Annexure II

Department of Statistics

H.N.B. Garhwal University, Srinagar Garhwal (Uttarakhand)
(A Central University)

Fourth Year (7th and 8th Semester) Bachelors Honours/ Honours with Research Programs along with P G Syllabus Under NEP Framework

STATISTICS SYLLABUS

Academic Session 2025-26 Onwards

Fourth year (U.G. with Honors)

Entry requirement	(After completing requirements of a 3-year bachelor's degree (120 credits) and 2 additional credits under SSD, will be allowed to continue studies in the fourth year Of the under graduate programme leading to the four years bachelor's degree (with Honours).							
Course Type	Semester-VII				Semester-VIII			
	Subject/Title	No. of paper	Credits		Subject /Title	No. of paper	Credits	
			T	P			T	P
Core Major Subject (One)	Core Major -I *Measure Theory and Probability*	1	5		Core Major-I *Sample Surveys*	1	5	
	Core Major – II *Matrices*	1	5		Core Major–II *Statistical inference*	1	5	
	Core Major – III *Real analysis and complex analysis*	1	5		Core Major– III *Linear algebra*	1	5	
	Core Major Elective– I(Chose Any one paper) *Research Methodology* *OR* *Decision theory and Bayesian analysis* *OR* *Distribution theory*	1	2	2	Core Major Elective–I (Chose Any one paper) *Design of experiment* *OR* *Actuarial statistics* *OR* *Financial statistics*	1	2	2
Core Major Practical	Major Practical	1		5	Major Practical	1		5
Minor Subject (One)	Core Minor –I Probability theory and Expectation	1	2	2	Core Minor–I *Basic Sampling Techniques*	1	2	2
Total		6	19	9		6	19	9
Student on exit after successfully completing four years (i.e., securing minimum required 160 credits along with securing additional 2 credits under SSD course work) will be awarded "Four Years Bachelor's Degree (Honours)", in related field/ discipline/subject								

Fourth year (U.G. Honors with Research)

Entry requirement	(After completing requirements of a 3-year bachelor's degree (120 credits) and 2 additional credits under SSD, candidates who meet a minimum CGPA of 7.5 will be allowed to continue studies in the fourth year of the under graduate programme Leading to the four years bachelor's degree (Honours with Research).							
Course Type	Semester-VII				Semester-VIII			
	Subject/Title	No. of paper	Credits		Subject /Title	No. of paper	Credits	
			T	P			T	P
Core Subject (One)	Core Major-I *Measure Theory and Probability*	1	5		Core-I *Sample Surveys*	1	5	
	Core Major-II *Matrices*	1	5					
	Core Major Elective *Real analysis and complex analysis*	1	4		Core Major Elective *Statistical Inference*	1	4	
Core Major Practical	Major Practical	1		5	Major Practical	1		3
Core Course (Research Based)	*Research Methodology*	1	5		*Dissertation*	1	12	
Minor Subject One	Core Minor –I *Probability theory and Expectation*	1	2	2	Core Minor –I *Basic Sampling Technique*	1	2	2
Total		5	21	7		3	23	5

Student on exit after successfully completing four years (i.e., securing minimum required 160 Credits along with securing additional 2 credits under SSD coursework) will be awarded "Four years Bachelor's Degree "Honours with Research", in related field/discipline/subject

U.G Fourth Year - Seventh Semester (For U.G. with Honors)

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VII
Subject: STATISTICS			
Course Title: **Measure Theory and Probability**			
Credits:	T-5	**Core: Core Major I**	

Course Outcome: The aim of the course is to pay a special attention to applicant ions of measure theory in the probability theory and the Central Limit Theorem with their applications. To understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions. To gain the ability to understand the concepts of measurable functions, sequence of random variables, convergence, modes of convergence. To learn the concepts of weak and strong laws of large numbers and central limit theorem.

Syllabus

Measure and integration: Classes of sets, field, sigma fields, minimal sigma fields, Borel sigma fields, Limsup and liminf of a sets, Measure, Probability measure, properties of ameasure, Lebesgue and Lebesgue- Steljes measures, measurable functions.

Probability : Baye's theorem. Random variable. Marginal and conditional distributions,

Expectation. Tehebycheffs inequality and improvements on it, convergence in probability.

The weak law of large numbers Bernoulli's theorem. Convergence in distribution continuity theorem. Khinchin's theorem. Strong law of large numbers Kologorov's theorem, Borel zero-one law, Borel-Cantelli lemma.

Central limit theorem-Lindberg Levy's and liapouneff forms.

Books Recommended:

Goon Gupta and Das Gupta: An outline of Statistical theory, World Press Calcutta, Vol. 1. 6

2. Rohtagi, V.K. and Saleh A.K. (2005): Probability Theory, John Wiley.

3. B.R. Bhat(1985): Modern Probability Theory.

4. Basu, A.K. (2001): Probability and Measure theory, Narosa Pub.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VII
Subject: STATISTICS			
Course Title: **Matrices**			
Credits:	T-5	**Core: Core Major II**	

Course Outcome:

To acquire the knowledge of Matrices, determinants and their operations and their properties, solutions and applications.

Syllabus

Different type of matrices, algebra of matrices, row and column spaces of a matrix,elementary matrices, determinant, singular and non-singular matrices, adjoint of matrix, rankand inverse of matrix, portioned matrices and Kroneker product.

Canonical form, Hermit canonical form, diagonal form, triangular form, Jordan form,quadratic form, generalized inverse, Moore-Penrose generalized inverse, idempotent matrices.

Characteristic roots and vectors, algebraic multiplicity of characteristic roots, CaleyHamilton theorem, spectral decomposition of real symmetric matrix.

Positive, semi positive , negative and semi negative definite matrices, similar matrices

Derivative of determinant.

Books Recommended:

1. Biswas, S, (1984): Topics in Algebra of matrices, Academic Publications.
2. Shanti Narain: A text books of matrices, S. Chand and Company (Pvt) Ltd.
3. Frank Ayres , JR: Schaum's outline series Theory and problems.
4. A.I. Kostrikin, Introduction to Algebra, Springer Verlag, 1984.

S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.

Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VII
Subject: STATISTICS			
Course Title: **Real analysis and Complex Analysis**			
Credits:	T- 5	**Core Major III**	

Course Outcome:

The main objective of this course is to introduce students with the knowledge of real field and complex field with their properties and relativity between complex plane and real line. These properties and relations provide grounds for Probability Theory and help in theoretical research in Statistics.

Syllabus

Real Analysis: Continuity and discontinuity of functions, Differentiability, Roll's theorem, Mean Value theorem, Non differentiable functions, Riemann integration,

Fundamental theorem of integral calculus, convergence of integrals and uniform Convergence.

Complex Analysis: Analytic functions, Conformal representation, complex integration,

Cauchy's Theorem, Morea's Theorem, Taylor's and Laurentts Series, Zero's and Poles of

Functions, theory of Residues and Its application to Contour integration.

Books Recommended:

1. Apostol, T.M. (1975). Mathematical Analysis, Addison- Wesley.
2. Bartle, R.G. (1976). Elements of Real Analysis, John Wiley & Sons.
3. Berbarian, S.K. (1998). Fundamentals of Real Analysis, Springer-Verlag.
4. Conway, J.B. (1978). Functions of one Complex Variable, Springer-Verlag.
5. Priestley, H.A. (1985). Complex Analysis, Clarenton Press Oxford.
6. Rudin, W. (1985). Principles of Mathematical Analysis, McGraw Hill.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VII
Subject: STATISTICS			
Course Title: **Research Methodology**			
Credits:	T- 2/P-2	Core: **Core Major Elective I**	

Course Outcome:

A solid foundation in Statistical Theory and Methodology, will be able to communicate the major tenets of statistics, explain their work orally and identify areas of future research areas.

Syllabus

Foundations of Research: Meaning, Objectives, Motivation, Utility. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical, concept of applied and basic research process, criteria of good research. Analysis of Literature review – Primary and Secondary Sources, Web sources –critical Literature Review. Development of Working Hypothesis, Research Methods: Scientific method vs Arbitrary Method, Logical Scientific Methods: Deductive, Inductive, Deductive Inductive, pattern of Deductive –Inductive logical process – Different types of inductive logical methods. Research methods vs. Methodology.

Research design: Meaning, Need, Features of Good Design and Concepts. Research Design types. Selection of appropriate method for data collection, Case Study, Focus Group Discussion, Techniques of developing research tools, viz. Questionnaire and rating scales etc. Reliability and validity of Research tools. Sample size determination.

Preparation of Project Proposal, Title, Abstract, Introduction, Rationale, Objectives, Methodology, Time frame and work plan, Budget and Justification, References. Ethical Issues, Ethical Committees, Commercialization, copy right, royalty, Intellectual Property rights and patent law, Track Related aspects of intellectual property Rights, Reproduction of published material, Plagiarism, Citation and Acknowledgement, Reproducibility and accountability.

Meaning of Interpretation, Technique of Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation. Writing Research Project Report: Format and style. Review of related literature its implications at various stages of research. (Formulation of research problem, hypothesis, interpretation and discussion of results). Major findings, Conclusions and suggestions. Citation of references and Bibliography.

Books Recommended:

Garg. B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Vol 2, Ess Publication.

Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.

Programme/Class: U.G. with Honours	Year: Fourth	Semester: VII
Subject: STATISTICS		
Course Title: **Decision Theory and Bayesian Analysis**		
Credits: T- 2/P- 2	**Core Major Elective II**	

Course Outcome:

The objective of this course is to provide the understanding of the decision theory and fundamentals of Bayesian inference including concept of subjectivity and priors by examining some simple Bayesian framework.

Syllabus

Decision problem and two person game, Utility theory, loss functions, Randomized and nonrandomized decision rules, Essential completeness and completeness of class of rules based on sufficient statistic and the class of nonrandomized rules for convex loss , Optimal decision rules – unbiasedness, invariance, Bayes Rule, extended Bayes rule, Minimax rule, methods for finding minimax rules, admissibility of decision rules Generalized bayes and limit of bayes rule, Concept of admissibility and completeness Bayes rules, Admissibility of Bayes and minimax rules, Supporting and separating hyper plane theorems, complete class theorem, Minimax estimators of Normal and Poisson means

Subjective interpretation of probability in terms of fair odds, Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter, Bayes theorem and computation of the posterior distribution, Natural Conjugate family of priors for a model, Hyper parameters of a prior from conjugate family

Bayesian point estimation as a prediction problem from posterior distribution, Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 -1 loss, Bayesian interval estimation: credible intervals, Highest posterior density regions.

Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval, Bayesian Testing Hypothesis: Specification of the appropriate from of the prior

distribution for a Bayesian testing of hypothesis problem, Prior odds, Posterior odds, Bayes factor.

Books Recommended:

James O Berger (1985) : Statistical Decision Theory and Bayesian analysis. Springer.

Fergusion T.S. (1967) : Mathematical Statistics - A decisions theoretic Approach. Academic Press.

3. DeGroot. M.H. : Optimal Statistical Decisions. McGraw Hill.

4. Leonard T and Hsu J.S.J. : Bayesian Methods. Cambridge University Press.

5. Bernardo, J.M. and Smith AFM : Bayesian Theory. John Willey.

6. Rao, C. R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.

7. Robert, C. P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer

Programme/Class: U.G. with Honours	Year: Fourth	Semester: VII
Subject: STATISTICS		
Course Title: **Distribution Theory**		
Credits: T- 2/P- 2	**Core Major Elective III**	

Course Outcome:
To provide the knowledge of discrete distributions, continuous distributions, discuss the appropriate distribution with their properties and application of to solve problems, knowledge of sampling distributions and order statistics.

Syllabus

Univariate Discrete distributions; properties and applications of Uniform Discrete, Binomial, Poisson, Hypergeometric, Geometric Negative Binomial distribution and Multinomial distribution.

Univariate continuous Distribution; statement, derivation of properties and applications of Normal, Beta, Gamma, Cauchy, Exponential

Sampling distribution from Binomial, Poisson, Exponential and Normal populations, Bivariate distributions; bivariate normal. Distribution of functions of random variables.

Large sample tests. Derivation and properties of chi-square, t and F distribution and their inter relationship. Test of significance based on chi-square, t and F distribution.

Order statistics, their distributions and properties, joint and marginal distributions of order statistics, extreme values and their asymptotic distributions (statement only) with applications.

Books Recommended:

1. Rao, C.R. (1973): Linear Statistical Inference and its Application, Wiley Eastern.
2. Kendall, M.G., Stuart, A: The Advanced Theory of Statistics: Distribution Theory. Vol. 1.
3. Johnson and Kotz: Continuous Univariate Distribution, Vol. 1 and Vol. 2, Wiley.
4. Dudwvicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley. International students edition.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VII
Subject: STATISTICS			
Course Title: **Probability Theory And Expectations**			
Credits:	T- 2/P-2	Core: **Core Minor I**	

Course Outcome:

The aim of the course is to pay a special attention to applications of measure theory in the probability theory and the Central Limit Theorem with their applications. To understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions. To gain the ability to understand the concepts of measurable functions, sequence of random variables, convergence, modes of convergence. To learn the concepts of weak and strong laws of large numbers and central limit theorem.

Syllabus

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.

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.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.) & their properties, Continuity theorem for m.g.f. (without proof). Chebyshev's inequality,

Books Recommended:

1. Goon Gupta and Das Gupta: An outline of Statistical theory, World Press Calcutta, Vol. 1. 6
2. Rohtagi, V.K. and Saleh A.K. (2005): Probability Theory, John Wiley.
3. B.R. Bhat(1985): Modern Probability Theory.
4. Basu, A.K. (2001): Probability and Measure theory, Narosa Pub.

U.G Fourth Year - Eighth Semester (U.G. with Honors)

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VIII
Subject: STATISTICS			
Course Title: **Sample Surveys**			
Credits:	T- 5	Core: **Core Major I**	

Course Outcome:
The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.

Syllabus

Basic Principles: Census and sample surveys, advantages and disadvantages of sample surveys. Basic principles in sampling, survey enquiries, choice of sampling units, problems of sample size, Bias in selection and estimation, simple random sampling, sampling from finite populations with and without replacement, sampling of attributes, unbiased estimates of population total, mean and estimation of their variances.

Stratified Sampling: Reason 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 allocation, 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.

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 variance.

Double Sampling: Multistage sampling with special reference to two stage design, Nonsampling errors, problems of non response, errors of measurements, Interpenetrating sub sampling. Randomized response techniques. Pilot survey.

PPS Sampling schemes, sampling techniques with varying probabilities for simple random sampling. Herwits Thompson Estimators, Mid Zuno Sen Sampling Scheme.

Books Recommended:

1. Cochran W.G.: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Des Raj and Chandhok (1998): Sampling Theory, Narosa Publishing House.
3. Mukhopadhayay Parimal: Theory and Methods of Survey Sampling-Prentice Hall of India Ltd. 4. Kish L: Survey Sampling.

Programme/Class: U.G. with Honours	Year: Fourth	Semester: VIII

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VIII
Subject: STATISTICS			
Course Title: **Statistical Inference**			
Credits:	T- 5	Core: **Core Major II**	

Course Outcome:

To make aware the students about parametric, non-parametric and sequential estimation (point, as well as, interval) and testing (simple, as well as, composite hypotheses) procedures. To apply various estimation techniques and testing procedures to deal with real life problems. To understand consistency, CAN estimator, MLE. Understand UMPU tests UMVU estimators.

Syllabus

Problem of point estimation: Unbiasedness, Consistency, Sufficiency, Efficiency, Complete statistics, Complete Sufficient statistics. Factorization theorem, Exponential family of distributions and its properties, Minimum-variance unbiased estimators, Rao Blackwell theorem. Lehmann Schefe'stheorm, Cramer-Rao Inequality.

Method of estimation- Method of Maximum Likelihood and its properties.

Interval estimation, Interval Estimation: Confidence Region, shortest confidence intervals, General method of finding confidence interval. Method of obtaining confidence intervals based on small and large samples, Relationship with the testing of hypothesis.

Testing of hypothesis: Basic concept, Simple and composite hypothesis, Two types of error, power of the test , Neyman-Pearson lemma and its generalization, Types A, A1 critical regions, Construction of most powerful test, Uniformly most powerful tests, Uniformly most powerful Unbiased test using N P lemma, likelihood ratio test and its properties.

General decision problem: Basic concept of loss function, risk function, Minimax and Bays rule.

Books Recommended:

1. Lehmann, E.L.(1986): Theory of Point Estimation, Student Edition.
2. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
3. Rao, C.R. (1973): Linear Statistical Inference and its applications, 2nd edition, John wiley and sons.
4. Kale, B.K. (1999): A First course on Parametric Inference, Narosa Publishing House.
5. Goon, A.M., M.K. Gupta, & B. Das Gupta: Outline of Statistics, Vol-II.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VIII
Subject: STATISTICS			
Course Title: **Linear Algebra**			
Credits:	T- 5	Core: **Core MajorIII**	

Course Outcome:

The main objective of this paper is to allow students to manipulate and understand multi-dimensional space.

Syllabus

Vector Space, subspace,

Linear dependence and independence, maximal linearly independent subset,

Basis and dimension of vector space, finite dimensional vector spaces,

Example of vector spaces over real and complex variable.

Linear transformation, algebra of linear transformation,

Null space and ranges, rank and nullity of linear transformation, Rank nullity theorem,

Eigenvalues and eigenvectors for Linear Transformations,

Matrix representation of linear transformation.

Vector spaces with an inner product,

Gram-Schmidt orthogonalization process, orthonormal projection of a vector.

Books Recommended:

1. Biswas, S, (1984): Topics in Algebra of matrices, Academic Publications.
2. Shanti Narain: A text books of matrices, S. Chand and Company (Pvt) Ltd.
3. Stephen H. Friedberg, Arnold J. Insel Lawrence E. Spence: Liner Algebra, Pearson Education Limited.
4. Kenneth Hoffman and Ray Kunje:Linear Algebra, Prentice-Hall Inc

Subject: STATISTICS			
Course Title: **Design and Analysis of experiment**			
Credits:	T- 2	P-2	Core: **Core Major Elective I**

Course Outcome:

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

Syllabus

Analysis of Variance for one-way, two-way with one/m observation per cell for fixed,mixed and random effects models, Tuckey's test for non- additivity. General theory ofanalysis of experimental designs; completely randomized design, Randomized block

design and Latin square design, Missing plot techniques in RBD and LSD.

Analysis of covariance for CRD and RBD. Split plot and strip plot designs. Complete and

Partial confounding. General factorial experiments: Definition, Estimation of factor's effect. Analysis of the factorial experiments using CRD and RBD.

Balanced Incomplete Block Designs: Balanced Incomplete Block Design with and without recovery of inter information.

Books Recommended:

9. Raghava Rao D. (1971) : Construction and Combinatorial problems in Design of experiment. Wiley
10. Aloke Dey (1986) : Theory of Block Designs, Wiley Eastern.
11. Das, M.N. & Giri, N.(1979): Design and Analysis of experiments, Wiley Eastern.
12. Giri, N. (1986) : Analysis of Variance, South Asian Publishers.
13. Rao, C.R. and Kleffe, J.(1988) : Estimation of Variance Components and applications, North Holland.
14. Searle, S.R., Casella, G. and McCulloch, C.E. (1992) : Variance Components, Wiley.
15. Nigam, Puri & Gupta (1987-88) : Characterisation and Analysis of Block Design, Wiley Eastern.
16. V.K. Gupta & A.K. Nigam (1978-79) : Handbook an analysis of Agriculture Experiment, IASRI Publication.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VIII
Subject: STATISTICS			
Course Title: **Acturial Statistics**			
Credits:	T- 2	P- 2	Core: **Core Major Elective II**

Course Outcome: In this course students learn about statistical models of transfers between multiple states, including processes with single or multiple decrements, and derive relationships between probabilities of transfer and transition intensities.

Syllabus

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, models for individual claims and their sums.

Survival function, Uncertainty of age at death, time until-death for a person, curate future lifetime, force of mortality. Life table and its relation with survival function, life table characteristics, assumptions for fractional ages, some analytical laws of mortality, select and ultimate life table

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. 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.

Life insurance: Insurance payable at the moment of death and at the end of the year of deathlevel benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities.

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. A brief outline of payment premiums and net premiums, Gross premiums and provisions. Profit testing Determining provisions using profit testing. Factor affecting mortality and selections.

Books Recommended:

1. 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.
2. Daykin, C. D., Pentikainen, T. and Pesonen, M. (1993). Practical Risk Theory for Actuaries. Chapman & Hall/CRC.
3. Deshmukh, S.R. (2009). Actuarial Statistics: An Introduction Using R, University Press, India.
4. Dickson, C. M. D. (2005). Insurance Risk and Ruin (International Series no.1 Actuarial Science), Cambridge University Press.
5. Klugman,S. A., Panjer, H. H., and Willmotand, G. E. (2019). Loss Models: From Data to Decisions. Willy publication.
7. Rotar, V.I. (2015). Actuarial Models: The Mathematics of Insurance, 2nd ed., CRC Press, New York.
8. Spurgeon, E.T. (1972). Life Contingencies, Cambridge University Press.

Subject: STATISTICS		
Course Title: **Financial Statistics**		
Credits:	T- 2/ P-2	Core: **Core Major Elective III**

Course Outcome:

To develop the practical knowledge towards Financial Statistics, Time models, Martingales and their Applications, CRR Model, to study the Financial Markets Instruments and Jump Processes etc.

Syllabus

Review and Extensions- Assets, Portfolios and Arbitrage, Derivatives, Pricing, Hedging, Greeks, Discrete Time Models, Continuous Time Models, Random walk, Geometric Random Walk, Brownian Motion, Wiener Process.

Review and Extensions- Stochastic Calculus, Stochastic Differential Equations, Partial Differential Equations, Black- Scholes' PDE, Martingales and their Applications in Pricing of Assets, Plain Vanilla Options, Greeks of Plain Vanilla Options, Estimation of Volatility, CRR Model.

Financial Markets Instruments- Exotic Options, Reflection Principle, Asian Options, Change of Numeraire, Pricing of Exchange Options, Forward Rates Modelling, Forward Vesicek Rates, Interest Rates Derivatives and their Pricing, Default Risk in Bond Markets, Credit Default Swaps.

Jump Processes- Poisson Process, Compound Poisson Processes, Stochastic Integrals with Jumps, Itô- Integral with Jumps, Stochastic Differential Equations with Jumps, Girsanov Theorem for Jumps Processes, Lèvy Processes, Pricing and Hedging in Jump Processes, Risk Neutral Measures, Black Scholes' PDE with jumps.

Books Recommended:

Lamberton, D. and Lepeyre, B. (2008). Introduction to Stochastic Calculus Applied to Finance, 2nd ed., Chapman and Hall/CRC Press.

Privault, N. (2014). Stochastic Finance –An Introduction with Market Examples, Chapman and Hall/CRC. Financial Mathematics Series, CRC Press, Boca Raton, 2014.

3. Tankov, P. (2010). Financial Modeling with Lèvy Processes, e-Book.

Programme/Class: U.G. with Honours		Year: Fourth	Semester: VIII
Subject: STATISTICS			
Course Title: **Basic Sampling Techniques**			
Credits:	T- 2//P-2	Core: **Core Minor I**	

Course Outcome:

The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.

Syllabus

Basic Principles: Census and sample surveys, advantages and disadvantages of sample surveys. Basic principles in sampling, survey enquiries, choice of sampling units, problems of sample size, Bias in selection and estimation,

simple random sampling, sampling from finite populations with and without replacement, sampling of attributes, unbiased estimates of population total, mean and estimation of their variances.

Stratified Sampling: Reason 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 allocation, 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.

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 variance.

Books Recommended:

1. Cochran W.G.: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Des Raj and Chandhok (1998): Sampling Theory, Narosa Publishing House. 3. Mukhopadhayay Parimal: Theory and Methods of Survey Sampling-Prentice Hall of India Ltd. 4. Kish L: Survey Sampling.

Fourth Year- (U.G. Honours With Research) -VII Semester

Subject: STATISTICS		
Course Title: **Measure Theory and Probability**		
Credits:	T-5	**Core Major I**

Course Outcome: The aim of the course is to pay a special attention to applicant ions of measure theory in the probability theory and the Central Limit Theorem with their applications. To understand the concepts of random variables, sigma-fields generated by random variables, probability distributions, and independence of random variables related to measurable functions. To gain the ability to understand the concepts of measurable functions, sequence of random variables, convergence, modes of convergence. To learn the concepts of weak and strong laws of large numbers and central limit theorem.

Syllabus

Measure and integration: Classes of sets, field, sigma fields, minimal sigma fields, Borel sigma fields, Limsup and liminf of a sets, Measure, Probability measure, properties of ameasure, Lebesgue and Lebesgue- Steljes measures, measurable functions.

Probability : Baye's theorem. Random variable. Marginal and conditional distributions,

Expectation. Tehebycheffs inequality and improvements on it, convergence in probability.

The weak law of large numbers Bernoulli's theorem. Convergence in distribution continuity theorem. Khinchin's theorem. Strong law of large numbers Kologorov's theorem, Borel zero-one law, Borel-Cantelli lemma.

Central limit theorem-Lindberg Levy's and liapouneff forms.

Books Recommended:

Goon Gupta and Das Gupta: An outline of Statistical theory, World Press Calcutta, Vol. 1. 6

6. Rohtagi, V.K. and Saleh A.K. (2005): Probability Theory, John Wiley.
7. B.R. Bhat(1985): Modern Probability Theory.
8. Basu, A.K. (2001): Probability and Measure theory, Narosa Pub.

Subject: STATISTICS		
Course Title: **Matrices**		
Credits:	T-5	**Core Major II**

Course Outcome:

To acquire the knowledge of Matrices, determinants and their operations and their properties, solutions and applications.

Syllabus

Different type of matrices, algebra of matrices, row and column spaces of a matrix,elementary matrices, determinant, singular and non-singular matrices, adjoint of matrix, rankand inverse of matrix, portioned matrices and Kroneker product.

Canonical form, Hermit canonical form, diagonal form, triangular form, Jordan form,quadratic form, generalized inverse, Moore-Penrose generalized inverse, idempotent matrices.

Characteristic roots and vectors, algebraic multiplicity of characteristic roots, CaleyHamilton theorem, spectral decomposition of real symmetric matrix.

Positive, semi positive , negative and semi negative definite matrices, similar matrices

Derivative of determinant.

Books Recommended:

7. Biswas, S, (1984): Topics in Algebra of matrices, Academic Publications.
8. Shanti Narain: A text books of matrices, S. Chand and Company (Pvt) Ltd.
9. Frank Ayres , JR: Schaum's outline series Theory and problems.
10. A.I. Kostrikin, Introduction to Algebra, Springer Verlag, 1984.
1. S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
2. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.

Subject: STATISTICS		
Course Title: **Real analysis and Complex Analysis**		
Credits:	T- 4	**Core: Core Major Elective**

Course Outcome:

The main objective of this course is to introduce students with the knowledge of real field and complex field with their properties and relativity between complex plane and real line. These properties and relations provide grounds for Probability Theory and help in theoretical research in Statistics.

Syllabus

Real Analysis: Continuity and discontinuity of functions, Differentiability, Roll's theorem, Mean Value theorem, Non differentiable functions, Riemann integration,

Fundamental theorem of integral calculus, convergence of integrals and uniform Convergence.

Complex Analysis: Analytic functions, Conformal representation, complex integration,

Cauchy's Theorem, Morea's Theorem, Taylor's and Laurentts Series, Zero's and Poles of

Functions, theory of Residues and Its application to Contour integration.

Books Recommended:

7. Apostol, T.M. (1975). Mathematical Analysis, Addison- Wesley.
8. Bartle, R.G. (1976). Elements of Real Analysis, John Wiley & Sons.
9. Berbarian, S.K. (1998). Fundamentals of Real Analysis, Springer-Verlag.
10. Conway, J.B. (1978). Functions of one Complex Variable, Springer-Verlag.
11. Priestley, H.A. (1985). Complex Analysis, Clarenton Press Oxford.
12. Rudin, W. (1985). Principles of Mathematical Analysis, McGraw Hill.

Subject: STATISTICS		
Course Title: **Research Methodology**		
Credits:	T- 5	Core: **Core Major (Research Based)**

Course Outcome:

A solid foundation in Statistical Theory and Methodology, will be able to communicate the major tenets of statistics, explain their work orally and identify areas of future research areas.

Syllabus

Foundations of Research: Meaning, Objectives, Motivation, Utility. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical, concept of applied and basic research process, criteria of good research. Analysis of Literature review – Primary and Secondary Sources, Web sources –critical Literature Review. Development of Working Hypothesis, Research Methods: Scientific method vs Arbitrary Method, Logical Scientific Methods: Deductive, Inductive, Deductive Inductive, pattern of Deductive –Inductive logical process – Different types of inductive logical methods. Research methods vs. Methodology.

Research design: Meaning, Need, Features of Good Design and Concepts. Research Design types. Selection of appropriate method for data collection, Case Study, Focus Group Discussion, Techniques of developing research tools, viz. Questionnaire and rating scales etc. Reliability and validity of Research tools. Sample size determination.

Preparation of Project Proposal, Title, Abstract, Introduction, Rationale, Objectives, Methodology, Time frame and work plan, Budget and Justification, References. Ethical Issues, Ethical Committees, Commercialization, copy right, royalty, Intellectual Property rights and patent law, Track Related aspects of intellectual property Rights, Reproduction of published material, Plagiarism, Citation and Acknowledgement, Reproducibility and accountability.

Meaning of Interpretation, Technique of Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation. Writing Research Project Report: Format and style. Review of related literature its implications at various stages of research. (Formulation of research problem, hypothesis, interpretation and discussion of results). Major findings, Conclusions and suggestions. Citation of references and Bibliography.

Books Recommended:

Garg. B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Vol 2, Ess Publication.

Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.

Subject: STATISTICS			
Course Title: **Probability Theory And Expectation**			
Credits:	T- 2	P-2	Core: **Core Minor I**

Course Outcome:

The aim of the course is to pay a special attention to applications of measure theory in the probability theory and the Central Limit Theorem with their applications. To understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions. To gain the ability to understand the concepts of measurable functions, sequence of random variables, convergence, modes of convergence. To learn the concepts of weak and strong laws of large numbers and central limit theorem.

Syllabus

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.
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.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.) & their properties, Continuity theorem for m.g.f. (without proof). Chebyshev's inequality,

Books Recommended:

5. Goon Gupta and Das Gupta: An outline of Statistical theory, World Press Calcutta, Vol. 1. 6
6. Rohtagi, V.K. and Saleh A.K. (2005): Probability Theory, John Wiley.
7. B.R. Bhat(1985): Modern Probability Theory.
8. Basu, A.K. (2001): Probability and Measure theory, Narosa Pub.

Fourth Year- (U.G. Honours With Research) -VIII Semester

Subject: STATISTICS		
Course Title: **Sample Surveys**		
Credits:	T- 5	Core: **Core Major I**

Course Outcome:
The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.

Syllabus

Basic Principles: Census and sample surveys, advantages and disadvantages of sample surveys. Basic principles in sampling, survey enquiries, choice of sampling units, problems of sample size, Bias in selection and estimation, simple random sampling, sampling from finite populations with and without replacement, sampling of attributes, unbiased estimates of population total, mean and estimation of their variances.

Stratified Sampling: Reason 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 allocation, 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.

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 variance.

Double Sampling: Multistage sampling with special reference to two stage design, Nonsampling errors, problems of non response, errors of measurements, Interpenetrating sub sampling. Randomized response techniques. Pilot survey.

PPS Sampling schemes, sampling techniques with varying probabilities for simple random sampling. Herwits Thompson Estimators, Mid Zuno Sen Sampling Scheme.

Books Recommended:

4. Cochran W.G.: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
5. Des Raj and Chandhok (1998): Sampling Theory, Narosa Publishing House.
6. Mukhopadhayay Parimal: Theory and Methods of Survey Sampling-Prentice Hall of India Ltd. 4. Kish L: Survey Sampling.

Subject: STATISTICS			
Course Title: **Statistical Inference**			
Credits:	T- 4		Core: **Core Major Elective I**

Course Outcome:

To make aware the students about parametric, non-parametric and sequential estimation (point, as well as, interval) and testing (simple, as well as, composite hypotheses) procedures. To apply various estimation techniques and testing procedures to deal with real life problems. To understand consistency, CAN estimator, MLE. Understand UMPU tests UMVU estimators.

Syllabus

Problem of point estimation: Unbiasedness, Consistency, Sufficiency, Efficiency, Complete statistics, Complete Sufficient statistics. Factorization theorem, Exponential family of distributions and its properties, Minimum-variance unbiased estimators, Rao Blackwell theorem. Lehmann Schefe'stheorm, Cramer-Rao Inequality.

Method of estimation- Method of Maximum Likelihood and its properties.

Interval estimation, Interval Estimation: Confidence Region, shortest confidence intervals, General method of finding confidence interval. Method of obtaining confidence intervals based on small and large samples, Relationship with the testing of hypothesis.

Testing of hypothesis: Basic concept, Simple and composite hypothesis, Two types of error, power of the test , Neyman-Pearson lemma and its generalization, Types A, A1 critical regions, Construction of most powerful test, Uniformly most powerful tests, Uniformly most powerful Unbiased test using N P lemma, likelihood ratio test and its properties.

General decision problem: Basic concept of loss function, risk function, Minimax and Bays rule.

Books Recommended:

6. Lehmann, E.L.(1986): Theory of Point Estimation, Student Edition.
7. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
8. Rao, C.R. (1973): Linear Statistical Inference and its applications, 2nd edition, John wiley and sons.
9. Kale, B.K. (1999): A First course on Parametric Inference, Narosa Publishing House.
10. Goon, A.M., M.K. Gupta, & B. Das Gupta: Outline of Statistics, Vol-II.

Subject: STATISTICS		
Course Title: **Dissertation**		
Credits:	**T- 12**	**Core : Core Major (Research Based)**
Course Outcome: A dissertation showcases a student's research skills and expertise in a specific field of study. It demonstrates their ability to identify research gaps, develop research questions, analyse data, and draw meaningful conclusions.		

Syllabus

The topic for the dissertation should be a theme or a problem in an area of your choice within the framework of the contents of the courses studied. You are free to work on any topic or theme of any discipline.

Format of the Dissertation: The dissertation should be around 20,000 words in length (including the title page, acknowledgements and bibliographic references). Essential statistical and documentary appendices such as questionnaires, surveys, interview schedules or other data collection materials may be added to the total, but these should be kept to an absolutely relevant minimum. Dissertation should be typed or word-processed on A-4 size paper.

All material in the main part of the dissertation, excluding the bibliographic references, should have 1.5- line spacing and printed on one side of the paper with one-inch margins. Notes and references should be in the prescribed format. Pages should be numbered sequentially at bottom-centre.

The final dissertation should be bound. The sequence of the material in the dissertation should be in the following order:

1) The Cover Page of the dissertation should state the title of the dissertation, the name and enrolment number of the student, the name of the Academic supervisor, the degree programme for which it is prepared, the name of the university/college and the month and year of submission.

2) Title Page should give the same information as on the cover, together with the statement: "This dissertation is submitted in partial fulfilment of the requirements for the degree of …", followed by the date (month and year) of submission.

3) Certificate issued by the Academic Supervisor that the dissertation submitted by the candidate is his/ her own work and that the same be placed before the examiner.

4) Table of Contents should list the contents of the dissertation by chapters, with sections where appropriate, and the page number for each, together with the page number for the bibliographic references and figures, tables and maps, if any.

5) Acknowledgements: You may wish to acknowledge any help that you have received in the preparation of the dissertation.

6) Main Text comprises of the chapters (usually three, four or five, including the Introduction and Conclusion) bibliographic references and appendices, if any. Each main heading (chapters, bibliographic references and appendices) should start on a new page; sections within main headings may continue on the same page. Numbering of the main text of the dissertation should be sequential. Bibliographic references should list all works cited in the chapters and other valuable sources used in the preparation of the dissertation.

Subject: STATISTICS		
Course Title: **Basic Sampling Techniques**		
Credits:	T- 2/ P-2	Core: **Core Minor I**

Course Outcome:

The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.

Syllabus

Basic Principles: Census and sample surveys, advantages and disadvantages of sample surveys. Basic principles in sampling, survey enquiries, choice of sampling units, problems of sample size, Bias in selection and estimation,

simple random sampling, sampling from finite populations with and without replacement, sampling of attributes, unbiased estimates of population total, mean and estimation of their variances.

Stratified Sampling: Reason 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 allocation, 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.

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 variance.

Books Recommended:

3. Cochran W.G.: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
4. Des Raj and Chandhok (1998): Sampling Theory, Narosa Publishing House. 3. Mukhopadhayay Parimal: Theory and Methods of Survey Sampling-Prentice Hall of India Ltd. 4. Kish L: Survey Sampling.