SARDAR PATEL UNIVERSITY

DEPARTMENT OF STATISTICS
FACULTY OF SCIENCE
COURSE OF STUDY

RULES OF DEGREE OF THE MASTER OF SCIENCE (M.Sc.) STATISTICS

R.PG.Sc.1: A candidate who has obtained the degree of Bachelor of Science/Arts (Statistics) of this University or of any other University recognized as equivalent thereto, or a candidate who has obtained Bachelor of Science (General) degree with statistics as one of subjects or a student who has studied statistics at second year B.Sc of the University and obtained his B.Sc in Mathematics or Computer Science is eligible for the M.Sc. course in the Department.

R.PG.Sc.2: The M.Sc. course is divided in to four semesters. The teaching, evaluation of the various theory papers and laboratory work will be conducted under the semester system. For this purpose each academic year is divided into two semesters.

R.PG.Sc. 3: Candidates will be examined in each Theory paper for 100 marks and practicals for 100 marks wherever prescribed at the end of each semester. Project work will be undertaken during IV semester. There shall be a viva-voce examination of 50 marks at the end of each semester to be held by the University.

For deciding result of M.Sc. examination at each semester the ratio between the internal assessment and external assessment will be 30:70. For the purpose of internal assessment, the Department concerned will conduct at least one test in each semester. The Department will also arrange Quiz, Seminar etc. for internal assessment in theory course work. The distribution of marks will be as under: -

1. Structure for each theory paper:

   a) Quiz .. .. .. 5 marks
   b) Seminar .. .. .. 5 marks
   c) Test .. .. .. 20 marks

   Total 30 marks
2. Structure for each practical

| a) Regularity, records and results | … | 10 marks |
| b) Test | … | … | 20 marks |
|-----------------|---|---|
| **Total**       |   | 30 marks |

R.PG.Sc. 4: Every student is supposed to undertake a project work under the guidance of a teacher assigned by the Head of the Department. He/She may be allowed to have external guide from the place he/she will be doing the project. At the end of the project work students should submit, duly certified by the guide(s), two typed and bound volumes of the project report. The guide(s) evaluate the thesis for 50 marks. There will be a common board of examiners with at least an external examiner for the conduct of Project Viva. The students will be assessed for 50 marks by this board. In the final mark sheet the sum total of marks given by the guide(s) and the marks obtained in Project Viva will be entered against the Head “S-707 Project”. A student will be declared pass if he/she scores at least 40 marks.

R.PG.Sc. 5: Candidate shall be required to attend at least 75% of total theory lectures, practicals organized under each of the courses during the semesters. In project work student should work up to the satisfaction of the assigned project guide(s).

R.PG.Sc. 6: (i) The Head of the Department in consultation with other teachers of the department will prepare in the beginning of the year a detailed scheme of seminars, home work, quizzes, etc, and the Programme for the test examinations and the same will be announced to the candidates.

(ii) The records of the test examinations as well as seminars, homework, quizzes etc. will be maintained by the concerned faculty.

(iii) Every candidate shall maintain a regular record of his/her practical work that shall be duly certified by his/her teacher(s) from time to time.

R.PG.Sc. 7: Candidates will be required to obtain at least 33% marks in the internal evaluation separately in each head of passing. A candidate who fails to obtain 33% marks in not more than two heads of passing, may be allowed to appear at the University examination by the head of the department concerned on the recommendation of the committee appointed by him to assess the candidate's overall performance. (Note: A Head of passing will mean a course in theory or practical or project work).

R.PG.Sc. 8: A candidate desirous of appearing at each semester examination may forward his application in the prescribed form to the Registrar through the
Head of the University Post-graduate Department concerned on or before the date prescribed.

R.PG.Sc.9: The final result for the award of the degree will be declared on the basis of the grand total of all the Theory papers, Practicals, Project work and Viva-Voce Examinations prescribed for all the four semesters.

R.PG.Sc.10: Only those students who fail in not more than two heads of passing at each semester examination be allowed to keep terms at the next semester. No candidate will be allowed to reappear for the course in which he/she has already passed.

R.PGSc.11: Standard of passing:

The standard of passing at the M.Sc. degree examination will be as under:

(a) To pass any semester for the M.Sc. degree, a candidate must obtain at least 40% marks at the University Examination and 40% marks in the aggregate of University and Internal examination in each course of Theory, Practical and Project work and 40% marks in Viva-Voce Examination.

(b) Award of Classes:

(i) The successful candidates will be placed in Second class if they obtained at least 50% or more marks but less than 60% in the aggregate of all semesters examination taken together.

(ii) The successful candidates will be placed in First Class if they obtain at least 60% or more but less than 70% of the total marks in the aggregate of the all the semesters examinations taken together.

(iii) The successful candidates in First Class who obtain at least 70% or more marks in the aggregate all the semesters examinations taken together will be declared to have passed the examination in First Class with Distinction.

R.PG.SC.12:(i) A candidate who fails in more than two courses (any two of the total heads of passing in the particular semester) in a particular semester will not be admitted for further study at a subsequent semester and will be required to repeat the courses in which he/she has failed by joining the department as a regular student in the semester in which these courses are again offered. A candidate failing in not more than two courses at any semester examination will be promoted to the subsequent semester according to the following scheme:

(ii) A candidate failing in the First Semester will be permitted to prosecute his/her study up to the Third Semester but will not be permitted to go to the Fourth Semester until he/she has cleared all the courses of the First Semester even though he/she may have passed in the Second
and/or Third semester. A candidate failing in the Second Semester; will be permitted to prosecute his studies up to the Fourth Semester.

R.PG.Sc. 13: The following will be the course structure of M.Sc Programme in Statistics.
# M.Sc. Statistics

**I SEMESTER**

- **S 401** Probability Theory I
- **S 402** Matrix Algebra
- **S 403** Distribution Theory
- **S 404** Statistical Inference I
- **S 405** Statistical Computing
- **S 406** Practicals
- **S 407** Viva-voce

**II SEMESTER**

- **S 501** Probability Theory II
- **S 502** Linear Models and Regression Analysis
- **S 503** Statistical Inference II
- **S 504** Theory of Sample Surveys
- **S 505** Operations Research
- **S 506** Practicals
- **S 507** Viva-voce

<table>
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<th>Semester III</th>
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<tr>
<td><strong>S 601</strong> Deign of Experiments</td>
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<tr>
<td><strong>S 602</strong> Multivariate Analysis</td>
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<td><strong>S 603</strong> Reliability and Life Testing</td>
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<td><strong>S 604</strong> Stochastic Processes</td>
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<td><strong>S 605</strong> Practicals</td>
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<tr>
<td><strong>S 607</strong> Viva Voce</td>
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<tr>
<th>Semester IV</th>
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<tr>
<td><strong>S 701</strong> Computer Oriented Statistical Methods</td>
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<td><strong>S 702</strong> Statistical Quality Control Techniques</td>
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<tr>
<td><strong>S 703(A)</strong> Econometrics or <strong>S 703(B)</strong> Time Series</td>
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<tr>
<td><strong>S 704 Actuarial Statistics</strong></td>
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<td><strong>S 705 Practicals</strong></td>
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<td><strong>S 706 Project</strong></td>
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<td><strong>S 707 Viva Voce</strong></td>
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<th>Optional Courses</th>
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<tr>
<td>Financial Statistics</td>
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<td>Biostatistics</td>
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<tr>
<td>SF 704 Actuarial Statistics</td>
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<td>SB 704 Clinical Trials</td>
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<td>SF 704(A) Econometrics or SF 704(B) Time Series</td>
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<tr>
<td>SB 703 Bioassays</td>
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R.PG.Sc. 14: The following will be the marking scheme for the above-mentioned course.

**MARKING SCHEME IN DETAIL**

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>SUBJECT</th>
<th>INTERNAL</th>
<th>EXTERNAL</th>
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<td>I</td>
<td>S 401: Probability Theory I</td>
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<td>S 402: Matrix Algebra</td>
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<td>S 403: Distribution Theory</td>
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<td>S 407: Viva-Voce</td>
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<td>II</td>
<td>S 501: Probability Theory II</td>
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<td>S 502: Linear Models and Regression Analysis</td>
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<td>S 507: Viva-Voce</td>
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Convergence of sequence of sets, fields and sigma fields, monotone classes, Borel sets in R and R^n.

Additive set function, measures, probability measures, \(\sigma\)-finite measures, properties of measures, Caratheodory extension theorem (statement only), its application for the construction of Lebesgue and Lebesgue-Steiltjes measures.

Measurable functions, Borel measurable functions, convergence almost everywhere, convergence in measure.

Integration of measurable functions with respect to a measure, properties of integral.

Monotone convergence theorem. Fatou’s lemma, the dominated convergence theorem, its application to differentiation under integral sign.

Absolute continuity and singularity of measure, Lebesgue decomposition theorem and Radon-Nikodym theorem (statement only), product measures and iterated integrals, statement of Fubini’s theorem.

Introduction of probability space, random variables and random vectors, expectations, moments, convergence in probability, convergence almost surely in context of units 1 and 2.

Books Recommended:


S 402  MATRIX ALGEBRA

Vector Spaces, Subspaces, linear independence, spanning set and basis, dimension, linear transformation, kernel, range, gram-schmidt orthogonalization, Orthogonal Projection, Matrix Representation of a linear transformation.

Algebra of Matrices, canonical forms, diagonal form, Triangular form, Jordon Form, Inner-product spaces, Trace and Rank of a Matrix and their properties, Determinants, Inverse, Determinant and Inverse of special matrices, orthogonal and idempotent matrices and their properties.

Kronecker Product and Hadamard Product

6L

Matrix Factorizations

8L

Eigen Value and Eigen vectors, spectral decomposition, singular value decomposition, Quadratic forms, definiteness and related results with proofs.

6L

Generalized inverses(g-inverses) and related results with proofs, Methods of constructing g-inverses, general solution to a system of linear equations,

5L

Matrix derivatives and Jacobians

2L

Matrix inequalities

2L

Applications in Statistics

3L

Books Recommended:


S 403 DISTRIBUTION THEORY


Order statistics: their distributions and properties. Joint and marginal distributions of order statistics. Extreme value and their asymptotic distributions (statement only) with applications. Probability integral transformation, Rank orders and their exact null distributions. One and two sample examples of rank statistics such as sign statistic, Wilcoxon signed rank statistics, Wilcoxon two sample statistics etc.

Books Recommended:

S 404 STATISTICAL INFERENCE I

Sufficiency; factorization criterion, minimal sufficiency; completeness; Exponential family of distributions and its properties. Non-regular families admitting complete sufficient statistics.

Chapman-Robbin’s inequality, Bhattacharya system of lower bounds in case of single parameter; Rao-Cramer lower bound for multiparameter case

Unbiased estimators; Uniformly Minimum Variance Unbiased Estimators (UMVUE); Rao-Black and Lehmann-Scheffee theorems.

Maximum Likelihood Estimators (MLEs); asymptotic properties of MLEs; Newton-Raphson Method and Method of Scoring.

Equivariance; the principle of equivariance; location – scale family and their properties; Pitman’s minimum risk equivariance estimators.

Baye’s estimators: Statistical Problems viewed as problems of game theory; loss function; risk function; prior and posterior distributions; Bayes risk; Baye’s estimators of parameters and parametric functions for squared error loss functions.

Consistency and asymptotic normality of real and vector valued estimators of parameters; Best asymptotic normal estimators.

Books Recommended:
S 405 STATISTICAL COMPUTING WITH C++

Introductory Concepts: Algorithm, Programming logic. 2L
Structure of C++ program, Preprocessors, Header Files. 2L
Data Types: int, char, float, bool, enumeration. 5L
Operators, I/O statements. 3L
Control Statements: if, switch, for loop, while loop, do-while loop, break and continue statements. 8L
Arrays: one dimensional and multidimensional, array declaration, array initialization, processing with arrays, etc. 5L
Strings as a character array, manipulation of strings. 3L
Functions: introduction, defining function, return statement, types of functions, recursive functions, function overloading, call by value and call by reference, using arrays as function arguments, functions having default arguments. 8L
File Handling. 2L
Pointers: pointer declaration, pointer arithmetic, pointers and functions, pointers and arrays. 5L
Scope and Lifetime of Variables: local, global, static, automatic, external, register. 2L
Practicals: Writing some useful C++ programs for Statistical Computing.

Books Recommended:
Random variables, expectations, moments.

Holder’s inequality, Minkowski’s inequality, Schwartz’s inequality, Markov’s inequality, Jensen’s inequality.

Probability distribution of a random variable, distribution function (d.f.), the change of variable theorem, mixtures of distributions with examples, joint d.f.s, Jordon decomposition theorem (only statement), decomposition of mixture d.f.s into absolutely continuous and singular parts.

Convergence of d.f., weak convergence and complete convergence, weak compactness theorem, Helly Bray theorem (only statement).

Characteristic function (c.f.), its properties, c.f.’s and moments, inversion theorem (only statement): Application to various distributions, continuity theorem (only statement), composition of d.f.s, composition of c.f.’s, compound distributions.

Independent classes and independent random variables, the multiplication theorem, sequences of independent random variables: Borel 0-1 criterion, Borel-Cantelli lemma, Kolmogorov’s 0-1 law.

Weak law of large numbers, Strong law of large numbers (SLLN), Kolmogorov’s inequality, Kolmogorov’s sufficient condition for SLLN, Kolmogorov’s SLLN (only statement).


Books Recommended:


**S 502 LINEAR MODELS AND REGRESSION ANALYSIS**

Gauss-Markov set-up, Normal Equations and Least Square Estimates, Error and estimation spaces, variances and covariances of least square estimates, estimation of error variance, estimation with correlated observations, least square with correlated observations, least square estimates with (a) restriction on parameters (b) specification error, simultaneous estimates of linear parametric functions.

Tests of hypotheses for one and more than one linear parametric functions, confidence intervals and regions, Analysis of Variance, Power of F-test, Multiple comparison tests due to Tukey and Scheffe, simultaneous estimates of linear parametric functions.

Introduction to one-way random effects linear models and estimation variance components.

Simple linear Regression, multiple regression, fit of polynomials and use of orthogonal polynomials.

Residual and their plots as test for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers, Remedies.

Introduction to non-linear models.

Multicolinearity, Ridge regression and principle component regression, subset selection of explanatory variables, Mallow’s C_p Statistic.

Books Recommended:

S 503 INference II

Randomized test, randomized version of Neyman-Pearson lemma and its generalization (proof of sufficient condition only). Uniformly most powerful tests for one sided alternative for one parameter exponential class of densities and extension to the distributions having monotone likelihood ratio property.

Unbiased tests, its applications to one-parameter exponential family of distributions, Similar tests, UMP similar tests, test with Neyman structure, UMP unbiased tests for parameters of normal distribution

Confidence bounds: Neyman’s principal of confidence bounds, uniformly most accurate and uniformly most accurate unbiased confidence bounds.

Likelihood Ratio Test (LRT), large sample properties: consistency of tests, asymptotic distribution of LRT statistic, chi-square goodness of fit test.

Sequential Probability Ratio Test (SPRT), properties of SPRT, the fundamental identity of SPRT and its use in derivation of OC and ASN functions.


Books Recommended:

S 504 THEORY OF SAMPLE SURVEYS

General principles of sample surveys. Basic ideas in estimation from probability sampling. Review of important results in SRSWR, SRSWOR, Stratified sampling and Systematic sampling.

Varying probability sampling: PPS sampling with replacement and without replacement, Horvitz-Thompson estimator, Random group method, PPS systematic sampling.

Use of supplementary information for estimation: Ratio and Regression estimators with their properties and generalizations.

Cluster sampling, Two-stage sampling.

Double sampling for ratio and regression estimators and for stratification

Non-sampling errors, response and non-response errors and their treatments, randomized response

Books Recommended:

S 505 OPERATIONS RESEARCH

Linear Programming: Convex sets, supporting and separating hyperplanes, standard linear programming problem, basic feasible solutions, simplex algorithm and simplex method, geometry of simplex method. Duality in linear programming, duality theorems, dual simplex method with justification, post optimality analysis, sensitivity analysis and parametric linear programming.  

Integer Linear Programming: Introduction, Gomory Cut Method, Branch and Bound Method.  

Network Analysis: Definition and formulation, critical path method, Project Evaluation and Review Technique (PERT), Optimal allocation of resources (men-power) through time schedule.  

Queueing Theory: Introduction, steady state solution of M/M/c/∞/FIFO and M/M/C/N/FIFO with associated distributions of queue length and waiting time. (c=1 as particular case)  


Books Recommended:
S 601 DESIGN AND ANALYSIS OF EXPERIMENTS

Introduction to designed experiments; General block design and its information matrix (C), criteria for connectedness, balance and orthogonality; Intrablock analysis. BIBD, PBIBD(2)– recovery of interblock information; Youden square design – intrablock analysis. Analysis of covariance in a General –Markov model, applications to standard designs.

Missing plot technique – general theory and applications.

Introduction to Galois field and finite geometries. Construction of orthogonal Latin squares, construction of BIB designs using MOLS, and finite geometries.

General factorial experiments, factorial effects; best estimates and testing of significance of factorial effects; study of $2^n$ and $3^n$ factorial experiments in randomized blocks; Confounding and fractional factorial for symmetrical factorials. Split plot and split block experiments.

Application areas: Response surface experiments; clinical trials, treatment control designs.

Books Recommended:


Multivariate normal distribution (characterization) and its properties. Random sampling from a multivariate normal distribution. Maximum likelihood estimation of parameters, Distribution of the MLEs.


Distribution of sample intra-class correlation coefficient in a random sample from a symmetric multivariate normal distribution. Application in testing and interval estimation.

Distribution of Hotelling’s $T^2$ statistic. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of mean vector in a multivariate normal population.

Wilk’s lambda distribution. Test concerning covariance matrices. Test for identical populations.

Multivariate linear regression model, estimation of parameters, tests of linear hypotheses about regression coefficients using LRT. Multivariate analysis of variance (MANOVA) of one and two way classified data.

Books Recommended:
S 603 - RELIABILITY AND LIFE TESTING

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 distribution; reliability function; hazard rate; common life distributions-Exponential, Weibull, gamma, Pareto and lognormal distributions. Estimation of parameters and tests in these models.

Notion of ageing; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals; loss of memory property of the exponential distribution; closures of these classes under formation of coherent systems, convolutions and mixtures.

Reliability estimation based on failure times in various censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation

Reliability Growth models; probability plotting techniques; Hollander-Proshcan and Deshpande tests for exponentiality; tests for HPP against NHPP with repairable systems.

Estimation of survival function-Actuarial Estimator, Kaplan-Meier Estimator; Properties of K-M estimator; Estimation under the assumption IFR/DFR.

Books Recommended:

6. Zacks, S. Reliability
S.604 STOCHASTIC PROCESSES

**Introduction to Stochastic Processes:** Classification of stochastic processes according to state space and time domain. Countable state Markov Chains (MCs’), Chapman-Kolmogorov equations, calculation of n-step transition probability and its limits, classification of states. Stationary distribution, random walk and gambler’s ruin problem, Applications from social, biological and physical sciences. Statistical inference in Markov Chains

**Discrete state space continuous time stochastic processes:** Poisson process, Generalization of Poisson process. Renewal process.

**Birth and death process:** Special cases of birth and death process, Application to queues and storage problems etc.

**Branching process:** Galton-Watson branching process, probability of ultimate extinction, distribution of population size.

**Stationary processes:** weakly and strongly stationary processes. Moving average and auto regressive processes.

**Continuous time and continuous state space Markov process:** Kolmogorov-Feller differential equations, Diffusion processes with Wiener process and Ornstein-Uhlenbeck process as particular cases. First passage time and other problems.

**Books Recommended:**

S 701 COMPUTER ORIENTED STATISTICAL METHODS

**Statistical Packages:** Introduction of packages and their use for following Statistical problems.  

**Generation of random variables from:** (i) Normal (ii) Gamma (iii) Weibull (iv) F, t and $\chi^2$ (v) Binomial (vi) Poisson (vii) Multivariate Normal Distributions, and (viii) from different Markov chains

**Simulation:** Simulation of Probability distributions of different statistics whose probability distributions may not be obtained theoretically.

**Logistic Regression Analysis:** Introduction; The multiple logistic regression model; Fitting the logistic regression model; testing for the significance of the model. Application of logistic regression in study of Matched case control data.

**Cox’s regression model:** Proportional Hazard Model. Estimation and tests of parameters of the proportional hazard model. Use of this in comparison of two more life distributions.

**Bootstrap techniques:** Introduction; The Bootstrap estimate of standard error of the correlation coefficient. Application of Bootstrap in regression Models. The Bootstrap estimate of bias.

**Multivariate techniques:** (i) Canonical Correlation (ii) Discriminant Analysis (iii) Principal component analysis (iv) Factor Analysis (v) Cluster Analysis.

**Books Recommended:**

S 702 STATISTICAL QUALITY CONTROL TECHNIQUES

**Quality Improvement in the Modern Business Environment:** Meaning of quality and quality improvement. Usefulness of statistical methods in quality improvement. Total quality management. Link between quality and productivity; quality and cost. ISO-9000 and QS-9000 quality system standards. Recent advancement in quality management.

**Basic Concepts of quality control:** Process control and process capability. Relation between theory of testing hypotheses and charts. choice of control limits, rational subgroup principle, allocating sampling effort, average run length.

**Statistical Process Control:** Control charts for measurements and attributes. \( \bar{X}, R, s, p \) and np charts. (revision) CUSUM charts, EWMA chart –Use of these charts for prediction. CUSUM, EWMA for controlling process variability. Comparison of these charts with Shewart charts. Acceptance control charts.

**Process Capability Indices:** Purpose of capability Indices. Determining the process capability using \( \bar{X}, R \) charts. The role of normality in determining defective parts per million. One sided specification, non-normal distributions.

**Some special plans:** Chain sampling plans, continuous sampling plans, Dorrian-Shainin’s lot plot method, Skip –lot sampling plans.

**Process Design and Improvement with designed experiments:** Use of Design of Experiments in SPC: \( 2^k \)- factorial design with \( k \geq 1 \). \( 2^k-p \) fractional factorial design.

**Taguchi’s contribution to Quality Engineering:** Elements and principle of quality engineering. Steps in robust design; signal to noise ratio.

**Books Recommended:**

SB 703 : BIOASSAYS

Types of biological assays: Direct assays; Ratio estimators, asymptotic distributions; Fieller’s theorem

Regression approaches to estimating dose-response relationships: Logit and probit approaches when dose-response curve for standard preparation is unknown; Quantal responses; Methods of estimation of parameters; Estimation of extreme quantiles; Dose allocation schemes; Polychotomous quantal response

Estimation of points on the quantal response function
Sequential procedures
Estimation of safe doses
Bayesian approach to bioassay

Books Recommended:
SB 704 CLINICAL TRIALS

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials.

Data management: data definitions, case report forms, database design, datacollection systems for good clinical practice, protocol definition.

Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials.

Reporting and analysis: analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. Interim analysis method, motivating intent-to-treat analyses, Determining sample size.

Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data

Meta-analysis of clinical trials.

Books Recommended:
SF 703(A) ECONOMETRICS

Nature of Econometrics, Review of general linear model, use of dummy variables and seasonal adjustments, generalized least square estimation and prediction, Heteroscedastic disturbances.

Autocorrelation and its consequences and tests, Multicolinearity Problem, its implications and tools for handling the problem, ridge regression, use of principle component analysis.

Linear Regression with stochastic regressors, Instrumental variables, Errors in variables, Autoregressive linear regression.

Simultaneous Linear Equations Model:
(a) Examples, Identification problem, Restrictions on structural parameters, rank and order conditions, restriction on variances and covariances

(b) Estimations in simultaneous equations models, recursive system, 2SLS estimators, limited information estimators, Full information maximum likelihood method.

Books Recommended:
**SF 703(B): TIME SERIES ANALYSIS**

Time-series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties.

Exploratory time Series Analysis, Tests for trend and seasonality. Exponential and Moving average smoothing. Hot and winters smoothing. Forecasting based on smoothing, adaptive smoothing.

Detailed study of the stationary processes: (1) moving average (MA), (2) Auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA models parameters. Forecasting. Residual analysis and diagnostic checking. Use of computer packages like SPSS.


**Books Recommended:**

Additional Books for Reference:

SF-704: ACTUARIAL STATISTICS

Section I – Probability Models and Life Tables.
Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality
Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.
Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws
Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.
Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.
Section II – Insurance and Annuities

**Principles of compound interest:** Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.
**Life insurance:** Insurance payable at the moment’s of death and at the end of the year of death-level benefit insurance, endowment insurance, differed 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-immediate and apportion able annuities-due.
**Net Premiums:** Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

Payment premiums, apportionable premiums, commutation functions accumulation type benefits.

**Net premium reserves:** Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportion able or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

**Some practical considerations:** Premiums that include expenses-general expenses types of expenses, per policy expenses.

Claim amount distributions, approximating the individual model, stop-loss insurance.

**Books Recommended:**

   Section I – Chapters: 1, 2, 3, 8, 9, and 11
   Section II – Chapters: 4, 5, 6, 7, 13, and 14

**Books for Additional References:**