DEPARTMENT OF STATISTICS

Scheme and Syllabus

M.Sc. (Statistics)

w.e.f. 2016-17

CENTRAL UNIVERSITY OF HARYANA
JANT-PALI, MAHENDERGARH
HARYANA-123031
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Department of Statistics
Central University of Haryana
Mahendergarh, Haryana-123031

Scheme and Syllabus of M.Sc. Statistics
(CHOICE BASED CREDIT SYSTEM)

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Course Type

- Core Course (CC)
- Generic Elective Course (GEC)
- Discipline Centric Elective Course (DCEC)
- Skill Enhancement Elective Course (SEEC)

Total Credits: 96

Semester wise distribution of credits: 24 + 24 + 24 + 24.

SEMESTER I

Total credits: 24 (CC: 20, GEC: 4)

S. No.	Course Title	Course Code	Credits	Course Type
1.	Analysis and Linear Algebra	SPMS STAT 01 01 01 CC 4004	4	CC
2.	Statistical Methods	SPMS STAT 01 01 02 CC 4004	4	CC
3.	Probability Theory	SPMS STAT 01 01 03 CC 4004	4	CC
4.	Sampling Techniques	SPMS STAT 01 01 04 CC 4004	4	CC
5.	Practical	SPMS STAT 01 01 05 CC 0044	4	CC
6.	GEC (to be taken from other departments)		4	GEC

Courses for other departments (GEC):

S. No.	Course Title	Course Code	Credits	Course Type
1.	Interdisciplinary Statistics	SPMS STAT 01 01 01 GEC 3014	4	GEC
2.	Programming in R	SPMS STAT 01 01 02 GEC 3014	4	GEC

SEMESTER II

Total credits: 24 (CC: 16, DCEC: 4, GEC: 4)

S. No.	Course Title	Course Code	Credits	Course Type
1.	Distribution Theory	SPMS STAT 01 02 01 CC 4004	4	CC
2.	Statistical Inference-I	SPMS STAT 01 02 02 CC 4004	4	CC
3.	Linear Models and Regression Analysis	SPMS STAT 01 02 03 CC 4004	4	CC
4.	Practical	SPMS STAT 01 02 04 CC 0044	4	CC
5.	DCEC		4	DCEC
6.	GEC (to be taken from other departments)		4	GEC

Courses for students of M.Sc. (Statistics) only (DCEC):

S. No.	Course Title	Course Code	Credits	Course Type
1.	Reliability Theory	SPMS STAT 01 02 01 DCEC 4004	4	DCEC
2.	Survival Analysis	SPMS STAT 01 02 02 DCEC 4004	4	DCEC
3.	Operations Research and Queuing Theory	SPMS STAT 01 02 03 DCEC 4004	4	DCEC
4.	Statistical Computing using C	SPMS STAT 01 02 04 DCEC 4004	4	DCEC

Courses for other departments (GEC):

S. No.	Course Title	Course Code	Credits	Course Type
1.	Applied Statistics	SPMS STAT 01 02 01 GEC 3014	4	GEC
2.	Operations Research	SPMS STAT 01 02 02 GEC 4004	4	GEC

SEMESTER III

Total credits: 24 (CC: 16, DCEC: 8)

S. No.	Course Title	Course Code	Credits	Course Type
1.	Design of Experiments	SPMS STAT 01 03 01 CC 4004	4	CC
2.	Econometrics	SPMS STAT 01 03 02 CC 4004	4	CC
3.	Statistical Inference-II	SPMS STAT 01 03 03 CC 4004	4	CC
4.	Practical	SPMS STAT 01 03 04 CC 0044	4	CC
5.	DCEC		4	DCEC
6.	DCEC		4	DCEC

Courses for students of M.Sc. (Statistics) only (DCEC):

S. No.	Course Title	Course Code	Credits	Course Type
1.	Time Series and Statistical Quality Control	SPMS STAT 01 03 01 DCEC 4004	4	DCEC
2.	Biostatistics	SPMS STAT 01 03 02 DCEC 4004	4	DCEC
3.	Stochastic Process	SPMS STAT 01 03 03 DCEC 4004	4	DCEC
4.	Demography and Vital Statistics	SPMS STAT 01 03 04 DCEC 4004	4	DCEC
5.	Order Statistics	SPMS STAT 01 03 05 DCEC 4004	4	DCEC
6.	Simultaneous Inference	SPMS STAT 01 03 06 DCEC 4004	4	DCEC

SEMESTER IV

Total credits: 24 (CC: 12, DCEC: 4, Dissertation: 8)

S. No.	Course Title	Course Code	Credits	Course Type
1.	Multivariate Analysis	SPMS STAT 01 04 01 CC 4004	4	CC
2.	Bayesian Inference	SPMS STAT 01 04 02 CC 4004	4	CC
3.	Practical	SPMS STAT 01 04 03 CC 0044	4	CC
4.	Dissertation/Project	SPMS STAT 01 04 01 PROJ 0008	8	Dissertation
5.	DCEC		4	DCEC

Courses for students of M.Sc. (Statistics) only (DCEC):

S. No.	Course Title	Course Code	Credits	Course Type
1.	Generalized Linear Models	SPMS STAT 01 04 01 DCEC 4004	4	DCEC
2.	Categorical Data Analysis	SPMS STAT 01 04 02 DCEC 4004	4	DCEC
3.	Decision Theory and Sequential Analysis	SPMS STAT 01 04 03 DCEC 4004	4	DCEC
4.	Statistical Simulation And Computation	SPMS STAT 01 04 04 DCEC 4004	4	DCEC
5.	Actuarial Statistics	SPMS STAT 01 04 05 DCEC 4004	4	DCEC

ANALYSIS AND LINEAR ALGEBRA

(SPMS STAT 01 01 01 CC 4004)

Objectives: This course provides help to understand the mathematical concept of convergence and its mathematical formalisms. Students will be able to use some fundamental theorems of mathematical analysis. Students will have knowledge of the special character of functions of a complex variable and their properties. The students also will be well equipped to apply these techniques in many major Statistics courses like Linear Inference, Multivariate Analysis during this course.

UNIT I

Recap of elements of set theory, introduction to real numbers, open and closed intervals (rectangles), compact sets, Bolzano-Weirstrass theorem. Sequences and series, their convergence, real valued functions, continuous functions, Uniform continuity, Uniform convergence. Differentiation, maxima-minima of functions.

UNIT II

Complex numbers, Analytic function, Cauchy fundamental theorem, Cauchy integral theorem, contour integrations.

UNIT III

Determinant and trace, rank, ranks of product of two matrices, Elementary matrices and Echelon forms. Partitioned matrices: addition, multiplication and inverse. Cayley Hamilton Theorem, diagonalization, generalized inverse: Definition and its computation.

UNIT IV

Definite and semi definite quadratic forms, index and signatures, simultaneous diagonalization of symmetric matrices (equivalent quadratic forms), extrema of quadratic forms. Vector spaces, sub-spaces, linear dependence and independence, orthogonalization process, orthonormal basis.

Suggested Readings:

1. Apostol, T.M. (2002): Mathematical Analysis, 2nd Edition. Narosa Publishing House.
2. Bartle, R.G. (1976). Elements of Real Analysis, 2nd Edition. John Wiley & Sons.
3. Conway, J.B. (2000). Functions of One Complex Variable, Springer-Verlag.
4. Rudin, Walter (2013): Principles of Mathematical Analysis, 3rd Edition. McGraw Hill.
5. Graybill, F.A. (2002): Matrices with Applications in Statistics, 2nd Edition. Wadsworth International Group.
6. Rao, C.R. and Mitra, S.K. (1971): Generalized Inverse of Matrices and its Application, John Wiley and Sons Inc.
7. Biswas, S. (2012): A Textbook of Matrix Algebra, 3rd Edition. PHI Learning.

STATISTICAL METHODS

(SPMS STAT 01 01 02 CC 4004)

Objectives: The objective of the course is to make the students conversant with various techniques used in summarization and analysis of data. The focus will be both on theoretical as well as practical approach using commonly used statistical softwares.

UNIT I

Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Data on two attributes, independence and association of attributes in 2x2 contingency tables. Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots. Multiple and partial correlations. Basic concepts of Binomial, Poisson, Geometric, Normal, Exponential distributions along with applications.

UNIT II

Concept of population, parameter, random sample, statistic and sampling distribution. Expectations and standard errors. Sampling distributions of sample mean and sample variance from a normal distribution and their independence. Sampling distributions of chi-square, t and F distributions and their relations.

UNIT III

Statistical hypotheses, type I and type II errors, level 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 $(\rho = 0 \; and \; \rho = \rho_0)$.

UNIT IV

Time series and its components. Trend determination by mathematical curve fitting and by moving average methods. Measurement of seasonal variations by ratio to moving average and ratio to trend methods.

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics, Vol. I & II, World Press.
2. Daniel, W.W. and Cross, C. L. (2013): Biostatistics: A Foundation for Analysis in the Health Sciences. Wiley and Sons, Inc., New York.
3. Stuart, A. and Ord Keith (1994): Kendall's Advanced Theory of Statistics: Distribution Theory. Wiley and Sons, Inc., New York.

PROBABILITY THEORY

(SPMS STAT 01 01 03 CC 4004)

Objectives: This course will lay the foundation to probability theory and statistical modelling of outcomes of real life random experiments through various statistical distributions.

UNIT I

Classes of sets, field, sigma field, minimal sigma field, Borel field, sequence of sets, limits of a sequence of sets, measure, probability measure, Integration with respect to measure. Random experiment, outcomes, sample space, events, various definitions of probability, laws of total and compound probability. Boole's inequality. Conditional probability, independence of events. Bayes Theorem.

UNIT II

Random variable, probability mass function, probability density function, cumulative distribution function. Expectation of a random variable, properties of expectation, conditional expectation and its properties. Bivariate distributions and the joint probability distribution. Independence of random variables. Marginal and conditional distributions.

UNIT III

Moment generating function, probability generating function, cumulant generating function, characteristic function and their properties. Inversion, continuity and uniqueness theorems.

UNIT IV

Convergence in probability, almost sure convergence, convergence in distribution and their relationships. Chebyshev's inequality, weak law of large numbers (WLLN), strong law of large numbers (SLLN), central limit theorems.

Suggested Readings:

1. Rohatgi V.K. and Saleh A.K. Md.E. (2015): An Introduction to Probability and Statistics, 3rd Edition, Wiley India (P.) Ltd.
2. Bhat, B.R. (2004). Modern Probability Theory, 3rd Edition., New Age International, New Delhi.
3. Rao, B. L. S. Prakasa (2009): A First Course in Probability and Statistics. World Scientific.
4. Casella, G. and Berger, R. L. (2007): Statistical Inference, 2nd Edition, Cengage Learning.
5. Hogg, R. V., McKean, J. and Craig, A. T. (2013): Introduction to Mathematical Statistics, 7th Edition, Pearson Education.
6. Mukhopadhyay, P. (2015): Mathematical Statistics, New Central Book Agency, New Delhi.

SAMPLING TECHNIQUES

(SPMS STAT 01 01 04 CC 4004)

Objectives: The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits, demerits and comparisons in appropriate practical situations, (iii) role of various statistical organizations in national development.

UNIT I

Introduction to usual notations used in sampling. Basic finite population sampling techniques: Simple random sampling, simple random sampling without replacement (SRSWOR), simple random sampling with replacement (SRSWR), stratified random sampling, systematic sampling and related results on estimation of population mean/total. Relative precision of different sampling techniques. Allocation problem in stratified sampling.

UNIT II

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.

UNIT III

Unequal probability sampling: PPS WR/WOR methods [cumulative total and Lahiri's methods] and related estimators of a finite population mean [Horwitz -Thompson, Yates-Grundy, Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2].

UNIT IV

National sample survey 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.

Suggested Readings:

1. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and I.A.S.R.I., PUSA, New Delhi.
2. Singh, D. and Chaudhary, F.S. (2016): Theory and Analysis of Sample Survey Designs, Ist Edition. New Age International Publishers.
3. Cocharn, W.G. (2008): Sampling Techniques, 3rd Edition, Wiley India.
4. Mukhopadhyay, P. (2009): Theory and Methods of Survey Sampling, 2nd Edition, Prentice Hall of India.
5. Murthy, M.N. (1967): Sampling: Theory and Methods, Statistical Publishing Society, Kolkata.

PRACTICAL

(SPMS STAT 01 01 05 CC 0044)

Practicals based on Statistical Methods (SPMS STAT 01 01 02 CC 4004) and Sampling Techniques (SPMS STAT 01 01 04 CC 4004).

INTERDISCIPLINARY STATISTICS

(SPMS STAT 01 01 01 GEC 3014)

Objectives: The objective of this course is to define a variety of basic statistical terms and concepts, solve fundamental statistical problems, understanding of statistical fundamentals to interpret data.

UNIT I

Introduction to Statistical Analysis: Mean, median, mode, range, mean deviation, variance, standard deviation, coefficient of variation, skewness, kurtosis.

UNIT II

Random Variables and Probability Distribution: Random experiment, outcomes, sample space, classical definition of probability, random variable, probability mass function, probability density function, cumulative distribution function, mathematical expectation, Variance, Binomial, Poisson, Geometric, Exponential, Normal distributions.

UNIT III

Hypothesis Testing: Null hypothesis, alternative hypothesis, type I error, type II error, level of significance, p-value and power of test. Tests for mean based on normal distribution – one sample t-test, two-sample t-test, paired-sample t-test. Tests for variance based on normal distribution – one sample and two-sample problem. One-Way and Two-Way analysis of variance (ANOVA) techniques.

UNIT IV

Linear Regression and Correlation: Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient, principle of least square, lines of regression, simple linear regression, coefficient of determination.

Suggested Readings:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics, Vol. I & II, World Press.
2. Walpole, R.E., Myers, R.H., Myers, S.L. and Ye, K. E (2012): Probability and Statistics for Engineers and Scientists, Pearson Education.
3. Daniel, W.W. and Cross, C. L. (2012): Biostatistics: A Foundation for Analysis in the Health sciences, 10th Edition, Wiley Global Education.

PROGRAMMING IN R

(SPMS STAT 01 01 02 GEC 3014)

Objectives: The objective of the course is to enhance the programming skills and working knowledge of available numerical and statistical softwares.

UNIT I

Data types in R: numeric/character/logical; real/integer/complex, creation of new variables, vectors, matrices, dataframes, lists, accessing elements of a vector or matrix, import and export of files, for loop, repeat loop, while loop, if command, if else command.

UNIT II

Graphics in R: the plot command, histogram, bar-plot, box-plot, points, lines, segments, arrows, inserting mathematical symbols in a plot, pie diagram, customization of plot setting, graphical parameters, adding text, saving to a file, adding a legend.

UNIT III

Vector matrix operations: matrix operations such as addition, subtraction, multiplication, rank, eigenvalues, matrix inverse, generalized inverse, solution of linear equations.

UNIT IV

Basic statistics using R: measures of central tendency and dispersion. Covariance, correlation, regression, some discrete and continuous probability distributions, one and two sample z and t tests, Bartlett's test, F test for equality of variances, Chi-square tests, confidence intervals, one-way and two-way ANOVA, random number generation.

Suggested Readings:

1. Michael J. C. (2015): Statistics: An Introduction Using R, First Edition John Wiley and Sons.
2. Dalgaard, P. (2008): Introductory Statistics with R, 2nd Edition, Springer.
3. Zuur, A. F., Leno, E. N. and Meesters, E. H. W. G. (2009): A Beginner's Guide to R, Springer.
4. Maindonald, J. H. and Braun, J. (2010): Data Analysis and Graphics Using R, 3rd Edition, Cambridge University Press.
5. Spector, P. (2008): Data Manipulation with R, Springer, New York.
6. Rizzo, M. L. (2008): Statistical Computing with R, Chapman & Hall/CRC.
7. Murdoch, D. J. and Braun, J. (2016): A First Course in Statistical Programming with R, 2nd Edition, Cambridge University Press, Cambridge.

DISTRIBUTION THEORY

(SPMS STAT 01 02 01 CC 4004)

Objective: The main objective of the course is to provide the detailed knowledge of the characterization of all the useful discrete and continuous distributions.

UNIT I

Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Multinomial, Hypergeometric, Discrete Uniform distribution. Their means, variances, modes, moment generating functions, probability generating functions and characteristic functions. The various important properties with their proofs related to these distributions.

UNIT II

Continuous Uniform, Exponential, Gamma, Normal, Beta, Cauchy, Laplace, Weibull, Pareto, Lognormal, Logistic with their properties including proofs. Their means, variances, moment generating functions and characteristic functions.

UNIT III

Compound, truncated and mixture distributions. Non-central chi-square, t and F distributions with their properties.

UNIT IV

Bivariate normal distribution with its applications and important properties. Standard bivariate normal distribution. Development of the formula of recurrence relation for moments and other important related problems to this distribution.

Suggested Readings:

1. Rohatgi V.K and Saleh A.K. Md.E. (2015): An Introduction to Probability and Statistics, 3rd Edition, Wiley India (P) Ltd.
2. Mukhopadhyay, P. (2015): Mathematical Statistics. Books & Allied (P) Ltd.
3. Casella, G. and Berger, R. L. (2007): Statistical Inference, 2nd Edition. Cengage Learning.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics, Vol. I, World Press.
5. Mood, A., Grabill, F. and Boes, D. (2001): Introduction to the Theory of Statistics, McGraw Hill Education.
6. Mukhopadhyay, P. (1998): Theory and Methods of Survey Sampling, Prentice Hall of India.

7. Jhonson, N.L., Kemp, A.W. and Kotz, S. (2008): Univariate Discrete Distributions, 3rd Edition, Wiley-Blackwell.

8. Jhonson, N.L., Kotz, S., Balakrishnan, N. (1994): Continuous Univariate Distributions, Wiley-Blackwell.

STATISTICAL INFERENCE-I

(SPMS STAT 01 02 02 CC 4004)

Objective: The objective of estimation theory is to arrive at an estimator that exhibits optimality. The estimator takes observed data as an input and produces an estimate of the parameters. Also, to provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications.

UNIT I

Criteria of a good estimator- unbiasedness, sufficiency, consistency, efficiency. Minimal sufficient statistic. Exponential and Pitman families of distributions. Complete statistic, ancillary statistic, Rao-Blackwell theorem, Lehmann-Scheffe theorem, Cramer-Rao lower bound approach to obtain minimum variance unbiased estimator (MVUE).

UNIT II

Method of moments, Maximum likelihood estimation, minimum chi-square estimation, method of scoring, CAN & BAN estimators.

Concepts of critical regions, test functions, two kinds of errors, size function, power function, level of significance. Neyman - Pearson Lemma, Most Powerful (MP), Uniformly Most Powerful (UMP) and Uniformly Most Powerful Unbiased (UMPU) tests.

UNIT III

Likelihood ratio test (LRT) with its asymptotic distribution, Similar tests with Neyman structure, Basu' s theorem. Construction of similar and UMPU tests through Neyman structure. Wald's SPRT with prescribed errors of two types.

UNIT IV

Interval estimation: Confidence interval, confidence level, construction of confidence intervals using pivotal, 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.

Suggested Readings:

1. Rohatgi, V.K and Saleh, A.K. Md.E. (2015): An Introduction to Probability and Statistics, 3rd Edition, Wiley India (P) Ltd.

2. Lehmann, E.L. and Casella, G. (2003): Theory of Point Estimation, 2nd Edition, Springer.

3. Lehmann, E.L. and Romano, J.P. (2008): Testing Statistical Hypotheses, 3rd Edition, Springer.

4. Casella, G. and Berger, R. L. (2007): Statistical Inference, 2nd Edition, Cengage Learning.

5. Mood, A., Grabill, F. and Boes, D. (2001): Introduction to the Theory of Statistics, McGraw Hill Education.

6. Mukhopadhyay, P. (2015): Mathematical Statistics. Books & Allied (P) Ltd.

7. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013): An Outline of Statistical Theory, Volume II. 3rd Edition, World Press (P) Ltd.

8. Kale, B.K. (2005): A First Course on Parametric Inference, 2nd Edition, Alpha Science International Ltd.

LINEAR MODELS AND REGRESSION ANALYSIS

(SPMS STAT 01 02 03 CC 4004)

Objective: The students will get familiar with the need of modeling random responses using independent predictors through linear and logistic (for binary responses) models in real life situations. Least square estimation of parameters of these models will be discussed along with their statistical significance.

UNIT I

Linear Estimation: Gauss-Markov linear Models, Estimable functions, Error and Estimation Spaces, Best Linear Unbiased Estimator (BLUE), Least square estimator, Normal equations, Gauss-Markov theorem, generalized inverse of matrix and solution of Normal equations.

UNIT II

Variance and covariance of Least square estimators, applications of fundamental theorems of least squares. Test of Linear Hypothesis: One way and two way classifications. Fixed, random and mixed effect models (two way classifications only), variance components.

UNIT III

Regression Analysis: Simple and multiple regression, model validation, detection of outliers, remedies and tests about regression coefficients. Quadratic and cubic regression models including their geometrical interpretation, idea of nonlinear regression. Orthogonal Polynomials and their fitting. Analysis of covariance.

UNIT IV

Models for binary response –logistic regression model. Bartlett test for testing of homogeneity of variances.

Suggested Readings:

1. Rao, C.R. (2009): Linear Statistical Inference and its Applications, 2nd Edition, Wiley India (P) Ltd.
2. Draper, N.R. and Smith, H. (2011): Applied Regression Analysis, 3rd Edition, Wiley India (P) Ltd.
3. Kleinbaum, D.G. and Klein, M. (2010): Logistic Regression – A Self Learning Text, 3rd Edition, Springer Verlag.
4. Graybill, F.A. and Blackwell, D. (2013): An Introduction to Linear Statistical Models, Vol. – I, Literary Licensing.
5. Rencher, A.C. and Schaalage, G.B. (2008): Linear Models in Statistics, 2nd Edition, Wiley-Blackwell.
6. Weisberg, S. (2013): Applied Linear Regression, 4th Edition, Wiley-Blackwell.
7. Bowerman, B.L. and O'Connel, R.T. (2000): Linear Statistical Models: An Applied Approach, 2nd Edition, Duxbury Press.

PRACTICAL

(SPMS STAT 01 02 04 CC 0044)

Practicals based on Distribution Theory (SPMS STAT 01 02 01 CC 4004), Statistical Inference-I (SPMS STAT 01 02 02 CC 4004) and Linear Models and Regression Analysis (SPMS STAT 01 02 03 CC 4004).

RELIABILITY THEORY

(SPMS STAT 01 02 01 DCEC 4004)

Objective: This course covers the main statistical methods used in reliability and life data analysis. The main distributions used in reliability data analysis are overviewed. The ageing properties of different distributions are explored. A course in reliability helps in probabilistic modeling of the reliability of systems with multiple components and statistical modeling of reliability of individual components based on lifetime data.

UNIT I

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.

UNIT II

Life distributions and associated survival, conditional survival and hazard rate functions. Exponential, Weibull, gamma life distributions and estimation of their parameters.

UNIT III

Notions of ageing: IFR IFRA, NBU, DMRL, NBUE, and HNBUE classes; their duals and relationships between them. Closures of these classes under formation of coherent systems, convolutions and mixtures.

UNIT IV

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.

Suggested Readings:

1. Barlow R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless J.F. (2003): Statistical Models and Methods of Life Time Data, 2nd Edition, John Wiley.
3. Shaked M. and Shanthikumar G. (2010): Stochastic Orders, Springer.
4. Nelson, W.B. (2004): Applied Life Data Analysis, Wiley-Blackwell.
5. Zacks, S. (2011): Introduction to Reliability Analysis - Probability Models and Statistical Methods, Springer.

SURVIVAL ANALYSIS

(SPMS STAT 01 02 02 DCEC 4004)

Objective: The course gives the application of statistics in handling survival data. The course introduces the concept of censoring and the various distributions used to analyze such data. Various models are also suggested to deal with survival data.

UNIT I

Concepts of Type-I (time), Type-II (failure) 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.

UNIT II

Failure rate, mean residual life and their elementary properties. Ageing classes and their properties, bath tub failure rate.

UNIT III

Estimation of survival function – Actuarial estimator, Kaplan – Meier estimator. Tests of exponentiality against non-parametric classes: Total time on Test, Deshpande Test.

UNIT IV

Two sample problem: Gehan test, Log rank test, Mantel-Haenszel test. Cox's proportional hazards model, competing risks model.

Suggested Readings:

1. Kleinbaum, D.G. and Klein, M. (2012): Survival Analysis – A self-learning text, 3rd ed., Springer.
2. Miller, R.G. (2011): Survival Analysis, 2nd Edition, Wiley.
3. Moore, D.F. (2016): Applied Survival Analysis using R, Springer.
4. Kalbfleisch J.D. and Prentice R. (1980): The Statistical Analysis of Failure Time Data, John Wiley.
5. Klein, J.P. and Moeschberger, M.L. (2010): Survival Analysis: Techniques for Censored and Truncated Data, 2nd Edition, Springer.

OPERATIONS RESEARCH AND QUEUING THEORY

(SPMS STAT 01 02 03 DCEC 4004)

Objective: To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Govt./Pvt. Sectors. Also, to give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.

UNIT I

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.

UNIT II

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.

UNIT III

The duality problem of linear programming and its economic interpretation, transportation and assignment problems. Queueing Theory: Introduction of the queuing system, Various components of a queueing system.

UNIT IV

Pure Birth Process; Pure Death Process, Birth and Death Process, M/M/1 , M/M/1 (Generalised), M/M/1/FCFS/K/∞, M/M/C, Erlang's loss model.

Suggested Readings:

1. Hillier, F.S. and Liebermann, G.J. (2009): Introduction to Operations Research; 9th Edition, McGraw Hill.
2. Gass, S.I. (2010): Linear Programming, Methods and Applications, 5th Edition, Dover Books.
3. Kanti Swarup, Gupta,P.K. and Singh, M.M. (2010): Operations Research, Sultan Chand and Sons.
4. Saaty, T.L. (1984): Elements of Queueing Theory with applications, McGraw Hill, New York.
5. Jain, J.L., Mohanty, S.G. and Bohm, W. (2006): A Course on Queueing Models, Chapman & Hall/CRC.

STATISTICAL COMPUTING USING C

(SPMS STAT 01 02 04 DCEC 4004)

Objective: The objective of this course is to introduce students with basic knowledge of a computer system and to train them in the middle level computer programming language 'C'.

UNIT I

C Programming Language: Basic features of C language, constants, variables and data types, operators and expressions - arithmetic, relational and logical. Input and output statements with their formats, decision making statements, branching and looping, arrays, user and system defined functions, structures and pointers.

UNIT II

C Programs for Statistical Methods: Measures of central tendency and dispersion. Moments, correlation, regression, curve fitting. Tests of significance: t-test and Chi-Square test for given data.

C Programs for Matrix Algebra: Addition, Multiplication, Transpose, Determinant and Inverse of Matrices. Solution of system of Linear Equations.

UNIT III

C Programs for Numerical Methods: Roots of algebraic and transcendental equations by Bisection and Newton-Rapson methods. Difference table, Newton's forward and backward formulae, Lagrange's formulae for interpolation, Numerical integration, Trapezoidal, Simpson's $1/3^{rd}$ and $3/8^{th}$ rules.

UNIT IV

Properties of Statistical Distributions: Calculating pmf and cdf of Uniform, Binomial, Poisson, Normal, Cauchy, Gamma, Beta, Students' t and Chi-square distributions, Generation of random numbers from these distributions.

Suggested Readings:

1. Balagurusamy, E. (2012): Programming in ANSI C, 6th ed., Tata Mc-Graw Hill, New Delhi..
2. Kanetkar Y.P. (2016): Let us C, 14th ed., BPB Publications, New Delhi.
3. Kernighan, B.W. and Ritchie, D. (2015): The C Programming Language, 2nd Edition, Prentice Hall of India.

APPLIED STATISTICS

(SPMS STAT 01 02 01 GEC 3014)

Objective: The course aims to study various models and components of time series analysis for forecasting purposes and various methods to control the quality of a product. It also gives the study of distribution of population with respect to birth, migration, aging and death.

UNIT I

Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, measurement of trend by method of moving averages, method of semi-averages and method of least squares (linear, quadratic and modified exponential).

UNIT II

Measurement of seasonal variations by method of simple averages, method of ratio to trend. Statistical Quality Control: Importance of statistical methods in industrial research and practice, determination of tolerance limits, causes of variations in quality: chance and assignable.

UNIT III

General theory of control charts, process and product control, control charts for variables: X- bar and R-charts, control charts for attributes: p and c-charts. Demographic Methods: Introduction, measurement of population, rates and ratios of vital events, measurement of mortality: CDR, SDR (w.r.t. age and sex), IMR, Standardized death rates.

UNIT IV

Life (mortality) tables: definition of its main functions and uses, measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

Suggested Readings:

1. Mukhopadhyay, P. (2011): Applied Statistics, 2nd Edition, Books and Allied (P.) Ltd.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Montegomery, D.C. (2013): Statistical Quality Control: A Modern Introduction, 7th Edition, Wiley.

OPERATIONS RESEARCH

(SPMS STAT 01 02 02 GEC 4004)

Objective: To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Govt./Pvt. Sectors. Also, to give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.

UNIT I

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.

UNIT II

The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique.

UNIT III

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.

UNIT IV

Game theory problem as a linear programming problem, integer programming. Replacement models and sequencing theory, inventory models with single and multiple periods.

Suggested Readings:

1. Hillier, F.S. and Liebermann, G.J. (2009): Introduction to Operations Research; 9th Edition, McGraw Hill.
2. Gass, S.I. (2010): Linear Programming, Methods and Applications, 5th Edition, Dover Books.
3. Kanti Swarup, Gupta,P.K. and Singh, M.M. (2010): Operations Research, Sultan Chand and Sons.