SOLAPUR UNIVERSITY, SOLAPUR.

SYLLABUS
FOR
M.Sc. (Part-I) STATISTICS
(Semester I and II)
Choice Based Credit System (CBCS)

(With effect from academic year 2016-17)

SOLAPUR UNIVERSITY, SOLAPUR

SCHOOL OF COMPUTATIONAL SCIENCES

DEPARTMENT OF STATISTICS

Syllabus of M.Sc. Statistics (Choice Based Credit System)

1) **Title of the course:** M.Sc. in Statistics.
2) **Duration of the course**: Two years.
3) **Pattern:** Choice Based Credit System (CBCS)
4) **Eligibility:** For M. Sc. in Statistics following candidates are eligible.
   (i) B.Sc. with Statistics at principal level.
   (ii) B.Sc. with Mathematics at principal and Statistics at subsidiary level.
5) **Intake Capacity:** 20

M. Sc. program in Statistics consists of 100 credits. Credits of a course are specified against the title of the course.

A Four Semester M.Sc. Statistics Course

Semester	No. of Papers/ Practicals / Seminar	Marks	Credits
Semester I			
• Theory Papers	05	500	20
• Practical Paper	02	100	04
• Seminar/Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester II			
• Theory Papers	05	500	20
• Practical Paper	02	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester III			
• Theory papers	05	500	20
• Practical Paper	02	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester IV			
• Theory papers	05	500	20
• Practical Paper	01	50	02
• Project	01	50	02
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Total marks and credits for M.Sc. Course		**2500**	**100**

Solapur University, Solapur
School of Computational Sciences
M.Sc. Statistics Choice Based Credit System (CBCS)
Course Structure

M.Sc. Part-I (STATISTICS) w.e.f. 2016-17

M.Sc. STATISTICS SEMESTER-I								
Paper Code	**Title of the Paper**	**Semester Examination**			**L**	**T**	**P**	**Credits**
		Theory	**IA**	**Total**				
	Hard Core Theory							
HCT 1.1	Real Analysis	70	30	100	4	--	--	4
HCT 1.2	Linear Algebra	70	30	100	4	--	--	4
HCT 1.3	Distribution Theory	70	30	100	4	--	--	4
HCT 1.4	Estimation Theory	70	30	100	4	--	--	4
	Soft Core-Theory (Any one)							
SCT 1.1	Statistical Computing	70	30	100	4	--	--	4
SCT 1.2	Demography							
	Practical							
HCP1.1	Practical-1: (Based on HCT 1.2, 1.4)	35	15	50	--	--	4	2
HCP1.2	Practical-2: (Based on HCT 1.3, SCT)	35	15	50	--	--	4	2
	Seminar / Tutorial	---	25	25	--	1	--	1
Total for Semester-I		**420**	**205**	**625**	**--**	**--**	**--**	**25**
M.Sc. STATISTICS SEMESTER-II								
Code	**Title of the Paper**	**Semester Examination**			**L**	**T**	**P**	**Credits**
		Theory	**IA**	**Total**				
	Hard Core Theory							
HCT 2.1	Probability Theory	70	30	100	4	--	--	4
HCT 2.2	Stochastic Processes	70	30	100	4	--	--	4
HCT 2.3	Theory of Testing of Hypotheses	70	30	100	4	--	--	4
	Soft Core Theory (Any One)							
SCT 2.1	Sampling Theory	70	30	100	4	--	--	4
SCT 2.2	Actuarial Statistics							
	Open Elective Theory (Any one)							
OET 2.1	Statistical Methods	70	30	100	4	--	--	4
OET 2.2	Mathematical Statistics							
	Practical (Hard and Soft core)							
HCP 2.1	Practical-3: (based on HCT and SCT)	35	15	50	--	--	4	2
	Practical (Open Elective) Any One							
OEP 2.1	Practical -4: (based on OEP 2.1)	35	15	50	--	--	4	2
OEP 2.2	Practical-4: (based on OEP 2.2)							
	Seminar / Tutorial	---	25	25	--	1	--	1
Total for Semester-II		**420**	**205**	**625**	**--**	**--**	**--**	**25**

Evaluation Scheme:

Each theory paper will have 100 marks out of which 70 marks will be for Term End examination and 30 marks for Internal Assessment. The candidate has to appear for internal evaluation of 30 marks and external evaluation (University Examination) of 70 marks for each theory paper.

Each practical paper will have 50 marks out of which 35 marks will be for Term End examination and 15 marks for Internal Assessment. The candidate has to appear for internal evaluation of 15 marks and external evaluation (University Examination) of 35 marks for each practical paper.

Internal Evaluation:

- In case of theory papers internal examinations will be conducted by department / school.
- In case of practical papers, 5 marks shall be for day-to-day journal and 10 marks shall be for internal test, which will be conducted by the department / school.

External Evaluation (End of Term University Examination):

I) Nature of Theory question paper:

1) Each Theory paper is of 70 marks.
2) Each Theory paper will be of 2 hours and 30 minutes duration
3) There shall be 7 questions each carrying 14 marks.
4) Students have to attempt **five questions**.
5) Q.No.1 is **compulsory** and shall contain 14 objective type sub-questions each carrying 1 mark.
6) Q. No.2 is **compulsory** and shall contain 4 short answer type sub-questions each carrying 3 or 4 marks.
7) Students have to attempt **any three** questions from Q. N0. 3 to Q. No. 7.
8) Q. N0. 3 to Q. No. 7 shall contain 2 long answer type sub-questions.

II) Nature of Practical question paper: (End of Term Examination)

Sem-I and II: Practical examination will be conducted for 30 marks and is of two hours duration. There shall be 05 questions each of 10 marks, of which student has to attempt any 03 questions. VIVA will be for 5 marks.

M.Sc. I (STATISTICS) Sem-I

Paper No. I
Paper Code: HCT 1.1
REAL ANALYSIS

Unit-1: Set of real numbers, countable and uncountable sets, countability of rationals and uncountability of the interval (0, 1), Supremum and Infimum of bounded sets, limit point of a set, open, closed, dense and compact sets. Bolzano-Weierstrass and Heine-Borel Theorems (Statements only). Applications of these theorems. **(15 L)**

Unit-2: Sequence of real numbers, convergence, divergence, Cauchy sequence. Convergence of bounded monotone sequence. Limit inferior and limit superior of the sequences. Series of numbers, tests for convergence (without proof), test for absolute convergence, convergence of sequences of non-negative terms. **(15 L)**

Unit-3: Real valued function, Continuous function, Uniform continuity of sequence of functions, Uniform convergence of power series, Radius of convergence. Reimann, Reimann-Steltjes Integrals and their common properties. Integration by parts, Fundamental theorem on calculus, mean value theorem. (**15 L)**

Unit-4: Vector and Matrix differentiation, Maxima, minima of functions of variables. Constrained maxima, minima, Lagrange's method, Taylor's theorem (without proof) and its applications. Implicit function theorem and their applications. Multiple Integrals, Change of variables, Improper integrals, Applications in multivariate distributions. Theorem on differentiation under integral sign (without proof), Lebnitz rule (statement only) and applications. **(15 L)**

Reference Books:

1. Malik S.C. & Arora S. (1991): Mathematical Analysis- Wiley Eastern Limited 2nd edition.
2. Goldberg R.R.(1964): Methods of Real Analysis-Blaisell Publishing company, New York, U.S.A..
3. Bartly G.R. (1976): Element of Real Analysis-Wiley 2nd edition.
4. Bartly G.R. & Sherbert D.R. (2000): Introduction to Real Analysis-John Wiley & Sons Inc.
5. Royden (1988): Principles of Real Analysis-Macmillian.
6. Widder (1989): Advanced Calculus-Dover Publication.
7. Apostol T.M. (1985): Mathematical Analysis-Narosa Publishing House.

Paper No. II
Paper Code: HCT1.2

LINEAR ALGEBRA

Unit-1:Vector space, subspace, linear dependence and independence, basis, dimension of a vector space, example of vector spaces. Null space, Matrices, elementary operations, rank of a matrix and related results. Orthonormal basis and orthogonal projection of a vector, Orthogonal matrices, Gram-Schmidt orthogonalisation. Idempotent matrices, inverse of a matrix, their simple properties, partitioned matrices. **(15 L)**

Unit-2: G-inverse, Reduction of a matrix to echelon, diagonal, triangular forms, Hermitian matrices and its properties, Moore-Penrose inverse and its properties, Solution of a system of homogenous and non-homogenous linear equations and theorem related to existence of solution. **(15 L)**

Unit-3: Characteristic roots of a matrix, algebraic and geometric multiplicities, characteristics vectors and their orthogonal property. Cayley-Hamilton theorem and applications. Spectral decomposition, singular value decomposition and choleskey decomposition. **(15 L)**

Unit-4: Quadratic forms: Definition and classification, reduction, simultaneous reduction of two quadratic forms, maxima and minima of ratio of quadratic forms. **(15 L)**

Reference Books:

1. Rao A.R. & Bhimashankaram P. (1972): Linear Algebra-Tata McGraw Hill, New Delhi.
2. Hadely C. (1987): Linear Algebra-Narosa Publishing House.
3. Rao C.R. (1973): Linear Statistical Inference and Application, 2nd edition. John Wiley and Sons, Inc.
4. Searle S.R. (1982): Matrix Algebra useful for Statistics- John Wiley and Sons, Inc.
5. Graybill F.A. (1983): Matrices with application in Statistics- 2nd ed. Wadsworth

Paper No. III
Paper Code: HCT1.3

DISTRIBUTION THEORY

Unit-1: Brief review of basic distribution theory. Distribution function and its properties, Relation of distribution function with uniform variate. Decomposition of distribution function into discrete and continuous parts. Truncated Binomial, Truncated Poisson, Truncated Normal distributions. Functions of random variables, their distributions in case of univariate random variables and its applications. **(15 L)**

Unit-2: Expectation and moments, probability generating function, moment generating function, convolution and examples. Moment inequalities: Markov, Chebychev, Holder, Minkowski and Jensen inequalities with their applications. Basic inequality of Liapunov's. **(15 L)**

Unit-3: Bivariate discrete and continuous distributions, marginal distributions. Examples of joint distribution with given marginals, independence, conditional distributions and examples. Distribution function of bivariate random variable using Jacobian of transformation. Multinomial distribution, Bivariate Poisson, Bivariate exponential and Bivariate Normal distributions and their properties. **(15 L)**

Unit-4: Symmetric distributions, properties of symmetric distributions, non-regular families, location and scale families and examples. Order Statistics-their distributions and properties. Joint and marginal distributions of order statistics. Non-central χ^2, non-central t and F distributions. **(15 L)**

Reference Books:

1. Rohtagi V.K. & Saleh A.K. Md. E (2001): Introduction to Probability Theory and Mathematical Statistics- John Wiley and Sons Inc.
2. Rao C.R.(1973): Linear Statistical Inference and Applications- John Wiley and Sons, Inc.
3. Johnson N.L. and. Kotz S. (1996): Distribution in Statistics Vol-I, II and III- John Wiley and Sons, Inc.
4. Johnson N.L.and Kotz S.: Multivariate distributions- John Wiley and Sons, Inc.
5. Casella G. and Berger R.L. (2002): Statistical Inference-Duxbury Advanced Series, 2nd ed.

Paper No. IV
Paper Code: HCT1.4

ESTIMATION THEORY

Unit-1: Sufficiency principle, factorization theorem, minimal sufficiency, minimal sufficient partition, construction of minimal sufficient statistic, minimal sufficient statistic for exponential families, power series family and pitman family. Completeness, bounded completeness, ancillary statistic, Basu's theorem and applications. **(15 L)**

Unit-2: Problem of point estimation, unbiased estimators, minimum variance unbiased esimator, Rao-Blackwell and Lehmann-Scheffe theorems and their uses. Necessary and sufficient condition for MVUE. Fisher information and information matrix, Cramer-Rao inequality, Chapmann-Robinson bound, Bhattacharya bound, their applications. **(15 L)**

Unit-3: Methods of Estimation: Method of maximum likelihood estimation (MLE) and small sample properties of MLE, method of scoring and its application to estimation in multinomial distribution, Method of moments, Method of minimum Chi-square. **(15 L)**

Unit-4: Bayesian Estimation: The concept of Prior distributions, various types of priors, Posterior distribution, Posterior distribution conjugate family and standard examples of such families. Bayes estimator under absolute and quadratic error loss functions. **(15 L)**

Reference Books:

1. Rohtagi V.K. & Saleh A.K. Md. E (2001): Introduction to Probability Theory and Mathematical Statistics- John Wiley and Sons Inc.
2. Rao C.R.(1973): Linear Statistical Inference and Applications- John Wiley and Sons, Inc.
3. Casella G. and Berger R.L. (2002): Statistical Inference-Duxbury Advanced Series, 2nd ed.
4. Kale B.K. (2005): First Course on Parametric Inference- 2nd ed. Narosa Publishing House.
5. Lehmann E.L. (1983): Theory of Point Estimation- John Wiley and Sons.
6. Ferguson T.S. (1967): Mathematical Statistics, Academic Press.

Paper No. V
Paper Code: SCT1.1
STATISTICAL COMPUTING

Unit-1: Concept of Random Number Generator, Congruential Method of generating uniform variates, Concept of Simulation, Generation of Binomial, Poisson, Geometric, Negative Binomial & Multinomial variates. Generation of continuous random variables covering Exponential, Normal, Gamma, Chi-square, Bivariate Poisson, Bivariate Normal, Bivariate Exponential distributions and Mixture of distributions. Proofs of related results. **(15 L)**

Unit-2: MS-EXCEL and MINITAB: Introduction to Ms-Excel and exercise on using EXCEL for Statistical analysis covering frequency distribution, histogram, t-test, and test for independence in 2 x 2 contingency tables. Introduction to MINITAB and programming based on MINITAB macros for statistical analysis covering descriptive statistics, regression analysis and bootstrap technique. **(15 L)**

Unit-3: R-Language: Introduction to R, Elementary programming. Application to data analysis: Descriptive statistics, Fitting of distributions, Cross tables, Correlation and Regression, Hypothesis Testing, ANOVA. **(15 L)**

Unit-4: Numerical Methods: Newton Raphson method, Regula falsi method, Numerical integration using Trapezoidal rule and Simpson's rule for single and double integrals. Programming exercise on these methods. Bias Reduction Methods, Jack-Knife estimator, its properties and limitations. Bootstrap method and its simple properties. **(15L)**

Reference Books

1. Balagurusamy (2008), Object Oriented Programming with C++ , Tata McGraw-Hill
2. Ryan B. and Joiner, B.L.(2001).MINITAB Handbook, 4th Ed.Duxbury.
3. Thisted R.A.(1998*).* Elements of Statistical Computing, Chapman and Hall.
4. Kennedy William J. Jr., James E. Gentle (1980), Statistical Computing, Marcel Dekkar
5. Morgan B.J.T. (1984), Elements of Simulation, Chapman and Hall.
6. Purohit, Gore, and Deshmukh (2008), Statistics Using R, Alpha Science International

Paper- V

Paper Code: SCT1.2

DEMOGRAPHY

Unit-1: Demography and its interdisciplinary nature, sources of demographic data, Coverage and Content errors. The use of balancing equation, Chandrasekaran and Deming formula to check completeness of registration data. Use of Whipple's Myers's and UN Indices.stributions and Mixture of distributions. Proofs of related results. **(15 L)**

Unit-2: Measures of Mortality : Various measures of mortality, infant mortality rate, cause specific death rates and standardized death rates . Measures of Fertility: Period and cohort fertility measures, use of birth order statistics, child-women ratio, Brass P/F ratio to estimate current level of fertility, Measures of reproduction and replacement. Sheps and Perrin stochastic human reproductive process. **(15 L)**

Unit-3: Life Tables : Types of life tables, inter-relationships between life table functions, construction of life tables using Reed- Meerel and Greville's Method. Probability distribution of life table functions and their optimum properties. Population estimation and Projection : Mathematical , Statistical and Demographic Methods, Component method. **(15 L)**

Unit-4: Stable and Quasi – stable population: Derivation of Lotka's stable population model and properties, Intrinsic growth rate and derivation, age structure and birth rate of a stable population, mean length of generation, momentum of population growth, Quasi-stable population under changing fertility and mortality situations. **(15 L)**

References:

1) Shryoch,Henry S,Jacob S,Siegel and Associates (1964)-Methods and materials of demography (condensed edition) Academic press,London.

2) Barclay,George W.(1968) Techniques of population analysis,John Wiley and sons,New York.

3) Keyfitz N.(1968) Introduction to Mathematics of Population.Addision-Wesley Publishing Co,Reading , Messachusetts.

4) R.Ramkumar (1986) Technical Demography,Wiley Eastern,New Delhi.

5) Sudhendu Biswas (1988) , Stochastic processes in Demography and Applications,Wiley Eastern, New Delhi

Statistics Practical Paper-1
Paper Code: HCP1.1

Use of Statistical Software Packages:

- MINITAB Software
- R Software

1. Linear dependence of vectors and rank a matrix.
2. Gram -Schmidt orthogonalisation method.
3. Solving systems of equations.
4. Determinant, Inverse and g-inverse of a matrix.
5. Application of Cayley- Hamilton Theorem,
6. Characteristics roots, characteristic vectors and their applications.
7. Classifications and reduction of quadratic forms.
8. Construction of UMVUE.
9. Methods of Estimation: MME and MLE.
10. Method of Scoring.

Statistics Practical Paper-2
Paper Code: HCP1.2

Use of Statistical Software Packages:

- MINITAB Software
- R Software

1. Model Sampling from univariate distributions using MS-EXCEL
2. Model Sampling from bivariate distributions using MS-EXCEL
3. Model sampling from mixture of distributions using MS-EXCEL
4. Sketching of distribution functions and probability density functions.
5. At least six practicals should be conducted on soft core theory paper.

M.Sc. (STATISTICS) Semester-II

Paper No. VI

Paper Code: HCT2.1

PROBABILITY THEORY

Unit-1: Classes of sets, Sequence of sets, limsup and liminf and limit of sequence of sets, field, σ- field, σ- field generated by a class, Borel σ-field. Probability measure, Probability space, properties of probability measure-continuity, mixture of probability measures. Lebesgue and Lebesgue-Stieltjes measures on R. Independence of events. **(15 L)**

Unit-2: Measurable function, random variable, distribution of a random variable, simple random variable, elementary random variable, liminf, limsup and limit of sequence of random variables. Method of obtaining a random variable as a limit of sequence of simple random variables. Integration of a measurable function with respect to a measure. Expectation of a random variable, independence. Characteristic function, simple properties, Inversion theorem and uniqueness property (Statement only). **(15 L)**

Unit-3: Monotone convergence theorem, Fatous Lemma, Dominated Convergence theorem, Borel-Cantelli Lemma and their applications. Convergence of sequence of random variables, Convergence of distribution, Continuity theorem (Statement only), Almost sure convergence, a characterizing property, convergence in probability, uniqueness of limit. Yule-Slutsky results. convergence in r^{th} mean, interrelationships. **(15 L)**

Unit-4: Weak and Strong laws of large numbers, Kolmogorov's three series theorem for almost sure convergence (statement only), Liaponove's Lindeberg-Feller Theorems on CLT (statement only). Application of the above results. **(15 L)**

Reference Books:

1. Bhat B. R. (1999): Modern Probability Theory (3^{rd} ed.).New Age International (P) Ltd.
2. Billingsley P.(1986): Probability and Measure-.John Wiley and Sons.
3. Alan Karr (1993): Probability Theory-Springer Verlag.
4. Kingman, J F C and Taylor, S.J.(1966): Introduction to Measure and Probability-Cambridge University Press.
5. Dudly, R.M.(1989): Real Analysis and Probability- Wadsworth and Brooks/ Cole.
6. Ash Robert (1972): Real Analysis and Probability-Academic Press.

Paper No. VII

Paper Code: HCT2.2

STOCHASTIC PROCESSES

Unit-1: Definition of Stochastic process, classification of Stochastic processes according to state space and time domain. Finite dimensional distributions. Examples of various stochastic processes. Definition of Markov chain, Examples of Markov chains, Formulation of Markov models, initial distribution, transition probability matrix, Chapman-Kolmogorov equation, calculation of n-step transition probabilities. **(15 L)**

Unit-2: Classification of states of Markov chain, irreducible Markov chain, period of the state, random walk and gambler's ruin problem. First entrance theorem, First passage time distribution. Long run distribution of Markov chain, relation of mean recurrence time and stationary distribution. **(15 L)**

Unit-3: Discrete state space continuous time Markov chain. Poisson process and related results. Birth and death processes and associated cases. M/M/1, M/M/S queuing models and related properties. **(15 L)**

Unit-4: Galton-Watson branching process. Probability of ultimate extinction, distribution of population size and associated results. Simulation of Markov chain, Poisson process, branching process (Algorithms). **(15 L)**

Reference Books:

1. Medhi. J. (1982): Stochastic Process- Wiley Eastern.
2. Parzen E. (1962): Stochastic Process-Holden-Pay.
3. Karlin & Taylor (1975): A First Course in Stochastic Processes-Vol-I Academic Press.
4. Cinlar E. (1975): Introduction to Stochastic Process. Prentice Hall.
5. Srinivas and Mehta (1976): Stochastic Processes-Tata MgGraw-Hill.
6. Adke and Manjunath (1984): An introduction to finite Markov Processes- Wiley Eastern.
7. Bhat B.R. (2000): Stochastic Model: Analysis and Application- New Age International.
8. Sheldon Ross: Introduction to Probability Models, 11th Edition- Academic Press Publication

Paper No. VIII
Paper Code: HCT2.3

THEORY OF TESTING OF HYPOTHESES

Unit-1: Problem of testing of hypothesis: Simple and Composite hypotheses. Randomized and non-randomized tests. Most powerful test, Neyman-Pearson Lemma and its applications. Determination of minimum sample size to achieve the desired strengths. **(15 L)**

Unit-2: Monotone likelihood ratio (MLR) property, power function of a test, UMP tests and their existence for one-sided alternatives. UMP tests for two sided alternatives, their existence and non-existence. Examples. Generalized Neyman Pearson Lemma, Unbiased test, UMPU tests and their existence in the case of exponential families (Statements of the theorems only), Similar tests, Test with Neyman structure. **(15 L)**

Unit-3: Interval estimation, confidence level, construction of confidence intervals using pivots, shortest length confidence interval, UMA confidence interval and its relation to UMP test, UMAU confidence interval and its relation with UMPU test. **(15 L)**

Unit-4: Likelihood ratio test, application to standard distributions. Goodness of fit test based on Chi-square distribution, application to contingency tables. Non-parametric tests, One and two sample problem; Sign test, Run test, Wilcoxon Signed-Rank test, Mann- Whitney test. Definition of U-statistics, U-statistics theorem for one sample and two samples (statements only). **(15 L)**

Reference Books:

1. Kale B.K. (1999): A first Course on Parametric Inference-Narosa
2. Rohatgi V.K. (1988): Introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd. New Delhi. Student Edition.
3. Dudewicz E.J. & Mishra S.N.(1988): Modern Mathematical Statistics, Wiley Series
4. Lehman E.L. (1987): Theory of Testing of Hypotheses. Student Edition.
5. Srivastava M. and Srivastava N. (2009): Statistical Inference-Testing of Hypotheses, PHI Learning Pvt. Ltd.
6. Shanthakumaran A. (2001): Fundamentals of Testing of Hypotheses, Atlantic Publishers and Distributors.

Paper No. IX
Paper Code: SCT2.1

SAMPLING THEORY

Unit-1: Review of concept of population and sample, Need for sampling, Census and sample surveys, basic concepts in sampling and designing of large-scale survey design, sampling scheme and sampling strategy. Simple random sampling with and without replacement (SRSWR and SRSWOR). **(15 L)**

Unit-2: Stratified Sampling: Stratification, Allocation and estimation problems, Construction of Strata, deep stratification, method of collapsed strata. Systematic sampling: The sample mean and its variance, comparison of systematic sampling with random sampling, comparison of systematic sampling with stratified sampling, comparison of systematic sampling with simple and stratified random sampling for certain specified population. **(15 L)**

Unit-3: PPSWR Methods: Cumulative total method, Lahiri's method, related estimation problems, PPSWOR method and related estimation of a finite population mean (Horvitz-Thompson and Des Raj estimator for general sample size and Murthy's estimator for sample of size 2, Midzuno sampling, Rao-Hartley-Cochran sampling strategy, Poisson and modified Poisson sampling strategy. **(15 L)**

Unit-4: Use of supplementary information for estimation: Ratio and Regression estimators and their properties. Unbiased and almost Unbiased ratio type estimators, Double sampling, Cluster sampling, Two-stage sampling with equal number of second stage units. Non-sampling errors, Response and non-response errors, Hansen-Hurwitz and Deming's techniques. **(15 L)**

Reference Books:

1. Sukhatme P.V., Sukhatme P.V., Sukhatme S. and Ashok C. (1997): Sampling Theory of Surveys and Applications - Piyush Publications.
2. Des Raj and P. Chandhok (1998*):* Sample Survey Theory. Narosa publishing House.
3. William G. Cochran (1977): Sampling Techniques, 3rd edition- John Wiley & Sons.
4. Parimal Mukhopadhyay (1988): Theory and methods of Survey sampling, Prentice Hall of India Pvt. Ltd.
5. Murthy M.N. (1977): Sampling Theory and Methods, Statistical publishing Society, Calcutta.

Paper No. IX

Paper Code: SCT2.2

ACTUARIAL STATISTICS

Unit-1: Future life time random variable, its distribution function and density function, concept of force of mortality, curtate future life time random variable its probability mass function, deferred probabilities, all these functions in terms of international actuarial notation. Analytical laws of mortality such as Gompertz' law and Makeham's law, single decrement life table, select and ultimate life table **(15 L)**

Unit-2: Concept of compound interest rate, discount factor, present value of the money, nominal rate of interest, force of interest. Assurance contracts with level and varying benefits, such as whole life insurance, term insurance endowment insurance. Means and variances of the present value random variables of the payments under these contracts under the assumption of constant force of interest, when the benefit payments are made at the end of year (discrete set up) or when it is paid at the epoch of death(continuous set up). Actuarial present value of the benefit. Net single premiums. **(15 L)**

Unit-3: Annuity contracts, annuity certain, discrete annuity, m-thly annuity, continuous annuity, deferred annuity, present values and accumulated values of these annuities. Continuous and discrete life annuity, such as whole life annuity, temporary life annuity, n-year certain and life annuity, life annuities with mthly payments. Present value random variables for these annuity payments, means and variances. Actuarial present value of the annuity. (**15 L)**

Unit-4: Loss at issue random variable, various principle1s to decide net premiums for insurance products and annuity schemes defined in unit II and III, fully continuous premiums and fully discrete premiums, True m-thly payment premiums. Extended equivalence principle to decide gross premiums. Concept of reserve, prospective & retrospective approach. Fully continuous reserve.Fully discrete reserve. **(15 L)**

Reference Books:

1. Bowers, JR. N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, 2nd Edn., The Society of Actuaries.
2. Deshmukh S.R. (2009). Actuarial Statistics: An Introduction Using R, Universities Press. 3. Harriett, E.J. and Dani, L. L.(1999). Principles of Insurance: Life,Health, and Annuities, 2nd Edn., Life Office Management Association.
4. Neill, Alistair (1977). Life Contingencies, The Institute of Actuaries.
5. Palande, P. S., Shah, R. S. and Lunawat, M. L. (2003). Insurance in India - Changing Policies and Emerging Opportunities, Response Books.

Paper Code: OET2.1

STATISTICAL METHODS

Unit-1: Descriptive Statistics: Measures of central tendency, arithmetic mean, geometric mean, harmonic mean, median and mode for grouped and ungrouped data with examples. Measures of dispersion, range, quartile deviation, variance, standard deviation, coefficient of variation, skewness and kurtosis. Examples and problems. **(15 L)**

Unit-2: Correlation and regression: Scatter diagram, Karl Pearson's coefficient of correlation, rank correlation, regression, lines of regression, regression coefficients, fitting of regression lines. Examples and problems. **(15 L)**

Unit-3: Probability and Probability distributions: Random experiment, Trial, Sample space, Sample point and different types of events. Classical definition of Probability, addition and multiplication rules. Random variable (discrete and continuous) and its probability distribution. Probability mass function and Probability density function. Bernoulli, Binomial, Poisson, Uniform, Exponential and Normal distributions, their means and variances. **(15 L)**

Unit-4: Testing of hypothesis: Notion of hypothesis, null and alternative hypothesis, simple and composite hypothesis, test statistic, critical region, idea of one and two tailed test, type-I and type-II errors, level of significance, Hypothesis testing for mean and proportion. Hypothesis testing for difference of two means and two proportions. chi-square test for independence of attributes, Nonparametric run test, sign test and signed-rank test. **(15 L)**

Reference Books:

1. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics. Sultan Chand & Sons Publications, New Delhi.
2. Kapoor J.N and Saxana H.C *:* Mathematical Statistics, Sultan Chand & sons Publications, New Delhi
3. Kulkarni M.B., Gore A.P. and Ghatpande S.B.: Statistical Tests, Satyajeet Prakashan, Pune.

Paper Code: OET2.2

MATHEMATICAL STATISTICS

Unit-1: **Probability theory:** Sample space, Axioms of probability theory. Conditional probability, independent events. Baye's theorem, Examples.

Discrete random variables : Definition of a random variable, Probability mass functions and probability distribution functions, Bernoulli trials and related distributions, Poisson distribution, Discrete Uniform distribution, geometric distribution, Expectation and moments and their evaluation, Examples. **(15 L)**

Unit-2: Continuous random variables: Definition of a continuous random variable, Probability density function. Expectation and moments and their evaluation, uniform, exponential and gamma distributions, normal distribution. Distribution of functions of a continuous random variable, Examples. **(15 L)**

Unit-3: **Bivariate random variables:** Discrete bivariate distributions, continuous bivariate distributions. Covariance and correlation. Conditional distribution and conditional mean, Bivariate normal distribution, Examples. **(15 L)**

Unit-4: Generating functions: Probability generating function; moment generating function; and characteristic function; their properties.

Moment inequalities: Markov, Chebychev, Holder, Minkowski and Jensen inequalities with their applications. **(15 L)**

Reference Books:

1. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics. Sultan Chand & Sons Publications, New Delhi.
2. Kapoor J.N and Saxana H.C *:* Mathematical Statistics, Sultan Chand & sons Publications, New Delhi.
3. Bhat B. R. (1999): Modern Probability Theory (3rd ed.).New Age International (P) Ltd.

Statistics Practical Paper-3

Paper Code: HCP2.1

Use of Statistical Software Packages:

- MINITAB Software
- MATLAB Software
- R Software

1. At least four practicals should be conducted on hard core theory paper HCT 2.2.

2. At least four practicals should be conducted on hard core theory paper HCT 2.3.

3. At least four practicals should be conducted on soft core theory paper SCT 2.1/ SCT 2.2.

Statistics Practical Paper-4

Paper Code: OEP2.1/2.2

Use of Statistical Software Packages:

- MS-EXCEL Software

At least ten practicals should be conducted on open elective theory paper OEP 2.1 / OEP 2.2.