Syllabus for descriptive **Subject Aptitude Test (SAT)** for the recruitment to **post of Research Officer (Class-I Gazetted) in the Department of Economics and Statistics, H.P**. The SAT paper shall have two parts i.e. Part-I and Part-II and cover the following topics of **Master Degree (Statistics) level.**

PART-I (60 MARKS)

1. LINEAR ALGEBRA:-

Matrices: Determinant and trace, ranks of product of two matrices, Sylvester's law, Frobenius inequality. Elementary matrices and Echelon forms. Partitioned matrices: addition, multiplication and inverse, **Review of basic notions of vector spaces; Subspaces, Linear Transformations:** kernel and range, rank and nullity theorems, inverse transformations, matrices of linear transformations. Change of basis, similarity, **Inner product spaces:** norms, orthogonal bases. Cauchy-Schwarz inequality, Gram Schmidt orthogonalization, orthogonal projection, Bessel's inequality. Unitary and orthogonal transformations. Holder and Minkowski inequalities, **Eigen values and eigenvectors:** Cayley Hamilton Theorem, diagonalization, triangulization, unitary diagonalization. Spectral theorem for normal matrices, Jordan decomposition and singular value decomposition of matrices (only methods and not proofs). Generalized inverse: Definition and its computation, **Quadratic forms:** definite and semi definite quadratic forms, index and signatures, simultaneous diagonalization of symmetric matrices (equivalent quadratic forms).

2. DISTRIBUTION THEORY:-

Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability, combinatorial problems. Product sample spaces, conditional probability, Bayes' formula. Random variables (discrete and continuous), Distribution Function and its properties, expectation and variance. Bivariate random variable, joint, marginal and conditional pmfs and pdfs, correlation coefficient, conditional expectation. Functions of random variables and their distributions using Jacobian of transformation and other tools. Probability Integral transformation, order statistics and their distributions (continuous case only), Markov, Chebyshev and Jensen inequalities, Moment generating, Characteristic and probability generating functions, Discrete Distributions: Bernoulli, Binomial, Poisson, Hyper-geometric, geometric, negative binomial, uniform. Continuous Distributions: Uniform, normal, exponential, gamma, Beta, Cauchy, Weibull, Pareto, Chi-square, Laplace and Lognormal. Bivariate normal and multinomial distributions, Convergence in distribution. De-Moivre-Laplace and Lindeberg-Levy forms of Central Limit Theorem, Approximating distribution of a function of a statistic (Delta method).

3. STATISTICAL METHODS WITH PACKAGES:-

Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart. Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis, **Sampling distributions**: Normal, Chi-square, t and

F distributions and their relations. Population, random sample, parameter, statistic and sampling distribution. Sample mean and sample variance associated with a random sample from a normal distribution: their independence, sampling distributions, expectations and standard errors, **Tests of Significance**: Statistical hypotheses, Type I and II errors, level of significance, test of significance, concept of p-value. Tests of significance for the parameters of normal distribution (one sample and two sample problems) and the relevant confidence intervals. Chi-square test of goodness of fit and independence of attributes. Test of significance for correlation coefficient ($\rho = 0$, $\rho = \rho_0$), Data on two attributes, independence and association of attributes in 2x2 tables. Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots, **Vital Statistics (basics of demography)**: Rates of vital events, measurements of mortality, crude death rate, specific and standardized death rates. Life tables (description and construction). Measurement of fertility, crude birth rate, general fertility rate, age-specific and total fertility rates. Measurement of population growth, crude rate of natural increase and vital index, gross and net reproduction rates, **Index Numbers:** Meaning of index number. Problems in construction of index numbers: purpose of the index, choice of base period, choice of commodities, choice of weights, interpretation of the index. Laspeyer's, Paasche's and Fisher's index numbers. Errors in index numbers, tests for index numbers, cost of living index numbers. Uses of index numbers (real wages, splicing and deflating), **Time Series:** The four components of an economic time series. Trend determination: by mathematical curve fitting and by moving average methods. Measurement of seasonal variations: ratio to moving average method, ratio to trend method, **Use of Statistical packages**: Topics should include graphic representation of data, descriptive statistics, simple hypothesis tests, correlation and linear regression.

4. REAL ANALYSIS:-

Sequence of sets, limit sup and limit inf of a sequence of sets. Countable and uncountable sets, open and closed intervals (rectangles), compact sets, Bolzano-Weirestrass theorem (statement only). Heine – Borel theorem (statement only). Properties of continuous functions on compact sets, Functions of bounded variation and their properties. Riemann-Stieltjes integral. Integration by parts, change of variable. Mean value theorems. Differentiation under integral sign. Term-by-term differentiation and integration of an infinite series of functions, Fourier series of a function relative to an orthogonal system of functions, convergence of Fourier series to its defining functions.

5. NUMERICAL TECHNIQUES USING C:-

Hardware Concepts: Introduction and use of Computers, Computer system components and functions. The central processing unit, Input/Output Devices, Primary and Secondary memory. Overview of existing hardware configuration, **Software Concepts**: Overview of operating systems, types and functions of operating system, application software, overview of existing software packages for general and statistical use. Introduction to flowcharts and algorithms, **'C' Programming**: Introduction, constants, variables, keywords, Arithmetic Statements, Hierarchy of operations, Input/Output statement, control statements: Decision control statements, Loops (for, while, do-while), goto statement, Case control structure, Functions, Pointers, Recursion, Arrays, Strings, Structures, File handling, **Transcendental**

and Polynomial equations: Bisection method, Iteration methods based on first degree equation (Regula falsi Method, Secant method, Newton-Raphson Method), iteration method based on second degree polynomial (Mullar Method, Chebyshev Method). Rate of convergence of Secant and Newton Raphson method. General iteration methods (first and second order). Aitken's $\square^2$ method (Acceleration of convergence). Method for Complex Roots. Polynomial Equations: iterative methods (Birge-Vieta Method, Bairstow Method), Choice of an iterative method & implementation, **System of Linear Algebraic equations:** Direct Methods: Forward substitution and Backward substitution, Cramer Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization Method, Cholesky Method, Partition Method. Iteration methods: Jacobi iteration method and Gauss-Seidal iteration method, **Interpolation and approximation:** Lagrange & Newton interpolations, finite difference operators, interpolating polynomial using finite differences, Gregory Newton Forward and Backward difference interpolation, Stirling and Bessel interpolations, Hermite interpolation, bivariate interpolation (Lagrange bivariate interpolation, Newton's bivariate interpolation for equispaced points). Approximation (Weierstrass approximation), **Numerical Differentiation:** Methods based on interpolation, finite difference operators, undetermined coefficients. Extrapolation Methods, **Numerical Integration:** Methods based on interpolation (Newton Cotes method, Trapezoidal rule, Simpsons $1/3^{rd}$& $3/8^{th}$ rule). Method based on undetermined coefficients (Gauss-Legendre integration Method), Composite integration methods (Trapezoidal Rule, Simpson's Rule), Romberg integration, double integration.

6. ESTIMATION AND TESTING OF HYPOTHESES:-

Estimation: Introduction to the problem of estimation. Concepts of unbiasedness, sufficiency, consistency, efficiency, completeness, Unbiased estimation: Minimum and uniformly minimum variance unbiased estimation, Rao-Blackwell and Lehmann-Scheffe theorems. Ancillary statistic, Basu's theorem and its applications. Fisher information measure, Cramer- Rao inequality. Chapman-Robin inequality. Bhattacharya bounds. Methods of estimation: method of moments, maximum likelihood estimation, minimum chi-square method, method of scoring. Basic ideas of Bayes and Minimax estimators, **Tests of Hypotheses**: Concepts of critical regions, test functions, two kinds of errors, size function, power function, level of significance. MP and UMP tests in a class of size $\square$ tests. Neyman - Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper or lower end depends on the parameter and to distributions with MLR property. Non-existence of UMP test for simple null against two-sided alternatives in one parameter exponential family. Likelihood Ratio Tests. Wald's SPRT with prescribed errors of two types, **Interval estimation:** Confidence interval, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses. Tests of hypotheses and interval estimation viewed as decision problems with given loss functions.

7. SAMPLING THEORY AND OFFICIAL STATISTICS:-

Sample Surveys: Introduction to usual notations used in sampling. Basic finite population sampling techniques: SRSWOR, SRSWR, stratified, systematic and related results on estimation of population mean/ total. Relative precision of different sampling techniques. Allocation problem in stratified sampling, Ratio and regression estimators based on SRSWOR method of sampling. Two-stage sampling with equal size of first stage units. Double sampling for ratio and regression methods of estimation. Cluster sampling - equal clusters, **Unequal probability sampling:** PPS WR/WOR methods [cumulative total, Lahiri's schemes] and related estimators of a finite population mean [Thompson-Horwitz, Yates and Grundy estimator, Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2], National sample surveys organization (NSSO) and role of various statistical organizations in national development. Scope and contents of population census in India. Review of national income and their estimates.

PART-II (60 MARKS)

1. COMPLEX ANALYSIS:-

Complex Numbers, geometrical representation of complex numbers, functions of a complex variable, differentiability and analyticity, Cauchy-Riemann conditions, Elementary, exponential and logarithmic functions, Power series, radius of convergence, differentiation of a power series, Taylor's and Laurent's series, Residues. Integration of a function of a complex variable, Cauchy's theorem and Cauchy's Integral theorem (Statement and applications only), Applications of Residues: Evaluation of definite and improper integrals.

2. NONPARAMETRIC INFERENCE:-

Estimable parametric functions, kernel, symmetric kernel, one sample U-Statistic. Two sample U- Statistic, asymptotic distribution of U-Statistics, UMVUE property of U-Statistics, Empirical distribution function, confidence intervals based on order statistics for quantiles, tolerance regions, **Tests for randomness:** Tests based on the total number of runs and runs up and down. Rank-order statistics. One sample and paired-sample techniques: sign test and signed-rank test. Goodness of fit problem: Chi-square and Kolmogorov-Smirnov tests, **The General Two sample Problem:** Two sample stochastic dominance problem, stochastic modeling of two sample location and scale problems in Nonparametric setting.Wald Wolfwilz run test and Kolmogorov –Smirnov two sample test, **Linear Rank Statistics:** Linear Rank Statistics and its limiting distribution, Rank test, MP and LMP rank tests. Tests for two-sample location problem: Wilcoxon-Mann-Whitney, Terry-Hoeffding, Van der Waerden, Median tests. Tests for two-sample scale problem: Mood, Klotz, Capon, Ansari-Bradley, Siegel – Tukey and Sukhatme tests. Pitman asymptoitic relative efficiency. Independence in bivariate sample: Kendall's and Spearman's rank correlation, **Tests for the c-sample problem:** Kruskal-Wallis, Jonckheere- Terpstra tests. Concepts of Jackknifing, method of Quenouille for reducing bias, Bootstrap methods.

3. STATISTICAL PROCESS AND QUALITY CONTROL:-

The meaning of quality, quality assurance, technology and productivity. Statistical methods for quality–control and improvement, Chance and assignable causes of quality variation, general theory of control charts, control charts for variables: X and R chart, analysis of

pattern on control charts, control chart for attributes- np, p, c and u charts. Type I & Type II error and β risk for Control chart for variables & attributes along with the ARL of these Charts. Multiple stream processes: Group control charts. Specification limits and tolerance limits and modified Control limits, **The cumulative-sum control charts (cusum-charts):** using v – mask, A.R.L of cusum charts, exponentially weighted moving average control charts, control charts based on Moving Average, Process capability analysis, introduction, Capability indices- C_p , C_{pk} and C_{pm}. Estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics, **Acceptance sampling plans for attribute inspection:** single, double and sequential sampling plans and their properties, including OC, AOQL, ATI and ASN curves. Plans for inspection by variables for one- sided and two-sided specifications. Specification of sampling plan by LTPD and AOQL. Mill Std plans, Dodge and Rooming tables. Some brief introduction to Bayesian Sampling plan.

4. LINEAR INFERENCE:-

Non central sampling distributions associated with univariate normal distribution, central and non central sampling distributions associated with bivariate normal distribution, distributions of quadratic form in normal random variables. Fisher- cochran theorem and its applications. Symmetric normal distribution, distribution of intra class correlation coefficient, Point and interval estimates, best linear unbiased estimates, construction of confidence intervals of the parameters of linear model, Gauss-Mark off set-up, normal equations, least squares estimates and their precision, use of g-inverse, statements and applications of fundamental theorems of least squares, Introduction to fixed, mixed and random effect models. Tests of significance and interval estimates based on least squares theory in one-way and two-way classified data, a general model for two-way data, Bartlett test for testing of homogeneity of variances, **Regression Analysis :** Simple and multiple regression, model validation, tests about correlation (using Z-transformation) and regression coefficients. Quadratic and cubic regression models including their geometrical interpretation, idea of nonlinear regression. Orthogonal Polynomials and their fitting. Analysis of covariance. Models for binary response –logistic regression model.

5. MULTIVARIATE ANALYSIS:-

Multivariate normal distribution: definition, conditional & marginal distributions, characteristic function. Random sample from multivariate normal distribution. Maximum likelihood estimators of parameters. Distributions of sample mean vector and variance-covariance matrix and their independence, Null distribution of partial and multiple correlation coefficient. Application in testing and interval estimation, Null distribution of Hotelling's T^2 Statistic. Application in tests on mean vector for one and more multivariate normal populations and test of symmetry. Mahalanobis D^2 and its sampling distribution, Wishart distribution and its properties. Discriminant Analysis and Classification of a discriminant procedure for discriminating between two multivariate normal populations, Sample discriminant function and tests associated with discriminant functions, probabilities of misclassification and their estimation. Cluster analysis, Generalised variance and distribution of sample generalized variance, Wilk's criterion and Multivariate Analysis of Variance [MANOVA] of one-way classified data. Testing independence of sets of variates

and equality of covariance matrices, Principle components, Analysis and dimension reduction: Canonical variables and canonical correlation: definition, use, estimation and computation.

6. DESIGN AND ANALYSIS OF EXPERIMENTS:-

Three basic principles of design of experiments: randomisation, replication and local control. Design useful for one-way elimination of heterogeneity. Completely randomised, randomised complete block and balanced incomplete block designs. Concepts of balancing, orthogonality, connectedness and properties of C-matrix. General inter and intra block analysis of incomplete block designs, Factorial Experiments, 2^2, 2^3, 3^2 and 3^3 factorial designs. Confounding in factorial designs: Complete confounding, partial confounding, fractional replication and split-plot designs. Design useful for two-way elimination of heterogeneity and their general method of analysis by using fixed effect model, Latin squares, Graeco Latin squares and Youden squares designs, Missing plot techniques, illustrations of construction of s x s mutually orthogonal Latin squares and balanced incomplete block designs (by using finite geometries, symmetrically repeated differences and known B.I.B. designs).

7. ACTUARIAL STATISTICS:-

Probability Models and Life Tables: Loss distributions: Modelling of individual and aggregate losses, moments, fitting distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance, **Risk models:** models for individual claims and their sums, Distribution of aggregate claims, Compound distributions and applications, Introduction to credibility theory, Survival function, curtate future lifetime, force of mortality. Multiple life functions, joint life and last survivor status, Multiple decrement model, **Life Contingencies: Principles of compound interest:** Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, **Assurance and annuity contracts:** Definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various c ontinuous and discrete payments, **Calculation of various payments from life tables:** principle of equivalence, netpremiums, prospective and retrospective provisions/reserves.

Or

CATEGORICAL DATA ANALYSIS:-

Categorical response variables: Nominal, ordinal, interval Categorical data describing two-way contingency tables, measures of nominal and ordinal association, inference for two-way contingency tables, likelihood functions and maximum likelihood estimates, testing goodness of fit and testing independence. Screening tests, sensitivity, specificity, and predictive value positive and negative, partitioning chi-squared, large sample confidence intervals, delta method to estimate standard error, exact tests for small samples, Models for binary response variables: Generalized linear models, logit, log linear, linear probability and logistic regression models. Logit models for categorical data, probit and extreme value models, models with log-log link, model diagnostics, Fitting logit models, conditional logistic regression, exact trend test. Loglinear models for two dimensions –independence model, saturated model and models for cell probabilities. Log linear model for three dimensions.

Fitting Loglinear models. Strategies in model selection, analysis of residuals, Cochran-Mantel-Haenszel test.

Or

ECONOMETRICS:-

Nature of econometrics. The general linear model (GLM) and its assumptions. Ordinary least squares (OLS) estimation and prediction. Significance tests and confidence intervals, linear restrictions. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances, Auto correlation, its consequences and tests. Theil's BLUS procedure. Estimation and prediction.Multicollinearity problem, its implications and tools for handling the problem. Ridge regression, Linear regression with stochastic regressors. Instrumental variable estimation, errors in variables. Autoregressive linear regression. Distributed lag models: Partial adjustment, adaptive expectation and koyck's approach to estimation, Simultaneous linear equations model, examples. Identification problem. Restrictions on structural parameters – rank and order conditions. Restriction on variance and covariances, Estimation in simultaneous equations model. Recursive systems. 2 SLS estimators, k-class estimators. 3SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals. Monte Carlo studies and simulation.

Or

ECONOMIC STATISTICS:-

The theory of Consumer Behaviour: Utility function, indifference curves and their properties, price and income elasticities, substitution and income effects, **The Theory of the Firm**: Production function, output elasticity, elasticity of substitution. Optimizing behaviour: Output maximization, cost minimization and profit maximization. Cost functions: Short run and long run. Homogeneous production functions: Cobb-Douglas and CES Functions, **Market Equilibrium**: The perfect competition. Demand functions, supply functions, commodity marketequilibrium. Imperfect competition: Monopoly & equilibrium of the firm under monopoly. Profit Minimizations under Monopoly. Monopolistic competition, **Size Distribution of Income**: A Review. Distribution patterns and descriptive analysis. Income distribution functions: The Pareto law, Pareto –Levy law, week Pareto law, lognormal distribution, **Inequality of income:** Gini coefficient, Lorenz curve mathematically & its deviation for some well- known income distributions.

Or

ADVANCED INFERENCE:-

Review of convergence in probability and convergence in distribution, Cramer and Slutsky's Theorems, Consistent Estimation of real and vector valued parameters. Invariance of Consistent estimator under continuous transformation, consistency of estimators by method of moments, and method of percentiles, mean squared error criterion, asymptotic relative efficiency, error probabilities and their rates of convergence. Minimum sample size required to attain given level of accuracy, Consistent Asymptotic Normal (CAN) estimator, invariance of CAN estimator under differentiable transformation, CAN property of estimators obtained by moments and percentiles, CAN estimators obtained by moment, CAN estimators for one-parameter Cramer family, Cramer – Huzurbazar theorem, MLE method in one parameter

exponential family, extension to multi-parameter exponential family, examples of consistent but not asymptotically normal estimators from Pitman family. Method of maximum likelihood, Solution of likelihood equations, method of scoring, Newton – Raphson and other iterative procedures, Fisher Lower bound to asymptotic variance, extension to multi-parameter case (without proof). Multinomial distribution with cell probabilities depending on a parameter, MLE in Pitman family and double exponential distribution, MLE in censored and truncated distributions, Likelihood Ratio Test (LRT), asymptotic distribution of LRT statistic, Wald test, Rao's score test, Pearson's chi-square test for goodness of fit, Bartlett's test for homogeneity of variances. Large sample tests and confidence intervals based on CAN estimators, variance stabilizing transformation and large sample tests. Consistency of large sample tests, asymptotic power of large sample tests.

Or

MEASURE & PROBABILITY THEORY:-

Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma-field in R^k. Measure, probability measure,properties of a measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue- Stieljes measures on R^k. Measurable functions, Convergence in measure. Integration of a measurable function with respect to a measure, Fatou's Lemma, Monotone convergence theorem, Random variables, sequence of random variables. Limit Supremum & limit infimum, Borel Cantelli Lemma. Almost sure convergence, convergence in probability. Convergence in distribution, characteristic function, uniqueness theorem, inversion theorem (statement and applications only), Levy's continuity theorem (statement only), CLT for a sequence of independent random variables under Lindeberg's condition, CLT for iid random variables.

Or

OPERATIONS RESEARCH:-

Origin and development of operations research (O.R), modelling in O.R., applications of O.R., opportunities and shortcomings of O.R., Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the (LPP), generating extreme point solutions. The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, The artificial basis technique: Two phase method and Charnes M-method with artificial variables. The duality problem of linear programming and its economic interpretation, Transportation and assignment problems. Sensitivity analysis, network flow problem. Game theory problem as a linear programming problem, Integer programming, Replacement models, Sequencing theory, inventory models with single and multiple periods.

Or

RELIABILITY:-

Reliability concepts and measures: components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular decomposition, bounds on system reliability, structural and reliability importance of components, Life distributions and associated survival, conditional survival and hazard rate functions. Exponential, Weibull, gamma life distributions and estimation of their parameters, **Notions of ageing:** IFR IFRA, NBU, DMRL, NBUE, and HNBUE classes; their duals and relationshipsbetween them. Closures of

theses classes under formation of coherent systems, convolutions and mixtures, **Partial orderings:** convex, star, stochastic, failure rate and mean-residual life orderings. Univariate shock models and life distributions arising out of them, Maintenance and replacement policies, availability of repairable systems.

Or

SIMULTANEOUS INFERENCE:-

Introduction to simultaneous inference, error rates, Bonferroni inequality, p-mean significance levels, basic techniques of multiple comparisons and their geometrical interpretation for the case of two means, Studentized range, Scheffe's F-projections, Bonferroni t-statistics, studentized maximum modulus, many-one t- statistics, Duncan's multiple range test, Newman-Keuls test, Fisher's LSD test, Tukey's gap-straggler-variance test, Two-sample confidence intervals of predetermined length, and improved Bonferroni inequality, Many-one sign statistics, k-sample sign statistics, many-one rank statistics, k-sample rank statistics, signed-rank statistics, Kruskal-Wallis rank statistics, Friedman rank statistics, and permutation test, Multivariate techniques: Single population with covariance scalar unknown, single population with covariance matrix unknown.

Or

STATISTICAL SIMULATION AND COMPUTATION USING R:-

R Programming: Installing R, working directory, Arithmetic, Variables, functions, Vectors, Missing Data, Expressions and Assignments, logical expressions, Matrices, Basic Programming;(if, for, while, Vector- based programming), Input and output, Programming with functions, Recursive programming, Factors, Data frames, Lists, The apply family, **Simulation:** Introduction, Systems, Models, types of models, need of simulation, Monte Carlo method, physical versus digital simulation: Buffen's needle problem, **Random Number Generation:** Mid square method, Congruential generators, Shift generator, statistical tests for pseudo random numbers, **Pattern Recognition:** Introduction, Basic Concepts, Fundamental problems, Design concepts and methodologies, Examples of automatic systems, Pattern Recognition model, and Pattern classification by likelihood functions, **Random Variate Generation:** Inverse transformation method, Acceptance-Rejection method, Composition method. Simulation of Random vectors, Multivariate transformation method, Generation from Multinormal distribution, Generating random variates from continuous distributions, **Monte Carlo integration:** Hit or miss Monte Carlo method, sample mean Monte Carlo method, Efficiency of Monte Carlo method, **Variance Reduction Techniques:** Introduction, Importance sampling, Correlated sampling, Control variates, Stratified sampling.

Or

STOCHASTIC PROCESSES:-

Introduction to Stochastic Processes. Classification of stochastic processes according to state space and time domain. Processes with independent increments, stationary processes. Markov chains, classification of states of a Markov chains, Chapman-Kolmogorov equations, n-step transition probability matrices and their limits, stationary distribution. Random walk and gambler's ruin problem, Applications of stochastic processes. Stationarity of stochastic

processes, autocorrelation, power spectral density function, Poisson process, birth and death processes, Elementary Queueing Models: M/M/1, M/M/c models, **Renewal theory:** Renewal process, elementary renewal theorem and applications. Statement and uses of key renewal theorem, **Branching process**: Galton-Watson branching process, probability of ultimate extinction, distribution ofpopulation size.

Or

SURVIVAL ANALYSIS:-

Concepts of Type-I (time), Type-II (order) and random censoring likelihood in these cases. Life distributions, exponential, gamma, Weibull, lognormal, Pareto, linear failure rate. Inference for exponential, gamma, Weibull distributions under censoring, Failure rate, mean residual life and their elementary properties. Ageing classes and their properties, bathtub failure rate, **Estimation of survival function** – Actuarial estimator, Kaplan –Meier estimator, Tests ofexponentiality against non-parametric classes: Total time on Test, Deshpande Test, **Two sample problem**: Gehan test, Log rank test. Mantel-Haenszel test, Cox's proportional hazards model, competing risks model.

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