Techniques			25 + 75
				(iii) Financial Statistics			25 + 75
		36.	MNGEC	Fundamentals of Data Science: Statistics and Machine Learning with Python	Theory	04	25 + 75
		Total Credits				**20**	
	VI	37.	MJDSCC	Statistical Quality Control	Theory	04	25 + 75
		38.	MJDSCC	Introduction to Multivariate Analysis	Theory	04	25 + 75
		39.	MJDSCC	Practical	Practical	04	100
		40.	MJDSEC	(i) Operations Research	Theory	04	25 + 75
				(ii) Actuarial Statistics			25 + 75
				(iii) Psychological and Educational Statistics			25 + 75
		41.	MNGEC	Linear Algebra	Theory	04	25 + 75
		Total Credits				**20**	

Year		Sem.	Course Code	Major/ Minor	Paper Title	Theory/ Practical	Credits	MM Int – Ext
IV	Without Research	VII	42.	MJDSCC	Advanced Probability Theory & Measure	Theory	04	25 – 75
			43.	MJDSCC	Advanced Sampling Techniques	Theory	04	25 – 75
			44.	MJDSCC	Practical	Practical	04	100
			45.	Compulsory	Research Methodology	Theory	04	25 – 75
			46. (a)	MJDSEC	(i) Statistical Distributions & Order Statistics	Theory	04	25 – 75
					(ii) Reliability Theory			25 – 75
					(iii) Environmental Statistics			25 – 75
			Total Credit				**20**	
		VIII	47.	MJDSCC	Designs of Experiments	Theory	04	25 – 75
			48.	MJDSCC	Parametric Inference	Theory	04	25 – 75
			49.	MJDSCC	Practical	Practical	04	100
			50.	MJDSEC	(i) Advanced Operations Research	Theory	04	25 – 75
					(ii) Biostatistics			25 – 75
					(iii) Laplace Transform & Linear Difference Equations			25 – 75
					(iv) Stochastic Processes			25 – 75
			51.	Compulsory	Dissertation	Minor Research Project	04	100
			Total Credit				**20**	

Year		Sem.	Course Code	Major/ Minor	Paper Title	Theory/ Practical	Credits	MM Int + Ext
IV	With Research	VII	42.	MJDSCC	Advanced Probability Theory & Measure	Theory	04	25 + 75
			43.	MJDSCC	Advanced Sampling Techniques	Theory	04	25 + 75
			44.	MJDSCC	Practical	Practical	04	100
			45.	Compulsory	Research Methodology	Theory	04	25 + 75
			46 (b).	Compulsory	Dissertation	Minor Research Project	04	100
			Total Credit				**20**	
		VIII	47.	MJDSCC	Designs of Experiments	Theory	04	25 + 75
			48.	MJDSCC	Parametric Inference	Theory	04	25 + 75
			49.	MJDSCC	Practical	Practical	04	100
			52.	Compulsory	Dissertation	Major Research Project	08	200
			Total Credit				**20**	

Abbreviations:

MJDSCC: Major Discipline-Specific Core Course
MJDSEC: Major Discipline-Specific Elective Course
MNGEC: Minor Generic Elective Course
AEC: Ability Enhancement Course
SEC: Skill Enhancement Course
VAC: Value Addition Course

These six papers of Mathematics are to be taught compulsorily to students of Four year B.Sc. Honours in Statistics as Minor elective papers each of 04 credits spread over first six semesters

Semester	Paper Title	Theory/ Practical	Credits	MM Int + Ext
I	Computer fundamentals and Programming in C Language	Theory	04	25 + 75
II	Matrix Theory	Theory	04	25 + 75
III	Real Analysis and Laplace Transform	Theory	04	25 + 75
IV	Numerical Methods	Theory	04	25 + 75
V	Fundamentals of Data Science: Statistics and Machine Learning with Python	Theory	04	25 + 75
VI	Linear Algebra	Theory	04	25 + 75

Open Minor Elective course for B.Sc. Honours programme for subjects other than Statistics as major

Semester	Paper Title	Theory/ Practical	Credits	MM Int + Ext
II	Basic Statistics	Theory	04	25 + 75

Value added course may be pursued from SWAYAM platform as per availability.

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **First**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Univariate Descriptive Statistics**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of Statistics, its scope and importance in various fields.
- ✓ Ability to understand concepts of sample vs. population and difference between different types of data.
- ✓ Knowledge of methods for summarizing data sets, including common graphical tools(such as boxplots, histograms and stem plots). Interpret histograms and boxplots.
- ✓ Ability to describe data with measures of central tendency and measures ofdispersion.
- ✓ Ability to understand measures of skewness and kurtosis and their utility andsignificance.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	Introduction to Statistics, Meaning of Statistics, Importance of Statistics, Scope of Statistics in Industry, Introduction and contribution of Indian Scholars in Statistics. Concept of Statistical population, Attributes and Variables (Discrete and Continuous), Different types of scales – Nominal, Ordinal, Ratio and Interval.	10
II	Presentation of data: Classification, Tabulation, Diagrammatic & Graphical Representation of Grouped data, Frequency distributions, Cumulative frequency distributions and their graphical representations, Histogram, Frequency polygon and frequency curve, Ogives with their utility. Stem and Leaf plot, Box Plot.	15
III	Measures of Central tendency and Dispersion with their properties, Merits and Demerits. Relative measures of dispersion.	10
IV	Moments and Factorial moments, Shepard's correction for moments, Measures of Skewness and Kurtosis and their significance, Measures based on quartiles.	10

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, WorldPress, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th Ed.),Sultan Chand and Sons.
3. Hanagal, D.D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa.

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **First**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Introduction to Probability Theory**	

Course outcomes:

After completing this course a student will have:

- ✓ Ability to understand the concept of probability along with basic laws and axioms ofprobability.
- ✓ Ability to understand the terms mutually exclusive and independence and their relevance.
- ✓ Ability to identify the appropriate method (i.e. union, intersection, conditional, etc.) for solving a problem.
- ✓ Ability to apply basic probability principles to solve real life problems.
- ✓ Ability to understand the concept of random variable (discrete and continuous)

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0.**

Unit	Topic	No. of Lectures
I	Random experiment, Trial, Sample point and Sample space, Events, Operations of events, Concept of equally likely, Mutually exclusive and Exhaustive events. Definition of Probability: Classical, Relative frequency and Axiomatic approaches.	8
II	Discrete Probability Space, Properties of Probability under Set Theory Approach, Independence of Events, Conditional Probability, Total and Compound Probability theorems, Bayes theorem and its Applications.	12
III	Random Variables – Discrete and Continuous, Probability Mass Function (pmf) and Probability density function (pdf), Cumulative distribution function (cdf). Joint distribution of two random variables, Marginal and Conditional distributions, Independence of random variables.	12
IV	Expectation of a random variable and its properties, Expectation of sum of random variables and product of independent random variables, Conditional expectation and related problems. Moments, Moment generating function (m.g.f.), characteristic function (c.f.) & probability generating function (p.g.f.) and their properties, Continuity theorem for c.f. (without proof). Chebyshev's inequality with its proof and related problems.	13

Suggested Readings:

1. Hogg, R.V., Craig, A.T., and McKean, J.W. (2013). Introduction to Mathematical Statistics, 7th Edition. Pearson Education.
2. Rohatgi, V.K., and Saleh, A.K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Edition. John Wiley & Sons.
3. Goon, A.M., Gupta, M.K., and Dasgupta, B. (2017). Fundamentals of Statistics, Vol. I. The World Press, Kolkata.
4. Gupta, S.C., and Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics, 12th Edition. Sultan Chand & Sons, New Delhi.

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **First**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Basic Probability Distributions**	

Course outcomes:

After completing this course, a student will be able to:

- ✓ Understand the basic concepts and properties of discrete and continuous probability distributions.
- ✓ Compute probabilities and measures such as moments and generating functions.
- ✓ Apply probability distributions to solve statistical problems.
- ✓ Fit standard probability distributions to observed data and interpret the results.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	**Discrete Probability Distributions** Bernoulli Distribution, Binomial Distribution, Poisson Distribution, and Geometric Distribution with their classical situations/development, fitting, Uniform distribution and its properties.	15
II	Raw, central, and factorial moments, measure of skewness, m.g.f. and p.g.f., limiting distributions, mode, important properties with their proofs, and related important theorems.	8
III	**Continuous Probability Distributions** Rectangular, Exponential, Normal, and Log-Normal Distributions with their important properties including proof, their m.g.f., moments and uses.	15
IV	Fitting of normal distribution and its area properties. Problems based on above distributions.	7

Suggested Readings:

1. Rohatgi, V.K., and Saleh, A.K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Edition. John Wiley & Sons.
2. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics, 10th Edition. Sultan Chand and Sons.
3. Johnson, N.L. and Kotz, S. (1972). Distribution in Statistics Vol. I & II, Houghton and Mifflin.
4. Mood A.M., Graybill F.A. and Boes D.C. (2007). Introduction to the Theory of Statistics, 3rd Edition, Tata McGraw Hill Publishing Co. ltd, New Delhi.
5. Mukhopadhyay, P. (1996). Mathematical Statistics, New Central Book Agency Pvt., New Delhi.

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **First**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Data Analysis Lab using MS Excel**	

Course outcomes:

After completing this course a student will have:

- ✓ Ability to represent/summarize the data/information using appropriate Graphical methods including common graphical tools (such as boxplots, histograms and stem plots) and also to draw inferences from these graphs.
- ✓ Acquire the knowledge to identify the situation to apply appropriate measure of central tendency as per the nature and need of the data and draw meaningful conclusions regarding behavior of the data.
- ✓ Acquire the knowledge to identify the situation to apply appropriate measure of dispersion as per the nature and need of the data and draw meaningful conclusions regarding heterogeneity of the data.
- ✓ Ability to measure skewness and kurtosis of data and define their significance.
- ✓ Acquire the knowledge to compute conditional probabilities based on Bayes Theorem.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-6.**

	Topic	**No. of Hours**
	The following practical exercises to be solved using MS Excel: • Problems based on graphical representation of databy Histogram, Frequency polygons, frequency curves and Ogives, Stem and Leaf Plot, Box Plot. • Problems based on calculation of Measures of Central Tendency. • Problems based on calculation of Measures of Dispersion. • Problems based on calculation of Moments, Measures of Skewness and Kurtosis. • Computation of conditional probabilities based on Bayes theorem • Fitting of distributions. • Learning pivot table and Filter function in excel	90

Suggested Readings:

- Panneerselvam, R. (2023). Business Statistics Using Excel: A Complete Course in Data Analytics. Boca Raton, FL: CRC Press.
- Levine, D. M., Stephan, D. F., & Szabat, K. A. (2020). Statistics for Managers Using Microsoft Excel, 9th Ed, Pearson Education.

Programme/Class: **B.Sc. Hons. (Statistics)**	Year: **First**	Semester: **First**
Subject: **MATHEMATICS (Minor)**		
Course Code:	Course Title: **Computer Fundamentals and Programming in C Language**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of computer architecture.
- ✓ Ability to operate computer systems.
- ✓ Ability to analyse a real problem and develop an algorithm.
- ✓ Ability to write computer software programs in C language.
- ✓ Ability to write C programs to compute statistical measures.

Credits: **04**	Minor Elective
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Basic Computer Structure:** Overview of Computer System, Memory, C.P.U, I/O Units, Higher and Lower Levels Computer Languages. Basic Concepts of Computer Softwares, Compilers, Operating Systems and Statistical Software packages. Number systems (Binary, Octal, Hexadecimal Systems).	**15**
II	**Programming Methods:** Problem analysis, Algorithms, Flow charts, Programming Designs, Criteria for a good programming method.	**10**
III	**C Programming Language :** Basic features of C Language, constants, Variables and data types, operators and expressions Arithmetic, relational and logical, input and output statements with their formats, decision making statements, branching and looping, Arrays, user and system defined functions, structures and pointers.	**20**
IV	C Language Programs For Statistical Methods such as Measures of central tendency and Dispersion. Moments	**15**

Suggested Readings:

1. Balagurusamy E. (2024). Programming in ANSI C, 9th Ed., Mc-Graw Hill, New Delhi.
2. Kanetkar Yashwant P. (2024). Let us C, 20th Ed., BPB Publications, New Delhi.
3. Kernighan B.W and Ritchie Dennis M. (1997). The C Programming Language, Prentice Hall of India Pvt Ltd. New Delhi.
4. Raja Raman V. (1999). Computer Programming In C, Prentice Hall of India Pvt. Ltd. New Delhi.
5. Gottfried Byron S. (1999). Programming with C, (Schaum's Outline) Tata Mc Graw Hill Publishing

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **First**
Subject: **STATISTICS (VAC)**		
Course Code:	Course Title: **Indian Official Statistical System**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understanding of the historical development and evolution of statistics in India.
- ✓ Knowledge of major Indian contributions to statistics and national development.
- ✓ Understanding of the present official statistical system in India at the Centre and State levels.
- ✓ Knowledge of the role of MoSPI, CSO, NSSO and National Statistical Commission.
- ✓ Ability to understand official data sources, their methods of collection, reliability and limitations.

Credits: **02**	Core: **VAC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **2-0-0.**

Unit	Topic	No. of Lectures
I	**Historical Development and Indian Contribution to Statistics** History of the development of statistics in India; evolution of statistics in India; statistical development in ancient India with reference to data collection, census and administrative records. Development of statistics during British India and after independence. Contribution of Indian statisticians, especially P. C. Mahalanobis, C. R. Rao, R. C. Bose, S. N. Roy, P. V. Sukhatme and D. Basu. Contribution of statistics to national development, planning, sample surveys, Indian Statistical Institute and statistical education in India.	15
II	**Present Official Statistical System in India** Present official statistical system in India. Statistical offices at the Centre and in the States. Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics and Programme Implementation, Central Statistical Office, National Sample Survey Office and National Statistical Commission. Government of India's principal publications and data sources relating to population, agriculture, industry, finance, national income and other socio-economic sectors.	15

Suggested Readings:

1. Ghosh, J. K., Maiti, P., Rao, T. J., & Sinha, B. K. (1999). Evolution of Statistics in India. International Statistical Review, 67(1), 13–34.
2. Kanji, G. K. (1981). History of the Development of Statistics in India. Journal of Applied Statistics, 8(2), 157–167.
3. Saluja, M. R. (2017). Measuring India: The Nation's Statistical System. New Delhi: Oxford University Press.
4. Manna, G. C. (2025). 75 Years of the Indian National Sample Survey: Evolution of Sample Design, Key Challenges and Way Forward. Singapore: Springer.
5. Ministry of Statistics and Programme Implementation, Government of India. Annual Reports.

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **Second**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Bivariate Descriptive Statistics**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the method of least squares for curve fitting to theoretically describe experimental data with a function or equation and to find the parameters associated with the model.
- ✓ Knowledge of the concepts of correlation and simple linear regression and Perform correlation and regression analysis.
- ✓ Ability to interpret results from correlation and regression.
- ✓ Ability to compute and interpret rank correlation.
- ✓ Ability to understand concept of qualitative data and its analysis.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0.**

Unit	Topic	No. of Lectures
I	Bivariate data, Principles of least squares, Most plausible values, Meaning of curve fitting, Fitting of straight line, parabola, logarithmic, power curves and other simple forms by method of least squares.	10
II	Bi-Variate frequency table, Correlation, Types ofrelationships, Scatter diagram, Karl-Pearson's Correlation Coefficient and its properties.	12
III	Rank correlation and its coefficient (Spearman), Regression analysis through both types of regression equations for X and Y variables.	12
IV	Attributes: Notion and Terminology, Contingency table, Class frequencies and Ultimate class frequencies, Consistency, Association of Attributes, Independence, Measures of association for 2X2 table, Chi-square, Karl Pearson's and Tschuprow's Coefficient of Association.	11

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, WorldPress, Kolkata.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2011). Fundamental of Statistics, Vol II, WorldPress, Kolkata.
3. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.),Sultan Chand and Sons.
4. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications,(7th Edn.), Pearson Education, Asia.
5. Mood, A.M. Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **Second**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Advanced Probability Distributions**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the concepts and properties of advanced discrete probability distributions.
- ✓ Understand the concepts and properties of advanced continuous probability distributions.
- ✓ Apply probability distributions to solve statistical problems.
- ✓ Understand the properties and applications of the bivariate normal distribution.
- ✓ Select appropriate probability distribution models for real-life data analysis.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	**Advanced Discrete Probability Distributions** Classical situations of Negative Binomial, Multinomial, and Hypergeometric distributions. Their p.g.f. and factorial moments. Limiting distributions and mode of negative binomial and hypergeometric distributions. Mean vector, variance-covariance matrix, correlation matrix, and marginal and conditional distributions of multinomial distribution.	15
II	**Advanced Continuous Probability Distributions** Distributions of Gamma, Weibull, Beta-I, and Beta-II with their m.g.f., mean, variance, mode, and important related theorems. Cauchy distribution with its characteristic function and important theorems.	15
III	Bivariate Normal distribution, its m.g.f., marginal and conditional distributions. Its mean vector and variance-covariance matrix. Important related theorems of BVN distribution, Standard Bivariate Normal distribution with its recurrence relation for (r, s)-th central moment.	15

Suggested Readings:

1. Dudewicz, E.J. and Mishra, S.N. (2008). Modern Mathematics Statistics, Wiley.
2. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.),Sultan Chand and Sons.
3. Johnson, N.L. and Kotz, S. (1972). Distribution in Statistics Vol. I, II & III, Houghton and Mifflin.
4. Forbes, C., Evans, M., Hastings, N., & Peacock, B. (2011). Statistical Distributions, 4th Ed, Hoboken, NJ: John Wiley & Sons

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **Second**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Introduction to R Software**	

Course outcomes:

After completing this course a student will have:

- ✓ Basic Knowledge of R programming with some basic notions.
- ✓ Ability to develop simple programs and visualizing graphics in R.
- ✓ Ability to perform data analysis for both univariate and multivariate data sets using R.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	Introduction to R software and R Studio, Installing R, R as a calculator. Creating a data set, Understanding a data set, Data structure: Vectors, Matrices, Arrays, Data Frames, Factors and Lists. creating new variables, recoding variable, renaming variables. Data inputs: Entering data from the keyboard, Importing Data from text file, CSV file, fixed format file, Excel file, Exporting R data frame. Data cleaning.	15
II	Plotting in R: High level plotting functions: Scatter plot, pair plots, line charts, pi charts, histogram, bar plots, box plot, Cleveland dot plot, time series plot, stip chart, contour plot, qqnorm plot, cdf plot, steam and leaf plots and density plots. Low level plotting functions: adding points, adding lines, adding text, segments, title, legend, axis's to the existing plots. Graphical parameter functions.	15
III	Logical operators and conditional statements such as if, if else and nested if else statements, Looping such as for loop, while loop. Functions and recursion. Descriptive Statistics with R: mean, median, mode, skewness, kurtosis, skewness, probability distribution functions	15

Suggested Readings:

1. Chambers, J. (2008). Software for Data Analysis: Programming with R, Springer.
2. Crawley, M.J. (2014). Statistics: An Introduction Using R, 2nd Edition, Wiley.
3. Crawley, M.J. (2022). The R Book, Third Edition, Wiley.
4. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley.
5. Heumann, C., Schomaker, M., and Shalabh (2022). Introduction to Statistics and Data Analysis: with Exercises, Solutions and Applications in R, Second Edition, Springer
6. Matloff, N. (2011). The Art of R Programming, No Starch Press, Inc.

Programme/Class: **B.Sc. (Hons.)**	Year: **First**	Semester: **Second**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Data Analysis Lab using R**	

Course outcomes:

After completing this course a student will have:

- ✓ Ability to deal with the problems based on fitting of curves by method of least squares e.g. fitting of straight line, second degree polynomial, power curve, exponential curve etc.
- ✓ Ability to deal with problems based on determination of regression lines and calculation of Correlation coefficient – grouped and ungrouped data.
- ✓ Ability to deal with the problems based on determination of rank correlation.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-6.**

	Topic	**No. of Lectures**
	• Problems based on fitting of curves by Method of least squares e.g. fitting of straight line, second degree polynomial, power curve, exponential curve etc. • Problems on calculation of Correlation coefficient – grouped and ungrouped data. • Problems based on fitting of Regression lines. • Problems based on calculation of Rank correlation. •	**90**

Suggested Readings:

As suggested for theory paper codes and, An Introduction to R: Notes on R: A Programming Environment for Data Analysis and Graphics.

Programme/Class: **B.Sc. Hons. (Statistics)**	Year: **First**	Semester: **Second**
Subject: **MATHEMATICS (Minor)**		
Course Code:	Course Title: **Matrix Theory**	

Course outcomes:

After completing this course, a student will be able to:

- ✓ Perform matrix algebra and work with transpose, conjugate and conjugate transpose and their properties.
- ✓ Identify and use special matrices: symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal, unitary, idempotent, involutory and nilpotent.
- ✓ Evaluate determinants and compute adjoint and inverse of a matrix.
- ✓ Determine the rank of a matrix using elementary transformations and reduce it to normal form.
- ✓ Solve systems of linear (homogeneous and non-homogeneous) equations and test their consistency.
- ✓ Find characteristic roots and vectors and apply the Cayley–Hamilton theorem.

Credits: **04**	Minor Elective
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Algebra of Matrices & Special Matrices**: Addition, scalar multiplication and multiplication of matrices; associative and distributive laws. Transpose, conjugate and conjugate transpose with their properties. Symmetric, Skew-symmetric, Hermitian and Skew-Hermitian matrices with their properties. Related theorems on Symmetric, skew-symmetric, Hermitian and skew-Hermitian matrices. Trace of a matrix and their properties. Idempotent, involutory and nilpotent matrices.	15
II	**Determinants, Adjoint & Inverse:** Determinant of a square matrix, minors and cofactors, properties of determinants and related important theorems. Adjoint of a square matrix. Inverse of a matrix and related theorems. Applications of determinants (Cramer's rule).	15
III	**Rank & System of Linear Equations:** Concept of rank; elementary row and column transformations; invariance of rank under E-transformations; rank of a product of matrices; normal (canonical) form and reduction to normal form; elementary matrices and their inverses; inverse by elementary operations. System of linear homogeneous and non-homogeneous linear equations; Necessary and sufficient conditions for the consistency of non-homogeneous linear equations.	15
IV	**Eigenvalues & Cayley–Hamilton Theorem:** Characteristic matrix, characteristic equation and characteristic roots (eigenvalues) of a square matrix; characteristic vectors (eigenvectors); computation of eigenvalues and eigenvectors. Cayley–Hamilton theorem and its use to find inverse of a matrix; Unitary and Orthogonal matrices, Inner product of vectors and length of a vector, orthogonal vectors.	15

Suggested Readings:

1. Narayan, Shanti and Mittal, P. K. (2010). A Text Book of Matrices. 11th ed., S. Chand & Co. Ltd., New Delhi.
2. Biswas, Suddhendu (2012). Textbook of Matrix Algebra. 3rd ed., PHI Learning Pvt. Ltd., New Delhi.
3. Hadley, G. (2002). Linear Algebra. Narosa Publishing House, New Delhi.
4. Vasishtha, A. R. and Vasishtha, A. K. (2018). Matrices. 49th ed., Krishna Prakashan Media Pvt. Ltd., Meerut.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Theory of Point and Interval Estimation**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the concept of Sampling distributions.
- ✓ Ability to understand the difference between parameter & statistic.
- ✓ Knowledge of the concept of Point Estimation.
- ✓ Discuss characteristics of a good estimator.
- ✓ Ability to understand and practice various methods of estimations of parameters.
- ✓ Knowledge of constructing interval confidence intervals for interval estimation.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
	Theory of Estimation	
I	Point estimation: Characteristics of a good estimator: Unbiasedness, consistency, sufficiency and efficiency. Uniqueness of these estimators, Problems and examples in the case of discrete and continuous distributions like binomial, Poisson, exponential, normal etc.	20
II	Method of Maximum Likelihood estimation and properties of maximum likelihood estimators (without proof), method of moments for estimation of parameters.	15
III	Interval estimation: confidence regions, best confidence intervals, shortest confidence intervals, general method of construction of confidence interval using pivotal quantity. Confidence intervals for mean and variance of normal distribution when one or both parameters are unknown.	10

Suggested Readings:

1. Rohatgi, V. K. and Saleh, A.K. Md. E. (2015): An Introduction to Probability and Statistics. 4th Ed, John Wiley and Sons.
2. Casella, G., & Berger, R. L. (2002). Statistical Inference, 2nd Ed, Pacific Grove, Duxbury.
3. Freund J.E (2001) : Mathematical Statistics, Prentice Hall of India.
4. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.
5. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2005). An Outline of Statistical Theory, Vol. II, 3rd Ed., World Press, Kolkata.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Testing of Hypothesis and Non-Parametric Inference**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the terms like null and alternative hypotheses,
- ✓ Knowledge of two-tailed and one- tailed alternative hypotheses, level of significance and p value etc.
- ✓ Ability to understand the concept of MP, UMP and UMPU tests
- ✓ Ability to understand non-parametric tests.
- ✓ Ability to understand under what situations one would conduct the small sample and large sample tests (in case of one sample tests).

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0.**

Unit	Topic	No. of Lectures
	Testing of Hypothesis	
I	Statistical Hypothesis (Simple and Composite), Testing of hypothesis. Type – I and Type – II errors, Significance level, Power of a test, p-values.	12
II	Definitions of Most Powerful (MP), Uniformly Most Powerful (UMP) and Uniformly Most Powerful Unbiased (UMPU) tests. Cases of normal distribution when one or both parameters are unknown.	08
III	Non-parametric tests, Tests for randomness and test for goodness of fit. One sample tests : Sign test, Wilcoxon Signed rank tests.	13
IV	Two sample tests : Run test, Kolmogorov – Smirnov's test, Median test and Mann-Whitney U test.	12

Suggested Readings:

1. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2005). An Outline of Statistical Theory, Vol. II, 3rd Ed., World Press, Kolkata.
2. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edition. (Reprint) John Wiley and Sons.
3. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition.Marcel Dekker, CRC.
4. Ferund J.E (2001) : Mathematical Statistics, Prentice Hall of India.
5. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Designs of Sample Survey**	

Course outcomes:

After completing this course a student will have:

- ✓ Ability to understand the concept of sampling and how it is different from completeenumeration.
- ✓ Knowledge of various probability and non-probability sampling methods along withestimates of population parameters
- ✓ Ability to identify the situations where the various sampling techniques shall be used.
- ✓ Knowledge of sampling and non-sampling errors.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	Sample survey and complete enumeration, advantages of sampling over census, Sampling units and Sampling frame, Precision and efficiency of estimators, sampling and non-sampling errors, basic principles of sample survey, Use of random number tables in selection of simple random sample. Primary data – designing a questionnaire and schedule, collection of primary data, checking their consistency, Secondary data.	10
II	Simple Random sampling with and without replacement, Estimation of population mean and proportion, Derivation of expression for variance of these estimators, Estimation of variances, Sample size determination.	10
III	Stratified random sampling, Problem of allocation, proportional allocation, optimum allocation. Derivation of the expressions for the standard error of the usual estimators when these allocations are used, Gain in precision due to Stratification.	15
IV	Systematic Sampling: sampling frame for systematic sampling, Estimation of Population mean and Population total, standard errors of these estimators.	10

Suggested Readings:

1. Cochran, W. G. (2008). Sampling Techniques, 3rd Ed., Wiley India.
2. Mukhopadhyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.
3. Singh, D. and Choudhary, F. S. (2020). Theory and Analysis of Sample Survey Designs, 2nd Ed., New Age International Publishers, New Delhi.
4. Sukhatme, P. V. and Sukhatme, B. V. (1970). Sampling Theory of Surveys with Applications (2nd ed.). Iowa State University Press.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Third**
Subject: **STATISTICS (Major)**		
Course Code:	Course Title: **Sampling & Inference Lab using MS Excel and R**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of calculating point and interval estimates.
- ✓ Ability to formulate Simple Statistical Hypothesis and its Testing, Calculate Type –I & Type – II errors, and power of the test.
- ✓ Ability to draw a simple random sample with the help of table of random numbers.
- ✓ Ability to estimate population means and variance in simple random sampling.
- ✓ Ability to deal with problems based on Stratified random sampling for population means (proportional and optimum allocation).
- ✓ Ability to deal with problems based on Systematic random sampling

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-6.**

	Topic	No. of Hours
	• Problems based on point and interval estimation, testing of hypothesis. • Problems based on non-parametric methods. • Problems based on drawing a simple random samplewith the help of table of random numbers. • Problems based on estimation of population means and variance in simple random sampling. • Problems based on Stratified random sampling for population means (proportional and optimum allocation). • Problems based on Systematic random sampling.	90

Suggested Readings:

- As suggested for theory papers.
- Practicals will be done using R as well scientific calculators.
- An Introduction to R: Notes on R: A Programming Environment for Data Analysis and Graphics.

Programme/Class: B.Sc. Hons. (Statistics)	Year: Second	Semester: Third
Subject: MATHEMATICS (Minor)		
Course Code:	Course Title: **Real Analysis and Laplace Transform**	

Course outcomes:

- ✓ After completing this course a student will have:
- ✓ Knowledge of functions, limits with their properties
- ✓ Ability to analyze the nature of functions
- ✓ Knowledge of continuity and differentiability with its types
- ✓ Ability to deal with double and multiple integrals
- ✓ Knowledge of Laplace transforms
- ✓ Ability to solve various types of system of differential equations

Credits: 04	Minor Elective
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0.

Unit	Topic	No. of Lectures
I	Introduction of Function, definition, type of functions, composition of functions and invertible function, binary operations, odd and even functions, bounded and unbounded functions, monotonic functions. Limit of a function, one side limit-right hand and left hand limits, Continuous functions, discontinuity of a function, kinds of continuity, uniform continuity, theorems on continuity.	15
II	Differentiability: definition, meaning of sign of derivative, Rolle's theorem, geometrical interpretation of Rolle's theorem. Lagrange's mean value theorem, Taylor's theorem for expansion of functions with various forms of remainder. Maxima and minima, indeterminate forms, Jacobians,	15
III	Beta and gamma functions. Double and multiple integrals, change of order of integration, Dirichlet's theorem and its Liouville's extension.	15
IV	Laplace transforms and its properties such as additive property, derivative property, limit property, convolution property etc. Inverse Laplace-transform and its properties, Laplace-Stieltjes transform, Mean, Variance and moments by using Laplace transforms. Laplace transforms solution of simple differential equations.	15

Suggested Readings:

1. Narayan, S., and Raisinghania, M. D. (2014). Elements of Real Analysis, 15th Ed., S. Chand & Company, New Delhi.
2. Narayan, S., and Mittal, P. K. (2013). A Course of Mathematical Analysis, S. Chand & Company, New Delhi.
3. Rudin, W. (1976). Principles of Mathematical Analysis, 3rd Ed., McGraw-Hill, New York.
4. Sharma, J. N., and Vasishtha, A. R. (2019). Real Analysis, Krishna Prakashan Media, Meerut.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Fourth**
Subject: **STATISTICS (Major)**		
Course Code: **B060451T**	Course Title: **Linear Models and Regression Analysis**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the concept of Gauss Markov linear models.
- ✓ Ability to fit linear model using least square method.
- ✓ Knowledge of the concept of simple and multiple linear regression models.
- ✓ Ability to understand and check model fitting.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	Gauss-Markov linear Models, theory of linear estimation, Estimability of linear parametric functions, method of least squares, normal equations, Gauss-Markov theorem, estimation of error variance.	12
II	Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Coefficient of determination.	10
III	Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2.	11
IV	Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test based on Studentized Residual (R-student).	12

Suggested Readings:

1. Bapat, R. B. (2012). Linear Algebra and Linear Models, 3rd Ed., Hindustan Book Agency, New Delhi.
2. Montgomery, D. C., Peck, E. A., and Vining, G. G. (2021). Introduction to Linear Regression Analysis, 6th Ed., John Wiley & Sons, Hoboken, NJ.
3. Khuri, A. I. (2010). Linear Model Methodology, Chapman & Hall/CRC, Boca Raton, FL.
4. Rao, C. R. (2002). Linear Statistical Inference and Its Applications, 2nd Ed., Wiley Classics Library, John Wiley & Sons, New York.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Fourth**
Subject: **STATISTICS (Major)**		
Course Code: **B060452T**	Course Title: **Time Series and Index Numbers**	

Course outcomes:

After completing this course a student will have:

- ✓ Familiarity with different aspects of Applied Statistics and their use in real lifesituations.
- ✓ Ability to understand the concept of Time series along with its different components.
- ✓ Knowledge of Index numbers and their applications along with different types of Index numbers.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	Introduction & Definition of Time Series, its different components, illustrations, additive and multiplicative models. Determination of trend by free hand curve, semi average method, moving average method, method of least squares,	10
II	Analysis of Seasonal Component by Simple average method, Ratio to moving Average, Ratio to Trend, Link relative method. Measurement of cyclic variations.	13
III	Index number – its definition, application of index number, price relative and quantity or volume relatives, link and chain relative, problem involved incomputation of index number, use of averages, simple aggregative and weighted average method.	12
IV	Laspeyre's, Paasche's and Fisher's index number, time and factor reversal tests of index numbers, consumer price index.	10

Suggested Readings:

1. Croxton, F. E., Cowden, D. J., and Klein, S. (1973). Applied General Statistics, 3rd Ed., Prentice Hall of India, New Delhi.
2. Gupta, S. C., and Kapoor, V. K. (2022). Fundamentals of Applied Statistics, 5th Ed. (Reprint), Sultan Chand & Sons, New Delhi.
3. Mukhopadhyay, P. (2016). Applied Statistics, 2nd Ed. (Revised Reprint), Books and Allied (P) Ltd., Kolkata.
4. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. II, 9th Ed., The World Press Pvt. Ltd., Kolkata.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Fourth**
Subject: **STATISTICS (Major)**		
Course Code: **B060453T**	Course Title: **Sampling Distributions and Test of Significance**	

Course outcomes:

After completing this course a student will have:

- ✓ Ability to understand the uses of tests of significance.
- ✓ Ability to understand the applications of sampling distributions.
- ✓ Ability to understand under what situations one would conduct the small sample and large sample tests (in case of one sample and two sample tests).
- ✓ Familiarity with different aspects of statistical tests and their use in real lifesituations.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **3-0-0**.

Unit	Topic	No. of Lectures
I	Sampling Distributions: The concept of sampling distribution, Parameter, Statistic and Standard error. The sampling distribution for the sum of independent random variables of Binomial, Poisson and Normal distribution.	15
II	Central limit theorem, sampling distribution of Z. Sampling distribution of t, F, and chi-square without derivations, Simple properties of these distributions and their interrelationships.	15
III	Test of significance: Large sample tests for (Attributes and Variables) proportions and means (i) for one sample (ii) for two samples, tests of significance of correlation and regression coefficients. Small sample test based on t, F and chi-square distributions.	15

Suggested Readings:

1. Rohatgi, V. K., and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.
2. Gupta, S. C., and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, 12th Ed., Sultan Chand & Sons, New Delhi.
3. Hogg, R. V., McKean, J. W., and Craig, A. T. (2019). Introduction to Mathematical Statistics, 8th Ed., Pearson Education, Boston, MA.
4. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I, 9th Ed., The World Press Pvt. Ltd., Kolkata.
5. Devore, J. L. (2016). Probability and Statistics for Engineering and the Sciences, 9th Ed., Cengage Learning, Boston, MA.

Programme/Class: **B.Sc. (Hons.)**	Year: **Second**	Semester: **Fourth**
Subject: **STATISTICS (Major)**		
Course Code: **B060454P**	Course Title: **Applied Statistics Lab**	

Course outcomes:

After completing this course a student will have:

- ✓ Ability to fit linear regression models on given data.
- ✓ Ability to test fitted model accuracy.
- ✓ Ability to apply small and large sample tests to attributes and variables.
- ✓ Ability to analysis time series data for future predictions.
- ✓ Ability to calculate index numbers from economic data for policy making.

Credits: **03**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-6**.

	Topic	No. of Hours
	• Problems based on the regression analysis. • Problems based on tests of significance. • Problems based on time series and its different components. • Problems based on index number.	**90**

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. Hons. (Statistics)**	Year: **Second**	Semester: **Fourth**
Subject: **MATHEMATICS (Minor)**		
Course Code:	Course Title: **Numerical Methods**	

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of types of errors
- ✓ Ability to solve non-linear equations using iterative methods.
- ✓ Ability to interpolate value of dependent variable using past data.
- ✓ Ability to differentiate complex functions numerically.
- ✓ Ability to numerically solve complex integrals.

Credits: **04**	Minor Elective
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Errors in Computation-** Floating point representation of numbers, Significant Digits, Rounding and chopping, Absolute and relative errors, computation of errors using differentials, Truncation error. **Solution of non-linear equations:** bisection, Newton Raphson's method, successive iteration method	**20**
II	**Interpolation-**Some operators and their properties, Finite difference table, Error in approximating a function by polynomial, Newton forward and backward Difference formulae, Gauss forward and backward formulae, Stirling's and Bessel formulae, Lagrange's method, Divided differences and Newton's divided difference formula.	**20**
III	**Numerical differentiation** - Differentiation methods based on Newton's forward and backward formulae, Differentiation by central difference formula,	**10**
IV	**Numerical Integration:** Trapezoidal, Weddle, Simpsons Newton Cotes Formulas, Gaussian Quadrature Formulas.	**10**

Suggested Readings:

1. Gupta, R. K. (2019). Numerical Methods: Fundamentals and Applications, 1st Ed., Cambridge University Press, New Delhi.
2. Jain, M. K., Iyengar, S. R. K., and Jain, R. K. (2019). Numerical Methods for Scientific and Engineering Computation, 7th Ed., New Age International Publishers, New Delhi.
3. Bradie, B. (2006). A Friendly Introduction to Numerical Analysis, Pearson Education, Upper Saddle River, NJ.
4. Gerald, C. F., and Wheatley, P. O. (2008). Applied Numerical Analysis, 7th Ed., Pearson Education, New Delhi.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MJDSCC)**		
Course Code:	Course Title: **Introduction to ANOVA & Design of Experiments**	

Course outcomes:

After completing this course, a student will be able to:

- ✓ Understand the basic concepts of ANOVA, general linear models and different effect models.
- ✓ Apply one-way and two-way ANOVA for the analysis of experimental data.
- ✓ Understand the principles of design of experiments and analyze CRD, RBD, and Latin Square Designs, including missing plot techniques.
- ✓ Apply Analysis of Covariance and understand split plot and strip plot designs.
- ✓ Interpret and compare the efficiency of different experimental designs for practical applications.

Credits: **04**	Core: **MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Overview of general linear model, Fixed, Random & Mixed effect models, Conditions for Quadratic forms to be Chi-Square distributed, and Cochran's Theorems. Introduction to Analysis of Variance (ANOVA).	15
II	One-way ANOVA, Two-way ANOVA with one observation per cell, Two-way ANOVA with *m* observations per cell, and their layout & statistical analysis.	15
III	Principles of design of experiments, Uniformity trials, completely randomized, Randomized block and Latin square designs including missing plot techniques and their efficiency comparison.	15
IV	Analysis of Covariance for a one-way layout with one concomitant variable. Split plot and strip plot designs.	15

Suggested Readings:

1. Gupta, S. C., and Kapoor, V. K. (2022). Fundamentals of Applied Statistics, 5th Ed. (Reprint), Sultan Chand & Sons, New Delhi.
2. Mukhopadhyay, P. (2016). Applied Statistics, 2nd Ed. (Revised Reprint), Books and Allied (P) Ltd., Kolkata.
3. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2016). Fundamentals of Statistics, Vol. II, 9th Ed., The World Press Pvt. Ltd., Kolkata.
4. Das, M. N., and Giri, N. C. (2024). Design and Analysis of Experiments, 3rd Ed., New Age International Publishers, New Delhi.
5. Montgomery, D. C. (2019). Design and Analysis of Experiments, 10th Ed., John Wiley & Sons, Hoboken, NJ.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MJDSCC)**		
Course Code:	Course Title: **Econometrics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of econometrics and model building.
- ✓ Understanding of general linear model and linear restrictions.
- ✓ Ability to identify and handle multicollinearity.
- ✓ Knowledge of autocorrelation and heteroscedasticity in regression models.
- ✓ Understanding of generalized least squares, Aitken estimator, autoregressive and lag models.

Credits: **04**	Core: **MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Introduction: Objective behind building econometric models, nature of econometrics, model building and role of econometrics. Generalized least squares estimation, Aitken estimator, Gauss-Markov theorem for GLSE.	15
II	Problem of Multicollinearity, its implications. Source of multicollinearity, tools for handling the problem of multicollinearity. Remedies for multicollinearity. Ridge regression. Heteroskedasticity, consequences and tests for it, estimation procedures under heteroskedastic disturbances, Bartlett's test, Breusch Pagan test and Goldfeld-Quandt test.	15
III	Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation. Instrumental variable estimation.	15
IV	Simultaneous equations model, problem of identification, necessary and sufficient condition for the identifiability of parameters in a structural equation, ordinary least squares, indirect least squares, two-stage least squares and limited information maximum likelihood method.	15

Suggested Readings:

1. Gujarati, D. N., and Porter, D. C. (2009). Basic Econometrics, 5th Ed., McGraw-Hill Irwin, New York.
2. Johnston, J., and DiNardo, J. (1997). Econometric Methods, 4th Ed., McGraw-Hill, New York.
3. Koutsoyiannis, A. (2003). Theory of Econometrics, 2nd Ed., Palgrave Macmillan, Basingstoke, UK.
4. Maddala, G. S., and Lahiri, K. (2009). Introduction to Econometrics, 4th Ed., John Wiley & Sons, Chichester, UK.
5. Greene, W. H. (2018). Econometric Analysis, 8th Ed., Pearson Education, New York.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MJDSCC)**		
Course Code:	Course Title: **Practical**	

Course outcomes:

After completing this course, a student will be able to:

- ✓ Understand and apply generalized least squares estimation.
- ✓ Identify problems of multicollinearity, heteroskedasticity, and autocorrelation.
- ✓ Apply ANOVA for comparing different groups or treatments.
- ✓ Analyze data based on CRD, RBD, and LSD designs.
- ✓ Apply ANOCOVA for suitable practical problems.

Credits: **02**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-6**.

	Topic	No. of Hours
	• Problem based on the generalized least squares estimation. • Problem based on the multicollinearity. • Problem based on the heteroskedasticity. • Problem based on autocorrelation. • Problem based on ANOVA. • Problem based on CRD, RBD, LSD. • Problem based on ANOCOVA.	120

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MJDSEC)**		
Course Code:	Course Title: **Demography and Vital Statistics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of demography and vital statistics.
- ✓ Identify errors in census and registration data.
- ✓ Calculate different mortality measures such as CDR, SDR, IMR, and standardized death rates.
- ✓ Understand the concept and construction of life tables.
- ✓ Calculate fertility and population growth measures such as CBR, GFR, TFR, GRR, and NRR.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Introduction to Vital Statistics** Introduction and sources of collecting data on vital statistics, errors in the census, and registration data. Measurement of population, rate, and the ratio of vital events.	15
II	**Measurements of Mortality** Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR), and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates, and Force of Mortality.	15
III	**Life Tables** Life(Mortality) Tables: Assumption, description, construction of Life Tables, and Uses of Life Tables	15
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).	15

Suggested Readings:

1. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2002). Fundamentals of Statistics, Vol. II, 8th Ed., The World Press Pvt. Ltd., Kolkata.
2. Biswas, S. (2004). Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, 2nd Ed., New Central Book Agency, Kolkata.
3. Mukhopadhyay, P. (1999). Applied Statistics, Books and Allied (P) Ltd., Kolkata.
4. Keyfitz, N., and Beekman, J. A. (1984). Demography Through Problems, Springer-Verlag, New York.
5. Preston, S. H., Heuveline, P., and Guillot, M. (2023). Demography: Measuring and Modeling Population Processes, 2nd Ed., Wiley-Blackwell, Hoboken, NJ.
6. Srivastava, O. S. (1996). A Textbook of Demography, Vikas Publishing House, New Delhi.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MJDSEC)**		
Course Code:	Course Title: **Statistical Simulation and Optimization Techniques**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of simulation and Monte-Carlo methods.
- ✓ Understanding of random number generation and testing of pseudo-random numbers.
- ✓ Ability to generate random variates from different distributions.
- ✓ Basic knowledge of single-objective and multi-objective optimization.
- ✓ Ability to apply genetic algorithms and GOSET to solve optimization problems.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Simulation and Monte-Carlo Methods: Introduction to Simulation and Monte-Carlo Method; Random Number Generation: Linear congruential generator, Multiplicative congruential generator, Combined linear congruential generator, Statistical tests for pseudo-random numbers, frequency test, Kolmogrov-Smirnov test, Chi-square test, Test for autocorrelation.	15
II	Random Variate Generation: Inverse transform method and generation of random variates from Exponential, Weibull, Uniform, Triangular, Geometric, Empirical continuous and discrete distributions, Generation of nominal variates. Acceptance and rejection method and generation of Poisson and Gamma variates.	15
III	Single Objective Optimization and Genetic Algorithms, Basic concepts of optimization; objective function, decision variables and constraints; feasible solution, local optimum and global optimum; introduction to Genetic Algorithms; fitness function, selection, crossover and mutation; application of Genetic Algorithms to single objective optimization problems.	15
IV	Multi-Objective Optimization and GOSET Basic concepts of multi-objective optimization; conflicting objectives, Pareto optimality and Pareto front; introduction to Multi-Objective Genetic Algorithms; basic idea of non-dominated sorting and diversity preservation; introduction to GOSET; solving single and multi-objective optimization problems using GOSET.	15

Suggested Readings:

1. Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M. (2010). Discrete-Event System Simulation, 5th Ed., Prentice Hall, Upper Saddle River, NJ.
2. Rubinstein, R. Y., and Kroese, D. P. (2017). Simulation and the Monte Carlo Method, 3rd Ed., John Wiley & Sons, Hoboken, NJ.
3. Goldberg, D. E. (1989). Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, Reading, MA.
4. Deb, K. (2001). Multi-Objective Optimization Using Evolutionary Algorithms, John Wiley & Sons, Chichester, UK.
5. Rao, S. S. (2020). Engineering Optimization: Theory and Practice, 5th Ed., John Wiley & Sons, Hoboken, NJ.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Financial Statistics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of investments, interest rates, bonds, and portfolio theory.
- ✓ Understanding of derivatives, futures, forward contracts, and options.
- ✓ Knowledge of discrete and continuous stochastic processes in finance.
- ✓ Understanding of Brownian motion, Wiener process, stochastic calculus, and Itô's lemma.
- ✓ Ability to understand Black-Scholes model, option pricing, and hedging techniques.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Introduction to investment and markets: Cash flows- deterministic and random, Basic theory of interest, bonds and yields, Term structure of interest rates, Portfolio Theory.	15
II	Introduction to derivatives, Tools Needed for Option Pricing: Forward contracts, spot price, forward price, future price, Call and put options, Zero-coupon bonds and discount bonds, Pricing derivatives: Arbitrage relations and perfect financial markets, Pricing futures, Put-call parity for European and American options, Relationship between strike price and option price. Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models, Trinomial models.	15
III	Continuous time processes – Brownian motion, Geometric Brownian motion, Wiener process; Introduction to stochastic calculus: stochastic integration, stochastic differential equations and their solutions; Itô's lemma.	15
IV	Intrinsic of option markets: Black-Scholes differential equation, Black-Scholes formula for European and American options, Implied volatility, Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends, Trinomial model for American options, Hedging portfolios: Delta, Gamma and Theta hedging.	15

Suggested Readings:

1. Luenberger, D. G. (2014). Investment Science, 2nd Ed., Oxford University Press, New York.
2. Franke, J., Härdle, W. K., and Hafner, C. M. (2019). Statistics of Financial Markets: An Introduction, 5th Ed., Springer, Cham, Switzerland.
3. Ross, S. M. (2011). An Elementary Introduction to Mathematical Finance, 3rd Ed., Cambridge University Press, Cambridge, UK.
4. Hull, J. C. (2022). Options, Futures, and Other Derivatives, 11th Ed., Pearson Education, Harlow, UK.
5. Shreve, S. E. (2004). Stochastic Calculus for Finance I: The Binomial Asset Pricing Model, Springer, New York.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Fifth**
Subject: **STATISTICS (MNGEC)**		
Course Code: -	Course Title: **Fundamentals of Data Science: Statistics and Machine Learning with Python**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of Data Science.
- ✓ Use Python for forecasting: apply libraries like pandas, NumPy, and scikit-learn to real datasets.
- ✓ Build simple machine learning models such as regression and time-series forecasting models.
- ✓ Evaluate predictions: check accuracy, understand errors, and improve models.
- ✓ Apply forecasting to real problems in areas like sales, healthcare, engineering, or public policy.
- ✓ Communicate results clearly: present forecasts and insights in reports, charts or dashboards.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Introduction to Data Science and Applied Statistics** Descriptive statistics: mean, median, mode, range, standard deviation, covariance, Sampling and sample design, Confidence intervals and margin of error, Probability Distributions – Normal, Poisson, Bernoulli, Binomial etc.	15
II	**Regression, Testing and Forecasting Basics with Python** Regression analysis: Simple linear regression, forecasting basics: moving averages, smoothing. Python Lab Integrated: Python basics: variables, loops, functions, data structures, NumPy for numerical computing, Pandas for data manipulation.	15
III	**Python for Data Handling and Machine Learning Fundamentals** Python Lab Integrated: Data cleaning and transformation, Data visualization using matplotlib and seaborn, Hands-on statistical analysis with real datasets, Supervised vs. unsupervised learning, ML metrics and evaluation, Bias-variance trade-off.	15
IV	**Model Building, Evaluation and Applications** Model training, validation and testing, Key algorithms: linear regression, classification, decision trees, k-means clustering. Python Lab Integrated: Implementing ML algorithms using Python, End-to-end ML workflows, Model evaluation and comparison, Practical applications using real-world datasets	15

Suggested Readings:

1. James, G., Witten, D., Hastie, T., Tibshirani, R., and Taylor, J. (2023). An Introduction to Statistical Learning with Applications in Python, Springer, Cham, Switzerland.
2. McKinney, W. (2022). Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter, 3rd Ed., O'Reilly Media, Sebastopol, CA.
3. Géron, A. (2022). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Ed., O'Reilly Media, Sebastopol, CA.
4. Bruce, P., Bruce, A., and Gedeck, P. (2020). Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python, 2nd Ed., O'Reilly Media, Sebastopol, CA.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Statistical Quality Control**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of quality concepts and quality improvement techniques.
- ✓ Understanding of control charts for variables and attributes.
- ✓ Ability to use acceptance sampling plans and OC curves.
- ✓ Knowledge of producer's risk, consumer's risk, AOQL, and LTPD.

Credits: **04**	Core: **MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Concept of quality and control. Product and process control. Chance and assignable causes of variation. Statistical basis of quality control, 3-sigma limits, modified limits and specification limits.	15
II	Control charts for variables. Construction and interpretation of X-bar and R charts. Control limits, revised limits and industrial applications.	15
III	Control charts for attributes. Defectives and defects. Construction and interpretation of p, np and c charts with industrial applications.	15
IV	Inspection and acceptance sampling. 100% inspection versus sampling inspection. Single, double, multiple and sequential sampling plans. OC, AOQL, ASN and ATI curves. Producer's risk, consumer's risk, AQL, LTPD and variable sampling plans.	15

Suggested Readings:

1. Gupta, S. C., and Kapoor, V. K. (2022). Fundamentals of Applied Statistics, 5th Ed. (Reprint), Sultan Chand & Sons, New Delhi.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, World Press, Kolkata.
3. Montgomery, D. C. (2020). Introduction to Statistical Quality Control, 8th Ed., John Wiley & Sons, Hoboken, NJ.
4. Grant, E. L., and Leavenworth, R. S. (1996). Statistical Quality Control, 7th Ed., McGraw-Hill, New York.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Introduction to Multivariate Analysis**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of multivariate normal distribution.
- ✓ Understanding of mean vector, covariance matrix, and their estimation.
- ✓ Knowledge of Wishart distribution and generalized variance.
- ✓ Ability to apply Hotelling's T^2, Mahalanobis D^2 and discriminant analysis.

Credits: **04**	Core: **MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Multivariate Normal Distribution and its properties, MGF, characteristics function, moments, Singular and non-singular multivariate normal distributions. Marginal and conditional distributions.	15
II	Maximum likelihood estimators of μ and $\sum$ in $Np(\mu, \sum)$. Sufficient statistics for population mean vector and variance covariance $\sum$. Test and confidence regions for μ when $\sum$ is known.	15
III	Wishart distribution: Definition, its distribution and properties. Derivation of characteristic function without and with pdf of A. Wishart distribution as a multivariate generalization of chi-square distribution. Distribution of S.	15
IV	Hotelling's T^2: Definition, distribution and its optimum properties. Application in tests on mean vector for one and more multivariate normal population. Mahalanobis's D^2. Discriminate analysis: Classification of observations into one of the two groups.	15

Suggested Readings:

1. Anderson, T.W. (2003): An introduction to multivariate statistical analysis, 3rd Edition. John Wiley.
2. Giri, N.C. (1977): Multivariate statistical inference. Academic Press.
3. Singh, B.M. (2002): Multivariate statistical analysis. South Asian Publishers.
4. Johnson, R.A. and Wichern, D.W. (2015): Applied Multivariate Statistical Analysis, 6th Edition, PHI Learning Private Limited.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Practical**	

Course outcomes:

After completing this course a student will have:

- ✓ Understand the basic practical concepts of Statistical Quality Control.
- ✓ Apply control charts and related SQC techniques to practical problems.
- ✓ Analyze multivariate data using suitable statistical methods.

Credits: **02**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-6.**

	Topic	No. of Hours
	• Problems based on the SQC • Problems based on Multivariate Analysis.	120

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Operations Research**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of operations research and model building.
- ✓ Ability to formulate and solve linear programming problems.
- ✓ Understanding of transportation and assignment problems.
- ✓ Knowledge of game theory problems.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Introduction:** Definition and scope of operations research, Different types of models used in OR. Various phases of OR. **Allocation Problems:** Mathematical formulation of L.P.P, Graphical method to solve a L.P.P, Convex set, Convex combination and extreme points. Simplex method to solve a L.P.P with slack, Surplus and Artificial variables. Construction of dual of a L.P.P.	20
II	**Transportation Problem:** Mathematical formulation of a transportation problem, Northwest corner rule, unit cost penalty method and method of matrix minima. Optimality test, Unbalanced transportation problem, Degeneracy in transportation problems.	15
III	**Assignment Problems:** Assignment problems, formulation of these problems and their solutions, Unbalanced Assignment problems.	10
IV	**Game Theory:** Criteria of pure and mixed strategies, pay-off matrix and saddle point. Solution of zero sum two person games- 2×2, 2×n, m×2 and m×n by minimax and maximin technique, arithmetic method, algebraic method, dominance principle, graphical method matrix method, sub-game method and linear programming techniques.	15

Suggested Readings:

1. Taha, H. A. (2022). Operations Research: An Introduction, 11th Ed., Pearson Education, Hoboken, NJ.
2. Gass, S. I. (2003). Linear Programming: Methods and Applications, 5th Ed., Dover Publications, Mineola, NY.
3. Swarup, K., Gupta, P. K., and Man Mohan (2019). Operations Research, 20th Ed., Sultan Chand & Sons, New Delhi.
4. Sharma, J. K. (2024). Operations Research: Theory and Applications, 7th Ed., Trinity Press (Laxmi Publications), New Delhi

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Actuarial Statistics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of probability distributions used in insurance.
- ✓ Understanding of utility theory and premium calculation principles.
- ✓ Ability to analyze individual risk models and aggregate claims.
- ✓ Knowledge of survival distributions, life tables, and force of mortality.
- ✓ Understanding of life insurance, life annuities, and premium calculations.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.	15
II	Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.	15
III	Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.	15
IV	Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.	15

Suggested Readings:

1. Atkinson, M.E. and Dickson, D.C.M. (2011). An Introduction to Actuarial Studies, Elgar Publishing.
2. Dickson, C. M. D. (2005). Insurance Risk and Ruin (International Series No. 1 Actuarial Science), Cambridge University Press.
3. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Psychological and Educational Statistics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of statistics in psychology and education.
- ✓ Understanding of psychological measurement, tests, and test construction.
- ✓ Knowledge of item writing, item analysis, reliability, and validity.
- ✓ Ability to convert raw scores into percentile, standard scores, T-scores, and Stanine scores.
- ✓ Understanding of intelligence tests, psychological scaling, rankings, and ratings.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	Introduction; need and importance of statistics in psychology and education. Measurements: Levels of measurements. Distinction between psychological and physical measurements; general problems, sources of errors. Tests: Meaning of tests in psychology and education; history of psychological measurement and testing, uses, limitations and varieties, characteristics of a good test, general steps of test construction. Test administration. Item writing - Meaning and types; Item analysis – meaning and purpose. Item difficulty (concepts only). Power tests and speed tests.	15
II	Reliability: Meaning, methods (or types); standard error of measurement, reliability of speed test, factors influencing reliability of test scores, factors for their improvement, estimation of true scores and index of reliability. Reliability of difference and composite scores.	15
III	Validity: Meaning; content, criterion related and construct validity. Statistical methods for calculating validity, factors influencing validity. Extra validity concerns, relation of validity to reliability.	15
IV	Meaning of norm referencing and criterion referencing. Raw score transformations- percentile score, standard scores, normalized standard scores, T-scores, C-scores and Stanine scores. Intelligence: Definition. Types of intelligence test scores. Spearman's two-factor theory and Thomson group factors theory. Psychological scaling methods – Scaling of Individual test items in terms of difficulty, scaling of rankings & ratings in terms of the normal probability curve.	15

Suggested Readings:

1. Garrett, H. E. (2021). Statistics in Psychology and Education. Notion Press.
2. Gregory, R. J. (2016). Psychological Testing: History, Principles, and Applications, 7th ed. Pearson.
3. Singh, A. K. (2006). Tests, Measurements and Research Methods in Behavioural Sciences. Bharati Bhavan, Patna.
4. Anastasi, A. and Urbina, S. (1997). Psychological Testing, 7th ed. Prentice Hall, Upper Saddle River.

Programme/Class: **B.Sc. (Hons.)**	Year: **Third**	Semester: **Sixth**
Subject: **STATISTICS (MNGEC)**		
Course Code: -	Course Title: **Linear Algebra**	

Course outcomes:

After completing this course, a student will be able to:

- ✓ Explain abstract vector spaces, subspaces, span, linear independence, basis and dimension.
- ✓ Understand linear transformations, their matrix representation, and the rank–nullity theorem.
- ✓ Work with inner product spaces, orthogonality and the Gram–Schmidt orthogonalization process.
- ✓ Diagonalize matrices and obtain the spectral decomposition of real symmetric matrices.
- ✓ Compute and apply the generalized (Moore–Penrose) inverse, including its use in statistics.
- ✓ Classify and reduce quadratic forms to canonical form.

Credits: **04**	**MNGEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Vector Space:** Vector and vector space, subspace (definitions and examples); sum and direct sum of subspaces; linear span; dependence and independence set of vectors with related theorems; basis of a subspace and dimension; coordinates of a vector; standard theorems on basis and dimension.	15
II	**Linear Transformations & Generalized Inverse:** Linear transformations; kernel and image; rank and nullity; rank–nullity theorem; matrix representation of a linear transformation. Generalized inverse: definition, existence, Moore–Penrose inverse and its properties; application to solving linear systems.	15
III	**Diagonalization and Canonical Forms:** Characteristic subspaces of a matrix, rank multiplicity theorem, algebraic and geometric multiplicity, minimal polynomial, similarity of matrices, diagonalizable matrix, Jordan canonical form, orthogonal diagonalization of real symmetric matrices (spectral theorem).	15
IV	**Quadratic Forms:** Quadratic forms, Congruence of quadratic forms, Canonical form, Definite, semi-definite and indefinite quadratic forms, Orthogonal reduction of a real symmetric matrix, Simultaneous reduction of a pair of quadratic forms	15

Suggested Readings:

1. Bapat, R. B. (2012). Linear algebra and linear models 3rd Ed. Hindustan Book Agency.
2. Searle, S. R., and Khuri, A. I. (2017). Matrix Algebra Useful for Statistics, 2nd Ed., John Wiley & Sons, Hoboken, NJ.
3. Rao, C. R., and Mitra, S. K. (1971). Generalized Inverse of Matrices and Its Applications, John Wiley & Sons, New York.
4. Krishnamurthy, V., Mainra, V. P., and Arora, J. L. (2015). An Introduction to Linear Algebra, East-West Press Pvt. Ltd., New Delhi.
5. Vasishtha, A. R., and Vasishtha, A. K. (2019). Matrices, Krishna Prakashan Media, Meerut.

Without Research

Programme/Class: **B.Sc. (Hons.) (Without Research)**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Advanced Probability Theory & Measure**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts of measure, probability measure, conditional probability, and independence.
- ✓ Understand random variables, distribution functions, expectation, and generating functions.
- ✓ Apply important probability inequalities such as Markov's, Chebyshev's, Jensen's, and Kolmogorov's inequalities.
- ✓ Understand different modes of convergence of random variables.
- ✓ Apply laws of large numbers and central limit theorems in probability theory.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Sequence of Sets, Lim_sup & Lim_inf of Sequence of Sets, Measure, Probability Measure, Conditional Probability, Bayes Theorem and Independent Events. Monotone classes, Measurable functions & properties, Lebseque measure	**15**
II	Random Variables, Distribution Function of Random Variables, Joint distribution of two Random Variables, Marginal & Conditional Distributions, Expectation, Moment Generating Function, Probability Generating function, Characteristic Functions & their properties, Uniqueness, Inversion & Continuity Theorems of Characteristic Function.	**15**
III	Chebychev's, Markov's, Basic, Kolmogorov's, Jenson's Inequalities. Three Series Criterion, Borel Zero-One Law, Schwartz inequality. Convergence of Sequences of Random Variables, Convergence in Distribution, Convergence in Probability, rth mean and Almost Sure, Borel-Cantelli Lemma	**15**
IV	Weak Law & Strong Law of Large Numbers for iid sequences, Bernoulli's, Khintchine's Theorems of Large Numbers, CLT for Sequence of Independent Random Variables under Lindeberg's & Liaounoff's Conditions, and CLT for iid Random Variables.	**15**

Suggested Readings:

1. Rohatgi, V. K., and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.
2. Hogg, R. V., McKean, J. W., and Craig, A. T. (2019). Introduction to Mathematical Statistics, 8th Ed., Pearson Education, Boston, MA.
3. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Ed., Books and Allied (P) Ltd., Kolkata.
4. Bhat, B. R. (2019). Modern Probability Theory: An Introductory Textbook, 4th Ed., New Age International Publishers, New Delhi.
5. Billingsley, P. (2012). Probability and Measure, Anniversary Ed., John Wiley & Sons, Hoboken, NJ.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Advanced Sampling Techniques**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts, principles, steps, and errors in sample surveys.
- ✓ Apply simple random sampling for estimation of population mean, total, and attributes.
- ✓ Use stratified and systematic sampling methods for suitable survey situations.
- ✓ Apply ratio, regression, and cluster sampling methods for population estimation.
- ✓ Understand PPS, multistage, and multiphase sampling techniques and their applications.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Introduction: Census and sample surveys, advantages and disadvantages of sample surveys, Limitations of sampling, Basic principles of sample survey, Principle steps in sample survey, Sampling and non-sampling errors, Inter-penetrating, Sub-samples, Pilot survey. Simple Random Sampling: Simple random sampling, Sampling from finite populations with and without replacement, Unbiased estimation and confidence intervals for population mean and total, Simple random sampling of attributes.	15
II	Stratified Random Sampling: Reasons for stratification, choice of strata, choice of sampling unit, stratified random sampling, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata. Systematic Sampling: Estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling.	15
III	Ratio and Regression Estimation: Ratio and regression methods of estimation, variances of the estimates, optimum property of ratio estimates, comparison among ratio and regression and simple and biased estimates. Cluster Sampling: Estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intra-class correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance.	15
IV	PPS Sampling: Sampling techniques with varying probabilities for simple random sampling with and without replacement. Herwits Thompson Estimator, Mid Zuno Sen Sampling Scheme. Multistage and Multiphase Sampling: Introduction of Multistage sampling, Two stage sampling with equal stage units, Estimation of its mean and variance, Introduction of Multiphase sampling, double sampling for stratification.	15

Suggested Readings:

1. Cochran, W. G. (1977). Sampling Techniques, 3rd Ed., John Wiley & Sons, New York.
2. Singh, D., and Chaudhary, F. S. (2020). Theory and Analysis of Sample Survey Designs, 2nd Ed., New Age International Publishers, New Delhi.
3. Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., and Asok, C. (1984). Sampling Theory of Surveys with Applications, 3rd Ed., Iowa State University Press, Ames, IA, and Indian Society of Agricultural Statistics, New Delhi.
4. Murthy, M. N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
5. Des Raj, and Chandhok, P. (1998). Sample Survey Theory, Narosa Publishing House, New Delhi.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Practical**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understanding of Data Analysis and Distributions fitting.
- ✓ Draw samples and estimate population parameters using simple random sampling.
- ✓ Apply stratified, systematic, ratio, regression and cluster sampling methods.
- ✓ Use PPS, multistage and multiphase sampling techniques for practical survey problems.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-8.**

	Topic	**No. of Lectures**
	Practicals based on Theory Courses Taught in this semester.	120

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Statistical Distributions & Order Statistics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand important discrete and continuous probability distributions and their properties.
- ✓ Calculate mean, variance, moments, generating functions and mode of different distributions.
- ✓ Understand truncated, compound and limiting forms of probability distributions.
- ✓ Apply bivariate normal distribution and sampling distributions in statistical problems.
- ✓ Understand order statistics, sample range, sample median and distributions of minimum and maximum observations.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Study with examples and applications of uniform, Binomial, Poisson and Geometric distributions. Their means, variances, measures of skewness, characteristic functions, moment and probability generating functions, rth descending factorial moments and mode. The various important properties with their proofs related to these distributions including truncated and compound.	15
II	Generations and applications of Negative Binomial, Multinomial and hyper geometric distributions. Their characteristic functions, moment and probability generating functions and descending factorial moment. Mean vectors, variance covariance matrix, marginal and conditional distributions of multinomial. Limiting compound and mode of negative binomial and hyper-geometric distributions. Theory of exceedency of hyper-geometric distribution. Distributions of rectangular, exponential and Gamma with their properties including proofs. Their mean, variance and characteristic functions.	15
III	Distributions of Weibull, Beta, Cauchy and Log normal with their properties including proofs. Their mean, variance and characteristic functions. The characterizations related to rectangular, exponential, Gamma, Weibull, Beta, Cauchy and Log normal distributions along with their truncated and compound. Bivariate normal distribution with its applications and important properties. Standard bivariate normal distribution. Development of the formula of recurrence relation for moments and other important related problems to this distribution.	15
IV	Sampling distributions of mean and variance, student's t, χ^2, F and sample correlation coefficient (r) when population correlation is zero. Their means, variances, measures of skewness, characteristic and moment generating functions, limiting distributions and important properties with their proofs. Distributions of order statistics, sample range, sample median, joint distributions	15

	of rth and sth order statistics. Distributions of minimum and maximum observations.	

Suggested Readings:

1. David, H. A., and Nagaraja, H. N. (2003). Order Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.
2. Arnold, B. C., Balakrishnan, N., and Nagaraja, H. N. (2008). A First Course in Order Statistics, Classics in Applied Mathematics Series, SIAM, Philadelphia, PA.
3. Ahsanullah, M., Nevzorov, V. B., and Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. 3, Atlantis Press, Paris.
4. Johnson, N. L., Kemp, A. W., and Kotz, S. (2005). Univariate Discrete Distributions, 3rd Ed., John Wiley & Sons, Hoboken, NJ.
5. Johnson, N. L., Kotz, S., and Balakrishnan, N. (1994, 1995). Continuous Univariate Distributions, Vols. 1 and 2, 2nd Ed., John Wiley & Sons, New York.
6. Rohatgi, V. K., and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Reliability Theory**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understanding of basic concepts of reliability, availability, hazard rate and failure rate models.
- ✓ Knowledge of common failure laws and their use in reliability analysis.
- ✓ Ability to analyze reliability of different system configurations such as series, parallel and k-out-of-n systems.
- ✓ Understanding of redundancy, standby systems, repair and preventive maintenance.
- ✓ Ability to study reliability and MTSF of repairable and redundant systems.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Basic Concepts and Failure Models** Concepts of reliability, point-wise and steady-state availabilities, hazard rate, failure and bath-tub failure rate curve. Constant, linearly increasing and non-linear increasing hazard models. Gamma, normal, log-normal and truncated normal failure laws.	15
II	**System Reliability and Redundancy** Mean time to system failure (MTSF) and mean time between failures. Series, parallel, k-out-of-n, series-parallel, parallel-series, and non-series parallel configurations. Concept of redundancy, comparison of component, unit and standby redundancies.	15
III	**Standby Redundancy and Repair Concepts** Analysis of reliability and MTSF of n-unit standby redundancy. Concepts of repair and preventive maintenance (P.M.). Analysis of n-non-identical unit series system with constant failure and repair rates.	15
IV	**Repairable and Redundant Systems** Two identical unit active and passive redundant systems with constant failure and repair rates. Concepts of imperfect switching device, priority and non-priority repairs, preemptive repeat and preemptive resume repairs.	15

Suggested Readings:

1. Barlow, R. E., and Proschan, F. (1996). Mathematical Theory of Reliability, Classics in Applied Mathematics Series No. 17, SIAM, Philadelphia, PA.
2. Srinath, L. S. (2005). Reliability Engineering, 4th Ed., Affiliated East-West Press Pvt. Ltd., New Delhi.
3. Balagurusamy, E. (2017). Reliability Engineering, McGraw Hill Education (India), New Delhi.
4. Govil, A. K. (1983). Reliability Engineering, Tata McGraw-Hill Publishing Company, New Delhi.
5. Medhi, J. (2009). Stochastic Processes, 3rd Ed., New Age International Publishers, New Delhi.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Environmental Statistics**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of the role of statistics in environmental science.
- ✓ Understanding of environmental sampling and monitoring methods.
- ✓ Ability to apply statistical models, ANOVA, control charts, and chi-square tests to environmental data.
- ✓ Knowledge of time series and spatial data analysis in environmental studies.
- ✓ Understanding of censored data and basic risk assessment methods.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	**Introduction:** The Role of Statistics in Environmental Science: Introduction, Examples, Base-line, Targeted, Regular monitoring, Role of Statistics in Environmental Science. Environmental Sampling: Introduction, Sampling Procedures, Sampling in the wild	15
II	**Models for Data and Environmental Monitoring:** Models for Data: Statistical models, Discrete statistical distribution, Continuous statistical distributions, Linear Models, ANOVA. **Environmental Monitoring:** Detection of changes by ANOVA, Detection of changes using control chart, Chi-squared tests for a change in a distribution.	15
III	**Time Series and Spatial-Data Analysis:** Introduction to Time Series Analysis, Components of Time Series, Serial correlation. Introduction to Spatial-Data Analysis, Types of spatial data, Spatial patterns in quadrant counts, and Correlation between quadrant counts.	15
IV	**Censored Data and Risk Assessment:** Introduction to Censored Data, Single sample estimation, Types of censoring. Introduction to Risk Assessment, Principles for Monte Carlo Risk Assessment, Risk Analysis using spreadsheet.	15

Suggested Readings:

1. Manly, B. F. J. (2009). Statistics for Environmental Science and Management, 2nd Ed., Chapman & Hall/CRC, Boca Raton, FL.
2. Barnett, V. (2004). Environmental Statistics: Methods and Applications, John Wiley & Sons, Chichester, UK.
3. Millard, S. P., and Neerchal, N. K. (2001). Environmental Statistics with S-PLUS, CRC Press, Boca Raton, FL.
4. Gilbert, R. O. (1987). Statistical Methods for Environmental Pollution Monitoring, John Wiley & Sons, New York.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Research Methodology**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic understanding of research, its objectives, types, methodology and research process.
- ✓ Knowledge of synopsis writing, project proposal, project report, thesis writing and research paper writing.
- ✓ Understanding of citation styles, reference writing, bibliography preparation and plagiarism-related issues.
- ✓ Awareness of Intellectual Property Rights, research ethics, publication ethics and academic integrity.
- ✓ Knowledge of citation indices, impact factor, h-index, i-10 index, peer-reviewed journals, open access journals and major research databases

Credits: **04**	**Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Perception and Definition of Research, Objectives and Motivations of Research, Importance of Research, Types of Research, Research Methods versus Methodology, Process of Research, Review of Literature, Formulation of the Research Problem, Sources and Identification of a Research Problem, Status of the Research Problem, Formulation of Hypothesis, Research Design.	15
II	Outlines of Synopsis, Project Proposal, Project Report Writing; Research Paper Writing, Components of Research Reports, Thesis Writing; Outlines of Thesis, Reference citing, Formats of Writing References, Bibliography; Plagiarism.	15
III	Intellectual Property (IP), Intellectual Property Rights (IPR), Intellectual Property Law, Different fields of Intellectual Property Rights, Patents, Publication Ethics: Definitions, importance, Conflicts of Interest, Publications Misconduct Definition, Concept, Problems that lead to Unethical Behavior and vice versa, Types Identification of publication misconduct, Complaints and Appeals; Violation of publication ethics, Authorship and Contributorship; Predatory Publishers and Journals, FFP, COPE/WAME	15
IV	Subject Classification Index, Citation, Citation Index, Impact Factor, h-index, i-10index, INFLIBNET, Introduction to Peer Reviewed and Open Access Journals, e-Journals, e-Library, Research Databases, Institute for Scientific Information (ISI) & Journal Citation Reports, Science Citation Index (SCI), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (AHCI), Databases: UGC care list, Web of Science (WoS), Scopus.	15

Suggested Readings:

1. Kothari, C. R. (2004). Research Methodology: Methods and Techniques (Second Revised Edition). New Age International.
2. Kumar, R. (2011). Research Methodology: A Step-by-Step Guide for Beginners (3rd Edition). SAGE Publications.
3. Creswell, J. W. (2018). Research Design: Qualitative, Quantitative and Mixed Methods Approaches. SAGE Publications.
4. Gupta, S. (n.d.). Research Methodology: Methods and Statistical Techniques. Deep & Deep Publications.
5. Gupta, S. P. (2014). Statistical Methods. Sultan Chand & Sons.
6. Melville, S., & Goddard, W. (n.d.). Research Methodology: An Introduction (2nd Edition). Juta Academic.
7. Shortis, T. (n.d.). The Language of ICT: Information and Communication Technology. Taylor & Francis.
8. UGC. (2019). Research and Publication Ethics. University Grants Commission.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Designs of Experiments**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts of linear estimation theory and Gauss-Markov set-up.
- ✓ Apply least square estimation, normal equations, BLUE, and related results in linear models.
- ✓ Perform analysis of variance and covariance for different experimental layouts.
- ✓ Understand and analyze basic experimental designs.
- ✓ Analyze factorial experiments, confounding, and balanced incomplete block designs under fixed effect models.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Linear Estimation Theory:** Linear Estimation, Gauss-Markov set-up, Random & Mixed Models, Error & Estimation Space, Gauss-Markov Theorem, Least Square Estimates, Normal Equations, Residual Sum of Squares, BLUE, Conditions for Quadratic forms to be Chi-Square distributed, and Cochran's Theorems.	**16**
II	**Design of Experiments** Analysis of Variance, One-way ANOVA, Two-way ANOVA and Three-way ANOVA with their layout and statistical analysis, Analysis of Covariance for a one-way layout with one concomitant variable, Analysis of Covariance for a RBD layout with one concomitant variable.	**16**
III	Principles of design of experiments, Uniformity trials, completely randomized, Randomized block and Latin square designs including missing plot techniques and their efficiency comparison, Split plot and strip plot designs	**14**
IV	Factorial experiments (2^n, 3^2, 3^3 systems only), Complete and Partial confounding, balanced incomplete block designs with parametric relations and analysis under a fixed effect model.	**14**

Suggested Readings:

1. Bapat, R. B. (2012). Linear Algebra and Linear Models, 3rd Ed., Springer, London, jointly published with Hindustan Book Agency, New Delhi.
2. Das, M. N., and Giri, N. C. (2017). Design and Analysis of Experiments, 2nd Ed., New Age International Publishers, New Delhi.
3. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2002). Fundamentals of Statistics, Vol. II, 8th Ed., The World Press Pvt. Ltd., Kolkata.
4. Cochran, W. G., and Cox, G. M. (1957). Experimental Designs, 2nd Ed., John Wiley & Sons, New York.
5. Montgomery, D. C. (2019). Design and Analysis of Experiments, 10th Ed., John Wiley & Sons, Hoboken, NJ.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Parametric Inference**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the main properties of good estimators.
- ✓ Apply important results such as Cramer-Rao inequality, Rao-Blackwell theorem and Lehmann-Scheffe theorem.
- ✓ Use different methods of point estimation.
- ✓ Construct confidence intervals for different distributions.
- ✓ Apply basic and advanced tests of statistical hypotheses.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Properties of good estimators:** consistency, unbiasedness, efficiency, sufficiency and completeness, minimal sufficiency, Crammer Rao-Inequality its applications and examples, Characterization of distribution admitting sufficient statistics, Rao-Blackwell theorem and Lehman-Scheffe' theorem, Uniformly minimum variance unbiased estimation. Exponential and Pitman family of distributions.	15
II	**Methods of Point Estimation**: Method of maximum likelihood, Moments, Minimum Chi-Square, properties of M.L.E, existence of a best asymptotically normal estimate under regulatory conditions, Hazor Bazar theorem.	15
III	**Interval Estimation:** Confidence Regions, Best Confidence Intervals, Shortest Confidence Intervals, General Method of finding Confidence Interval, Tolerance confidence interval and Relationship with the Testing of Hypothesis. Examples based on Normal, Poisson, Exponential and Gamma distributions.	15
IV	**Testing of Statistical Hypothesis**: Simple & Composite Hypothesis, Concept of Critical Regions, Test Functions, Two Types of Error, Power of the Test, Level of Significance, Neyman-Pearson Lemma & its Generalization, Uniformly Most Powerful Tests, UMP Test of One-sided Hypothesis for Distributions with Monotone Likelihood Ratio Test, Randomized Tests, UMPU, Types A, A1 Critical Regions, Likelihood Ratio Test, Similar Test.	15

Suggested Readings:

1. Lehmann, E. L., and Casella, G. (1998). Theory of Point Estimation, 2nd Ed., Springer, New York.
2. Lehmann, E. L., and Romano, J. P. (2022). Testing Statistical Hypotheses, 4th Ed., Springer, Cham, Switzerland.
3. Rohatgi, V. K., and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.

4. Hogg, R. V., McKean, J. W., and Craig, A. T. (2019). Introduction to Mathematical Statistics, 8th Ed., Pearson Education, Boston, MA.
5. Kale, B. K., and Muralidharan, K. (2015). Parametric Inference: An Introduction, 2nd Ed., Narosa Publishing House, New Delhi.
6. Casella, G., and Berger, R. L. (2002). Statistical Inference, 2nd Ed., Duxbury/Thomson Learning, Pacific Grove, CA.
7. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2003). An Outline of Statistical Theory, Vol. II, 3rd Ed., The World Press Pvt. Ltd., Kolkata.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Practical**	

Course outcomes:

After completing this course a student will have:

- ✓ Apply estimation and testing methods to practical problems.
- ✓ Construct confidence intervals for different distributions.
- ✓ Analyze data using ANOVA and ANCOVA.
- ✓ Apply CRD, RBD, LSD and factorial designs.
- ✓ Interpret results from statistical inference and experimental design problems.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-8**.

	Topic	No. of Hours
	• Problems based on point estimation and confidence intervals. • Problems based on testing of hypotheses, Neyman-Pearson lemma and likelihood ratio test. • Problems based on linear estimation, least square estimates and BLUE. • Problems based on ANOVA and ANCOVA. • Problems based on CRD, RBD, LSD, factorial experiments and BIBD.	120

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Fourth**	Semester: **Eighth**

Subject: **STATISTICS (MJDSEC)**

Course Code: -	Course Title: **Advanced Operations Research**

Course outcomes:

After completing this course, a student will have:

- ✓ Understanding of inventory control models and their applications.
- ✓ Ability to analyze basic and advanced queueing models.
- ✓ Knowledge of integer programming, sequencing and replacement problems.
- ✓ Ability to apply CPM and PERT techniques in project management.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Inventory Control: Problems of inventory and the various costs associated with inventory control. EOQ models with uniform/non-uniform rate of demands when shortages are allowed and not allowed while the replenishment of inventory is instantaneous. EOQ models with uniform rate of demands when shortages are allowed/not allowed and replenishment of the inventory is non-instantaneous. Single period inventory models with no set up cost and demand rate is discrete/continuous r.v. Newspaper Boy problem.	15
II	Queueing Theory: Introduction of the queuing system, Various components of a queueing system. Pure Birth Process; Pure Death Process, Birth and Death Process, M/M/1 , M/M/1 (Generalized), M/M/1 FCFS/K/∞, M/M/C, Ample Server models, Erlang's loss model, Machine repair problem.	15
III	Integer Linear Programming: Concept of integer linear programming problems, Gomory's all IPP techniques, Branch and Bound method for solving IPP, Applications of IPP. Job Sequencing: Assumptions, Solution of sequencing problems, Processing n jobs through two machines, Processing n jobs through three machines, Processing two jobs through n-machines, Processing n-jobs through n-machines. Replacement Problem: Replacement policy of items whose maintenance cost increases with time constant and varying scrap value.	15
IV	CPM-PERT: Development of CPM/PERT techniques, events and activities, application of CPM/PERT techniques. Network diagram representation, rules for drawing Network diagram, Critical Path Analysis, Project evaluation and review technique (PERT).Updating of the project, resource allocation.	15

Suggested Readings:

1. Taha, H. A. (2022). Operations Research: An Introduction, 11th Ed., Pearson Education, Hoboken, NJ.

2. Shortle, J. F., Thompson, J. M., Gross, D., and Harris, C. M. (2018). Fundamentals of Queueing Theory, 5th Ed., John Wiley & Sons, Hoboken, NJ.
3. Hillier, F. S., and Lieberman, G. J. (2021). Introduction to Operations Research, 11th Ed., McGraw-Hill Education, New York.
4. Sharma, J. K. (2024). Operations Research: Theory and Applications, 7th Ed., Trinity Press, New Delhi.
5. Swarup, K., Gupta, P. K., and Man Mohan (2019). Operations Research, 20th Ed., Sultan Chand & Sons, New Delhi.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Fourth**	Semester: **Eighth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Biostatistics**	

Course outcomes:

After completing this course, a student will be able to:

- ✓ Understand basic concepts of biostatistics and medical data.
- ✓ Study association between disease and risk factors.
- ✓ Understand censoring and basic survival analysis methods.
- ✓ Apply simple survival and epidemic models in health studies.
- ✓ Understand basic concepts of statistical genetics.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Medical Data and Clinical Studies** Types of medical studies: prospective, retrospective and cross-sectional studies. Association between disease and risk factors, 2×2 tables, relative risk, odds ratio, sensitivity, specificity and predictive values. Introduction to clinical trials and their phases.	15
II	**Survival Analysis** Time-to-event data, censoring and its types. Survival function and hazard function. Common survival distributions: exponential, Weibull and lognormal. Life table method, Kaplan-Meier estimate and median survival time.	15
III	**Survival and Epidemic Models** Basic idea of Cox proportional hazards model. Estimation and interpretation of survival and hazard functions. Simple epidemic model, general epidemic model and duration of an epidemic.	15
IV	**Statistical Genetics** Basic concepts: genotype, phenotype, dominance, recessiveness, linkage and recombination. Mendelian laws of heredity, random mating, gene frequency and genotype frequency. Hardy-Weinberg law and its applications.	15

Suggested Readings:

1. Biswas, S. (2007). Applied Stochastic Processes: A Biostatistical and Population Oriented Approach. 2nd ed., New Central Book Agency, Kolkata.
2. Indrayan, A. (2008). Medical Biostatistics. 2nd ed., Chapman and Hall/CRC, Boca Raton.
3. Lee, E. T. and Wang, J. W. (2003). Statistical Methods for Survival Data Analysis. 3rd ed., John Wiley & Sons, Hoboken.
4. Narain, P. (1990). Statistical Genetics. Wiley Eastern Limited, New Delhi.
5. Miller, R. G. Jr. (2011). Survival Analysis. 2nd Edition, Wiley Classics Library, John Wiley & Sons, Hoboken

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Fourth**	Semester: **Eighth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Laplace Transform & Linear Difference Equations**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts and properties of Laplace transforms.
- ✓ Find inverse Laplace transforms and apply them to solve ordinary differential equations.
- ✓ Understand first-order and higher-order linear difference equations.
- ✓ Solve linear difference equations using standard methods and Z-transform.
- ✓ Apply transform methods and difference equations to simple mathematical and statistical problems.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Laplace Transform and Basic Properties** Definition of Laplace transform, existence conditions, Laplace transforms of standard functions. Linearity property, change of scale property, first and second shifting theorems. Laplace transform of derivatives and integrals. Multiplication by t^n, division by t, and simple examples.	15
II	**Inverse Laplace Transform and Applications** Inverse Laplace transform and its properties. Inverse Laplace transform by partial fractions. Convolution theorem, initial and final value theorems. Heaviside unit step function. Applications of Laplace transform to solve ordinary differential equations with constant coefficients.	15
III	**Linear Difference Equations:** Basic concepts, formation of difference equations, first-order and second-order linear difference equations, homogeneous and non-homogeneous difference equations with constant coefficients.	15
IV	**Z-Transform and Applications:** Z-transform and inverse Z-transform of elementary functions, shifting theorem, convolution theorem, initial and final value theorem, solution of linear difference equations using Z-transform.	15

Suggested Readings:

1. Debnath, L. and Bhatta, D. (2015). Integral Transforms and Their Applications. 3rd Edition, Chapman and Hall/CRC, Boca Raton.
2. Spiegel, M. R. (1965). Schaum's Outline of Theory and Problems of Laplace Transforms. McGraw-Hill, New York.
3. Elaydi, S. (2005). An Introduction to Difference Equations. 3rd Edition, Springer, New York.
4. Kreyszig, E. (2011). Advanced Engineering Mathematics. 10th Edition, John Wiley & Sons, Hoboken.
5. Grewal, B. S. Higher Engineering Mathematics. Khanna Publishers, New Delhi.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Fourth**	Semester: **Eighth**
Subject: **STATISTICS (MJDSEC)**		
Course Code: -	Course Title: **Stochastic Processes**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic knowledge of stochastic processes and stationary processes.
- ✓ Understanding of generating functions and probability generating functions.
- ✓ Knowledge of Markov chains, transition probabilities, and classification of states.
- ✓ Understanding of Poisson process, birth-death process, and related models.
- ✓ Ability to understand gambler's ruin problem and renewal theory

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Stochastic Processes: Introduction, classification according to state space and time domain. Countable state Markov chains, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities and their limits, stationary distribution.	15
II	Branching Processes: Properties of generating function of branching processes, probability of ultimate extinction, distribution of the total number of progeny, generalization of the classical Galton-Watson branching process, general branching processes, random walk and gambler's ruin problem.	15
III	Continuous-time Markov Processes: Poisson process and related distributions, generalizations of Poisson process, simple birth-process, simple death-process, simple birth-death process, linear birth-death process. First passage time distribution.	15
IV	Renewal Theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, central limit theorem for renewals, study of residual and excess lifetime's process. Renewal reward Process, Markov renewal and semi-Markov processes, Markov renewal equations.	15

Suggested Readings:

1. Basu, A.K. (2005). Introduction to Stochastic Processes, Narosa Publishing.
2. Bhat,B.R. (2000). Stochastic Models: Analysis and Applications, New Age International Publishers.
3. Feller, W. (1968). Introduction to probability Theory and Its Applications, Vol I, 3rd Ed., Wiley International.
4. Medhi, J. (2009). Stochastic Processes, New Age International Publishers.
5. Taha, H. (1995). Operations Research: An Introduction, Prentice- Hall India.

Programme/Class: **B.Sc. (Hons.) Without Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Dissertation**	

Course outcomes:

After completing this course, a student will have:

- ✓ Ability to identify and formulate a research problem preferably in Statistics or its applications.
- ✓ Ability to prepare a dissertation and communicate research findings effectively through written reports and presentations.
- ✓ Ability to apply statistical knowledge to address real-world problems related to society, industry, public policy, health, agriculture, environment and sustainable development.

Credits: **04**	**Compulsory**
Max. Marks:	Min. Passing Marks: .....

With Research

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Advanced Probability Theory & Measure**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts of measure, probability measure, conditional probability, and independence.
- ✓ Understand random variables, distribution functions, expectation, and generating functions.
- ✓ Apply important probability inequalities such as Markov's, Chebyshev's, Jensen's, and Kolmogorov's inequalities.
- ✓ Understand different modes of convergence of random variables.
- ✓ Apply laws of large numbers and central limit theorems in probability theory.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0.**

Unit	Topic	No. of Lectures
I	Sequence of Sets, Lim_sup & Lim_inf of Sequence of Sets, Measure, Probability Measure, Conditional Probability, Bayes Theorem and Independent Events. Monotone classes, Measurable functions & properties, Lebseque measure	**15**
II	Random Variables, Distribution Function of Random Variables, Joint distribution of two Random Variables, Marginal & Conditional Distributions, Expectation, Moment Generating Function, Probability Generating function, Characteristic Functions & their properties, Uniqueness, Inversion & Continuity Theorems of Characteristic Function.	**15**
III	Chebychev's, Markov's, Basic, Kolmogorov's, Jenson's Inequalities. Three Series Criterion, Borel Zero-One Law, Schwartz inequality. Convergence of Sequences of Random Variables, Convergence in Distribution, Convergence in Probability, rth mean and Almost Sure, Borel-Cantelli Lemma	**15**
IV	Weak Law & Strong Law of Large Numbers for iid sequences, Bernoulli's, Khintchine's Theorems of Large Numbers, CLT for Sequence of Independent Random Variables under Lindeberg's & Liaounoff's Conditions, and CLT for iid Random Variables.	**15**

Suggested Readings:

1. Rohatgi, V. K., and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.

2. Hogg, R. V., McKean, J. W., and Craig, A. T. (2019). Introduction to Mathematical Statistics, 8th Ed., Pearson Education, Boston, MA.
3. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Ed., Books and Allied (P) Ltd., Kolkata.
4. Bhat, B. R. (2019). Modern Probability Theory: An Introductory Textbook, 4th Ed., New Age International Publishers, New Delhi.
5. Billingsley, P. (2012). Probability and Measure, Anniversary Ed., John Wiley & Sons, Hoboken, NJ.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Advanced Sampling Techniques**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts, principles, steps, and errors in sample surveys.
- ✓ Apply simple random sampling for estimation of population mean, total, and attributes.
- ✓ Use stratified and systematic sampling methods for suitable survey situations.
- ✓ Apply ratio, regression, and cluster sampling methods for population estimation.
- ✓ Understand PPS, multistage, and multiphase sampling techniques and their applications.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Introduction: Census and sample surveys, advantages and disadvantages of sample surveys, Limitations of sampling, Basic principles of sample survey, Principle steps in sample survey, Sampling and non-sampling errors, Inter-penetrating, Sub-samples, Pilot survey. Simple Random Sampling: Simple random sampling, Sampling from finite populations with and without replacement, Unbiased estimation and confidence intervals for population mean and total, Simple random sampling of attributes.	15
II	Stratified Random Sampling: Reasons for stratification, choice of strata, choice of sampling unit, stratified random sampling, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata. Systematic Sampling: Estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling.	15
III	Ratio and Regression Estimation: Ratio and regression methods of estimation, variances of the estimates, optimum property of ratio estimates, comparison among ratio and regression and simple and biased estimates. Cluster Sampling: Estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intra-class correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance.	15
IV	PPS Sampling: Sampling techniques with varying probabilities for simple random sampling with and without replacement. Herwits Thompson Estimator, Mid Zuno Sen Sampling Scheme. Multistage and Multiphase Sampling: Introduction of Multistage sampling, Two stage sampling with equal stage units, Estimation of its mean and variance, Introduction of Multiphase sampling, double sampling for stratification.	15

Suggested Readings:

1. Cochran, W. G. (1977). Sampling Techniques, 3rd Ed., John Wiley & Sons, New York.
2. Singh, D., and Chaudhary, F. S. (2020). Theory and Analysis of Sample Survey Designs, 2nd Ed., New Age International Publishers, New Delhi.
3. Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., and Asok, C. (1984). Sampling Theory of Surveys with Applications, 3rd Ed., Iowa State University Press, Ames, IA, and Indian Society of Agricultural Statistics, New Delhi.
4. Murthy, M. N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
5. Des Raj, and Chandhok, P. (1998). Sample Survey Theory, Narosa Publishing House, New Delhi.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Practical**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understanding of data analysis and distributions fitting.
- ✓ Draw samples and estimate population parameters using simple random sampling.
- ✓ Apply stratified, systematic, ratio, regression and cluster sampling methods.
- ✓ Use PPS, multistage and multiphase sampling techniques for practical survey problems.

Credits: **04**	**MJDSEC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-8**.

Unit	Topic	No. of Lectures
I	Practicals based on Theory Courses Taught in this semester.	120

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: Four	Semester: Seventh
Subject: **STATISTICS**		
Course Code: -	Course Title: **Research Methodology**	

Course outcomes:

After completing this course, a student will have:

- ✓ Basic understanding of research, its objectives, types, methodology and research process.
- ✓ Knowledge of synopsis writing, project proposal, project report, thesis writing and research paper writing.
- ✓ Understanding of citation styles, reference writing, bibliography preparation and plagiarism-related issues.
- ✓ Awareness of Intellectual Property Rights, research ethics, publication ethics and academic integrity.
- ✓ Knowledge of citation indices, impact factor, h-index, i-10 index, peer-reviewed journals, open access journals and major research databases

Credits: **04**	**Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	Perception and Definition of Research, Objectives and Motivations of Research, Importance of Research, Types of Research, Research Methods versus Methodology, Process of Research, Review of Literature, Formulation of the Research Problem, Sources and Identification of a Research Problem, Status of the Research Problem, Formulation of Hypothesis, Research Design.	15
II	Outlines of Synopsis, Project Proposal, Project Report Writing; Research Paper Writing, Components of Research Reports, Thesis Writing; Outlines of Thesis, Reference citing, Formats of Writing References, Bibliography; Plagiarism.	15
III	Intellectual Property (IP), Intellectual Property Rights (IPR), Intellectual Property Law, Different fields of Intellectual Property Rights, Patents, Publication Ethics: Definitions, importance, Conflicts of Interest, Publications Misconduct Definition, Concept, Problems that lead to Unethical Behavior and vice versa, Types Identification of publication misconduct, Complaints and Appeals; Violation of publication ethics, Authorship and Contributorship; Predatory Publishers and Journals, FFP, COPE/WAME	15
IV	Subject Classification Index, Citation, Citation Index, Impact Factor, h-index, i-10index, INFLIBNET, Introduction to Peer Reviewed and Open Access Journals, e-Journals, e-Library, Research Databases, Institute for Scientific Information (ISI) & Journal Citation Reports, Science Citation Index (SCI), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (AHCI), Databases: UGC care list, Web of Science (WoS), Scopus.	15

Suggested Readings:

1. Kothari, C. R. (2004). Research Methodology: Methods and Techniques (Second Revised Edition). New Age International.
2. Kumar, R. (2011). Research Methodology: A Step-by-Step Guide for Beginners (3rd Edition). SAGE Publications.
3. Creswell, J. W. (2018). Research Design: Qualitative, Quantitative and Mixed Methods Approaches. SAGE Publications.
4. Gupta, S. (n.d.). Research Methodology: Methods and Statistical Techniques. Deep & Deep Publications.
5. Gupta, S. P. (2014). Statistical Methods. Sultan Chand & Sons.
6. Melville, S., & Goddard, W. (n.d.). Research Methodology: An Introduction (2nd Edition). Juta Academic.
7. Shortis, T. (n.d.). The Language of ICT: Information and Communication Technology. Taylor & Francis.
8. UGC. (2019). Research and Publication Ethics. University Grants Commission.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Seventh**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Dissertation**	

Course outcomes:

After completing this course, a student will have:

- ✓ Ability to identify and formulate a research problem preferably in Statistics or its applications.
- ✓ Ability to prepare a dissertation and communicate research findings effectively through written reports and presentations.
- ✓ Ability to apply statistical knowledge to address real-world problems related to society, industry, public policy, health, agriculture, environment and sustainable development.

Credits: **04**	**Compulsory**
Max. Marks:	Min. Passing Marks: .....

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Designs of Experiments**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the basic concepts of linear estimation theory and Gauss-Markov set-up.
- ✓ Apply least square estimation, normal equations, BLUE, and related results in linear models.
- ✓ Perform analysis of variance and covariance for different experimental layouts.
- ✓ Understand and analyze basic experimental designs.
- ✓ Analyze factorial experiments, confounding, and balanced incomplete block designs under fixed effect models.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Linear Estimation Theory:** Linear Estimation, Gauss-Markov set-up, Random & Mixed Models, Error & Estimation Space, Gauss-Markov Theorem, Least Square Estimates, Normal Equations, Residual Sum of Squares, BLUE, Conditions for Quadratic forms to be Chi-Square distributed, and Cochran's Theorems.	**16**
II	**Design of Experiments** Analysis of Variance, One-way ANOVA, Two-way ANOVA and Three-way ANOVA with their layout and statistical analysis, Analysis of Covariance for a one-way layout with one concomitant variable, Analysis of Covariance for a RBD layout with one concomitant variable.	**16**
III	Principles of design of experiments, Uniformity trials, completely randomized, Randomized block and Latin square designs including missing plot techniques and their efficiency comparison, Split plot and strip plot designs	**14**
IV	Factorial experiments (2^n, 3^2, 3^3 systems only), Complete and Partial confounding, balanced incomplete block designs with parametric relations and analysis under a fixed effect model.	**14**

Suggested Readings:

1. Bapat, R. B. (2012). Linear Algebra and Linear Models, 3rd Ed., Springer, London, jointly published with Hindustan Book Agency, New Delhi.
2. Das, M. N., and Giri, N. C. (2017). Design and Analysis of Experiments, 2nd Ed., New Age International Publishers, New Delhi.
3. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2002). Fundamentals of Statistics, Vol. II, 8th Ed., The World Press Pvt. Ltd., Kolkata.
4. Cochran, W. G., and Cox, G. M. (1957). Experimental Designs, 2nd Ed., John Wiley & Sons, New York.
5. Montgomery, D. C. (2019). Design and Analysis of Experiments, 10th Ed., John Wiley & Sons, Hoboken, NJ.Winer, B. J. (1971). Statistical Principles in Experimental Design, 2nd ed. McGraw-Hill, New York.
6. Federer, W. T. (1955). Experimental Design: Theory and Application. Macmillan Company, New York.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Parametric Inference**	

Course outcomes:

After completing this course, a student will have:

- ✓ Understand the main properties of good estimators.
- ✓ Apply important results such as Cramer-Rao inequality, Rao-Blackwell theorem and Lehmann-Scheffe theorem.
- ✓ Use different methods of point estimation.
- ✓ Construct confidence intervals for different distributions.
- ✓ Apply basic and advanced tests of statistical hypotheses.

Credits: **04**	**MJDSCC**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **4-0-0**.

Unit	Topic	No. of Lectures
I	**Properties of good estimators:** consistency, unbiasedness, efficiency, sufficiency and completeness, minimal sufficiency, Crammer Rao-Inequality its applications and examples, Characterization of distribution admitting sufficient statistics, Rao-Blackwell theorem and Lehman-Scheffe' theorem, Uniformly minimum variance unbiased estimation. Exponential and Pitman family of distributions.	15
II	**Methods of Point Estimation**: Method of maximum likelihood, Moments, Minimum Chi-Square, properties of M.L.E, existence of a best asymptotically normal estimate under regulatory conditions, Hazor Bazar theorem.	15
III	**Interval Estimation:** Confidence Regions, Best Confidence Intervals, Shortest Confidence Intervals, General Method of finding Confidence Interval, Tolerance confidence interval and Relationship with the Testing of Hypothesis. Examples based on Normal, Poisson, Exponential and Gamma distributions.	15
IV	**Testing of Statistical Hypothesis**: Simple & Composite Hypothesis, Concept of Critical Regions, Test Functions, Two Types of Error, Power of the Test, Level of Significance, Neyman-Pearson Lemma & its Generalization, Uniformly Most Powerful Tests, UMP Test of One-sided Hypothesis for Distributions with Monotone Likelihood Ratio Test, Randomized Tests, UMPU, Types A, A1 Critical Regions, Likelihood Ratio Test, Similar Test.	15

Suggested Readings:

1. Lehmann, E. L., and Casella, G. (1998). Theory of Point Estimation, 2nd Ed., Springer, New York.
2. Lehmann, E. L., and Romano, J. P. (2022). Testing Statistical Hypotheses, 4th Ed., Springer, Cham, Switzerland.
3. Rohatgi, V. K., and Saleh, A. K. Md. E. (2015). An Introduction to Probability and Statistics, 3rd Ed., John Wiley & Sons, Hoboken, NJ.

4. Hogg, R. V., McKean, J. W., and Craig, A. T. (2019). Introduction to Mathematical Statistics, 8th Ed., Pearson Education, Boston, MA.
5. Kale, B. K., and Muralidharan, K. (2015). Parametric Inference: An Introduction, 2nd Ed., Narosa Publishing House, New Delhi.
6. Casella, G., and Berger, R. L. (2002). Statistical Inference, 2nd Ed., Duxbury/Thomson Learning, Pacific Grove, CA.
7. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2003). An Outline of Statistical Theory, Vol. II, 3rd Ed., The World Press Pvt. Ltd., Kolkata.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Third**	Semester: **Eighth**
Subject: **STATISTICS (MJDSCC)**		
Course Code: -	Course Title: **Practical**	

Course outcomes:

After completing this course a student will have:

- ✓ Apply estimation and testing methods to practical problems.
- ✓ Construct confidence intervals for different distributions.
- ✓ Analyze data using ANOVA and ANCOVA.
- ✓ Apply CRD, RBD, LSD and factorial designs.
- ✓ Interpret results from statistical inference and experimental design problems.

Credits: **04**	Core: **Compulsory**
Max. Marks:	Min. Passing Marks: .....

Total No. of Lectures-Tutorials-Practical (in hours per week): **0-0-8**.

	Topic	No. of Hours
	• Problems based on point estimation and confidence intervals. • Problems based on testing of hypotheses, Neyman-Pearson lemma and likelihood ratio test. • Problems based on linear estimation, least square estimates and BLUE. • Problems based on ANOVA and ANCOVA. • Problems based on CRD, RBD, LSD, factorial experiments and BIBD.	120

Suggested Readings:

- As suggested for theory papers.
- Practicals may be done using MS Excel, R and Scientific Calculators.

Programme/Class: **B.Sc. (Hons.) With Research**	Year: **Four**	Semester: **Eighth**
Subject: **STATISTICS**		
Course Code: -	Course Title: **Dissertation**	

Course outcomes:

After completing this course, a student will have:

- ✓ Ability to identify and formulate a research problem preferably in Statistics or its applications.
- ✓ Ability to prepare a dissertation and communicate research findings effectively through written reports and presentations.
- ✓ Ability to apply statistical knowledge to address real-world problems related to society, industry, public policy, health, agriculture, environment and sustainable development.

Credits: **08**	**Compulsory**
Max. Marks:	Min. Passing Marks: .....