SCHOOL OF STUDIES IN STATISTICS, Pt. R.S.U., RAIPUR

Credit-Based Syllabus for M.A./M.Sc. (Statistics) Semester Course, 2014-15

The M.A./ M.Sc. Course in Statistics shall be spread over four semesters. Each semester shall have four theory and two practical courses except the fourth semester. The fourth semester shall have four theory courses, one practical and one project course. Each theory course will be of 4 hours teaching per week carrying 4 credits. The theory course examination will be of 3 hours duration and shall carry 100 marks each out of which 20 marks will be based on internal assessment. Each practical course will be of 4 hours duration per week carrying 2 credits. The examination of each practical course will be of 4 hours duration and shall carry 100 marks out of which 10 marks shall be fixed for viva -voce and 20 marks for practical record. The project course shall be of 100 marks having 2 credits.

FIRST SEMESTER	Paper	Subject	Theory Marks	Internal Marks	Total Marks	Credit
	I	Real Analysis	80	20	100	4
	II	Statistical Methods	80	20	100	4
	III	Sampling Theory	80	20	100	4
	IV	Probability and Measure	80	20	100	4
	V	Lab Course- I			100	2
	VI	Lab Course -II			100	2
				Total	600	20
SECOND SEMESTER	Paper	Subject	Theory Marks	Internal Marks	Total Marks	Credit
	I	Linear Algebra	80	20	100	4
	II	Stochastic Processes	80	20	100	4
	III	Statistical Computing	80	20	100	4
	IV	Applied Statistics	80	20	100	4
	V	Lab Course -I			100	2
	VI	Lab Course -II			100	2
				Total	600	20
THIRD SEMESTER	Paper	Subject	Theory Marks	Internal Marks	Total Marks	Credit
	I	Multivariate Analysis	80	20	100	4
	II	Inference - I	80	20	100	4
	III	Operations Research-I	80	20	100	4
	IV	Statistical Quality Control	80	20	100	4
	V	Lab Course- I			100	2
	VI	Lab Course- II			100	2
				Total	600	20
FOURTH SEMESTER	Paper	Subject	Theory Marks	Internal Marks	Total Marks	Credit
	I	Design of Experiments	80	20	100	4
	II	Inference-II	80	20	100	4
	III	Operations Research II	80	20	100	4
	IV	Reliability and Life Testing	80	20	100	4
	V	Lab Course			100	2
	VI	Project Work			100	2
				Total	600	20

Grand Total (Semester I, II, III and IV)	2400	80

FIRST SEMESTER

Paper	– I	:	**Real Analysis**
Paper	- II	:	**Statistical Methods**
Paper	- III	:	**Sampling Theory**
Paper	- IV	:	**Probability and Measure**
Lab Course - I		:	**Practical based on course II**
Lab Course - 1I		:	**Practical based on course III**

PAPER–I
REAL ANALYSIS

UNIT-I

Recap of elements of set theory; Introduction to real numbers, Introduction to n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano - Weirstrass theorem, Heine - Borel theorem. Sequences and series and their convergence.

UNIT-II

Real valued function, Properties of real valued continuous function on R^n , Uniform continuity, Sequences and series of functions, Uniform convergence. Power series and radius of convergence.

UNIT-III

Differentiation, maxima - minima of functions; functions of several variables, constrained maxima - minima of functions. Multiple integrals and their evaluation by repeated integration, Dirichlet and Lioulle's Theorem. Change of variables in multiple integration.

UNIT-IV

Reimann-Stieltjes integral of real valued function & its properties, Mean value theorem, Integration by parts and change of variables, Term by term integration, Differentiation & integration under the integral sign. Improper integral, Uniform convergence in improper integrals, Test for absolute and conditional convergence.

UNIT-V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Apostol, T.M. (1985). Mathematical Analysis, Narosa, Indian Ed.
2. Courant, R. and John, F. (1965). Introduction to Calculus and Analysis, Wiley.
3. Miller, K.S. (1957). Advanced Real Calculus, Harper, New York.
4. Rudin, Walter (1976). Principles of Mathematical Analysis, McGraw Hill.
5. Hewitt and Stromberg : Real and Abstract Analysis.
6. G. Das and S. Pattanayk : Fundamental of Analysis, TATA Mc Graw Hill.
7. Shanti Narayan: A course of mathematical analysis. S. Chand & Co. Ltd.

PAPER –ll
STATISTICAL METHODS

UNIT-l

Frequency distribution, measures of location, dispersion and skewness, Moments and cumulates moment generating function.

Simple correlation coefficient, Multiple and Partial Correlation. Linear and Multiple Regression, fit of polynomials and use of orthogonal polynomials.

UNIT-II

Definition of probability, Bays theorem, Basic distribution function probability mass function, probability density function, joint, marginal and conditional p.m.f. . Random Variable and its mathematical expectation, conditional Expectation, Expectation of sum and multiplication of random variables. Markov, Holder-Jensen and Liapounov inequalities.

Standard Discrete Distributions- Bernoulli, Binomial, Poisson, Geometric, Hyper geometric and Multinomial distribution.

UNIT-III

Limiting form of Binomial and Poisson distributions. Standard continuous distributions-Uniform, Exponential, Normal, Cauchy. Order statistics-their distributions and properties. Joint & Marginal distributions of Order-Statistics.

UNIT-IV

Sampling distributions. Central and Non-central chi-square, t- and F- distributions, their properties and related tests. Sampling distributions of mean and variance of a sample from a normal population, sampling distribution of simple correlation coefficient in null case.

UNIT V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES

1. Dudewicz, E.J. and Mishra, S.N.(1988) : Modern Mathematical Statistics, Wiley, Int'I Student's Edition.
2. Rohatgi, V.K. (1984) : An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973) : Linear Statistical Inference and its Applications, 2/e, Wiley Eastern.
4. Weather ,Burn,C.E. : A first Course in Mathematical Statistics.
5. Keany,J.F. and Keeping,E.S. : Mathematics of Statistics Pt. I and II
6. Kendall,M.G. and stuart A : Advanced Theory of Statistics.
7. Mood ,gybrill and Boes : Introduction to theory of Statistics
8. Hogs and Craig : Mathematical Statistics
9. Goon,gupta and Dasgupta : Fundamental of Mathematical statistics Vol.I

PAPER -III
SAMPLING THEORY

UNIT-I

Sample Surveys : concept of population sample and properties of estimator for finite populations need for sampling, census and sample survey ,sample selection and sample size,Basic finite population sampling techniques ,simple random sampling with and without replacement, Estimation of population proportion ,Non-sampling errors, estimation of population mean in presence of non-response.

UNIT-II

Stratified sampling, systematic sampling and related results on estimation of population mean/total. Allocation problem in stratified sampling. Optimum allocation, Neyman allocation and Proportion allocation, Comparison of stratified, systematic and simple random sampling, estimation of gain in precision due to stratification, Post Stratification, Construction of strata.Systematic sampling under a linear model.

UNIT-III

Ratio and regression estimators based on srswor and stratified methods of sampling. Bias of ratio estimate, optimum property of ratio estimate, Ratio estimate in stratified sampling, Regression estimate with pre-assigned and with estimated regression coefficient, comparison of ratio and regression estimate with sample mean. Unequal probability sampling: pps wr/wor methods [including Lahiri's scheme] and related estimators of a finite population mean.

UNIT-IV

Cluster sampling. One stage cluster sampling, variance and cost functions ,sampling with probability proportional to cluster size, Hurwitz-Thompson estimation , two stage cluster sampling, Allocation of sample to two stages :equal first stage units, comparison of two stage with one stage sampling. Double sampling ratio and regression estimate with and without cost aspect .

UNIT-V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES

1.   Cochran, W.G. : Sampling Techniques [3rd Edition, 1977). Wiley
2.   Des Raj and Chandak (1998) : Sampling Theory. Narosa
3.   Murthy, M.N. (1977). Sampling Theory & Methods. Statistical Publishing Society, Calcutta.
4.   Sukhatme et al (1992). Sampling Theory of Surveys with Applications. lowa State University Press & IARS.
5.   Singh, D. and Chaudhary, F.S. (1986).   Theory and Analysis of Sample Survey Designs. New Age International Publishers.

PAPER -IV
PROBABILITY AND MEASURE

UNIT-I

Random experiment, Definition of Probability, Additive and multiplicative theorems of probability, Axiomatic approach to probability, Bayes Theorem. Classes of sets, fields, sigma-fields, minimal sigma-

field, Borel sigma-field in R_k, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Lebesgue and Lebesgue- Steljes measure on R_k.

UNIT-II
Measurable set, Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Unit III
Borel-Cantelli Lemma, Independence, Weak law and strong law of large numbers for iid sequences, Definition and examples of Markov dependence, Chebychev's Inequality, Probability generating function.

Unit IV Convergence in distribution, characteristic function, uniqueness theorem, Levy's continuity theorem (statement only), CLT for a sequence of independent random variables under Lindeberg's condition, CLT for iid random variables.

UNIT-V
Four short notes, one from each unit will be asked. Students have to answer any two.
REFERENCES
1. Ash, Robert.(1972): Real Analysis and Probability. Academic Press.
2. Billingsley, P.(1986): Probability and Measure. Wiley.
3. Dudley, R. M. (1989): Real Analysis and Probability, Wadsworth and Brooks/Cole.
4. Kingman, J F C and Taylor, S.J. (1966). Introduction to Measure and Probability. Cambridge University Press.

Lab Course - I	**:**	**Practical based on course II**
Lab Course - 1I	**:**	**Practical based on course III**

SECOND SEMESTER

Paper – I	**:**	**Linear Algebra**
Paper - II	**:**	**Stochastic Processes**
Paper - III	**:**	**Statistical Computing**
Paper - IV	**:**	**Applied Statistics**
Lab Course - I	**:**	**Practical based on courses I and III**
Lab Course - 1I	**:**	**Practical based on course IV**

PAPER -I
LINEAR ALGEBRA
UNIT-I
Fields, vector spaces, subspaces, linear dependence and independence, basis and dimension of a vector space, finite dimensional vector spaces, completion theorem, examples of vector spaces over real and complex fields, linear equations. Determinants.

UNIT-II
Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthonormal basis and orthogonal projection of a vector. Linear transformations, algebra of matrices, row and column spaces of a matrix, elementary matrices, rank and inverse of a matrix, null space and nullity, partitioned matrices, Kronecker product.

UNIT-III
Hermite canonical form, generalized inverse, Moore-Penrose generalized inverse, Idempotent matrices, Solutions of matrix equations. Real quadratic forms, reduction and classification of quadratic forms, index and signature, triangular reduction of a positive definite matrix.

UNIT-IV
Characteristic roots and vectors, Cayley-Hamilton theorem, minimal polynomial, similar matrices, algebraic and geometric multiplicity of a characteristic root, spectral decomposition of a real symmetric matrix, reduction of a pair of real symmetric matrices, Hermitian matrices. Singular values and singular value decomposition, Jordan decomposition, extrema of quadratic forms, vector and matrix differentiation**.**

UNIT-V
Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1.   Graybill, F.A.(1983). Matrices with applications in statistics, 2nd Ed. Wadsworth.
2.   Rao, C.R.(1973). Linear statistical inference and its applications, 2nd ed. John Wiley and Sons, Inc.
3.   Searle, S.R. (1982). Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.
4.   Shanti Narayan: Matrices
5.   Vashishtha, A. R.: Matrices

PAPER –II
STOCHASTIC PROCESSES

UNIT-I
Introduction to stochastic processes (sp's).; classification of sp's according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Probability generating function. Properties of probability generating function. Laplace transform & its properties.

Unit II
Stationary distribution, Classification of states; transient MC. Discrete state space continuous time MC ; Kolmogorov- Feller differential equations. Random walk and Gambler's ruin problem.

Unit III : Poisson process and its properties, birth process, Yule Process, death process, birth and death process ; Applications to queues and storage problems. Wiener process as a limit of random walk ; first - passage time and other problems.

UNIT-IV
Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem ; study of residual life time process. Branching process : Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Statistical inference in MC and Markov processes.

UNIT-V
Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Adke, S.R. and Manjunath, S.M. (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
2. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International, India.
3.   Cinlar, E. (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W. (1968): Introduction to Probability and its Applications, Vol.1, Wiley Eastern.
5.   Harris, T.E. (1963): The Theory of Branching Processes, Springur-Verlag.
6. Hoel, P.G., Port, S.C. and Stone, C.J. (1972): Introduction to Stochastic Processes,Houghton Miffin & Co.
7. Jagers, P. (1974): Branching Processes with Biological Applications, Wiley.
8. Karlin, S. and Taylor, H. M. (1975): A first Course in Stochastic Processes, Vol.1, Academic Press.
9. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.10. Parzen, E.(1962): Stochastic Processes, Holden-Day.

PAPER   - III
STATISTICAL COMPUTING

UNIT I
FORTRAN Language : constants & variables, Control statements, subroutine & function subprograms .Use of Excel for Statistical methods and graphical representation of data .

Unit II
Programming in C and in C^{++}: All syntax ,Pointers, Arrys, Functions and Input / Output statements. Use of Statistical package. SPSS for large sample data analysis.

Unit III
Numerical Analysis : Finite differences & interpolation, Interpolation with unequal intervals, Central differences Interpolation-Gausse's, Stirling's and Bessel's Formulae.

UNIT IV
Numerical differentiation and integration, Trapezoidal rule, Simpson's one third, 3/8 rule, Weddle's `rule, Euler-Maclaurin Summation Formula, Newton-cotes Formula, Gauss formula for approximation to factorials, Difference equation of first and second order.

UNIT V
Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Balagurusamy,E.: Programming in ANSI C .Tata McGraw Hill.
2. Kanetkar ,Y.P.:Working with C.BPB Publication.
3. Reddy,R.N. and Ziegler,C.A.: FORTRAN-77 With Application for Scientiests and engineers,JAICO Publishing House Bombay,Calcutta & Madras.
4. Rajaraman: Computer Programming in FOTRAN-77,Prentice Hall.
5. B.W. Kernighan and D.M. Ritchie (1988). The C Programming Language, Second Edition. Prentice Hall.
6. W.H. Press, S.A. Teukolsky, W.T. Vellering, and B.P. Flannery (1993). Numerical Recipes in C, Second Edition. Cambridge University Press.
7. R.A. Thisted (1988). Elements of Statistical Computing. Champman and Hall.
8. Rajaraman,V.: Computer Oriented Numerical Methods.
9. Grewal, B. S.: Numerical methods.
10. Saxena, H. C.: Finite differences.

PAPER   - IV
APPLIED STATISTICS

UNIT- I

 Index number :meaning and costruction of index number,different formulae for constructing index numbers, tests of consistency of index number formulae, Chain base index numbers, Cost of living index numbers, Whole sale price index numbers. Demand Analysis: Demand and supply curves, Price elasticity of demand and supply, determination of demand curves from market data, Engel' Law and Engle's Curve.

UNIT- II

 Different Component of time series, Measurement of secular trend: Fitting of mathematical curves, method of moving average, variate different method, effect of elimination of trend, merits and demerits of different methods of trend estimation. Determination of Seasonal and cyclical components. Periodogram analysis, Yule-Slutsky effect, correlogram Analysis.

UNIT-III

Sources of demographic data –census, register, adhoc survey, hospital records, measurement of mortality ,crude death rate, standardized death rate, age specific death rates, infant mortality rates, Complete and abridged life table-Kings method, Greville's method and method of Reed and Merrel, Construction of life table.

UNIT-IV

Measurement of fertility-crude birth rate, general fertility rate , age-specific birth rate, total fertility rate , Net reproduction rate and gross reproduction rate. The Stable and Stationary populations, Graduation Formulae, Makeham's Graduation Formula, Logistic curve for population growth, Population Projection, Migration, Push-Pull factor.

UNIT- V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. O. S. Srivastava (1983) – A text book of demography ,Vikas Publishing House.
2. Parimal Mukhopadhaya (1999) – Applied Statistics, Books and Allied (P) Ltd.
3. V. K. Kapoor and S. C. Gupta: Applied Statistics, Sultan Chand and Sons

Lab Course - I	**:**	**Practical based on courses I and III**
Lab Course - 1I	**:**	**Practical based on course IV**

THIRD SEMESTER

Paper – I	**:**	**Multivariate Analysis**
Paper - II	**:**	**Inference I**
Paper - III	**:**	**Operations Research I**
Paper - IV	**:**	**Statistical Quality Control**
Lab Course - I	**:**	**Practical based on courses I and II**
Lab Course - II	**:**	**Practical based on courses III and IV**

PAPER -I
MULTIVARIATE ANALYSIS

UNIT-I
Gauss- Markov set-up, Estimability condition, best point estimates/interval estimates of estimable linear parametric functions ,Normal equations and Least squares estimates, Gauss-Markov Theorem, Introduction to fixed, mixed and random effects linear models. Analysis of variance for one way and two way classified data.

UNIT-II
Multivariate Normal Distribution and its properties, Reproductive property, transformation by a vector, singular /non-singular matrix, conditional distribution of a sub-set of multivariate normal variable/ Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector.

UNIT-III
Distribution of sample generalized variance. Null and non-null distribution of simple correlation coefficient. Null distribution of partial and multiple correlation coefficient. Distribution of sample regression coefficients. 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 a mean vector in a multivariate normal population, Fisher-Behran statistic, Mahalanobis D^2 Statistic.

UNIT-IV
Wishart matrix - its distribution and properties, Characteristic function of Wishart distribution, chi-square distribution as a particular case of Wishart distribution. Classification and discrimination procedures for

discrimination between two multivariate normal populations - sample discriminant function, probabilities of misclassification and their estimation. Principal components, Dimension reduction, Canonical variables and canonical correlation - definition, use, estimation and computation. Factor Analysis

UNIT-V
Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Cook, R.D. and Weisberg, S. (1982). Residual and Influence in Regression. Chapman and Hall.
2. Draper, N.R. and Smith, H.(1998). Applied Regression Analysis. 3rd Ed. Wiley.
3. Gunst, R.F. and Mason, R.L.(1980). Regression Analysis and its Applications – A Data Oriented Aproach. Marcel and Dekker.
4. Rao, C.R.(1973). Linear Statistical Inference and Its Applications. Wiley Eastern.
5. Weisberg, S. (1985). Applied Linear Regression. Wiley.
6. Andrson, T.W.(1983) : An Introduction to multivariate statistical analysis. 2nd Ed. Wiley. Giri, N.C.(1977) : Multivariate Statistical inference. Academic Press.
7. Kshirsagar, A.M. (1972) : Multivariate Analysis. Marcel Dekker.
8. Morrison, D.F. (1976) : Multivariate statistical methods. 2nd Ed. McGraw Hill.
9. Muirhead, R.J.(1982) : Aspects of multivariate statistical theory, J. Wiley.
10. Seber, G.A. F.(1984) : Multivariate observations. Wiley.
11. Sharma, S.(1996) : Applied multivariate techniques. Wiley.
12. Srivastava, M.S. and Khatri, C.G. (1979). : An introduction to multivariate statistics. North Holland.
13. Johnson, R. and Wychern (1992) : Applied multivariate Statistical analysis, Prentice Hall, 3rd Ed.

PAPER - II
INFERENCE- I

UNIT I : Unbiasedness , Consistency, efficiency and sufficiency of point estimator ,. Fisher –Neymann factorization theorem, Cramer Rao inequality, Bhattacharya bounds, Minimum Variance unbiased estimators, Minimal sufficient statistics,

Unit II : Liklihood function, examples from standard discrete and continuous distributions. such as Bernoulli, Binomial, Possion, normal, exponential gamma etc) Methods of estimation – Method of maximum likelihood estimators, properties of maximum likelihood estimators. Method of scoring, method of moments, method of minimum chi-square, method of minimum variance, B.A.N. estimators.

Unit III : Rao Blackwell theorem. Completeness of sufficient statistics. Completeness and Bounded Completeness, Koopman's theorem (Distributions admitting sufficient statistics),.Lehmann-Scheffe theorem, Invariant estimators. Confidence interval and confidence coefficients, Theory of confidence set, Relationship with the theory of hypothesis testing, Confidence interval for large samples.

Unit IV : Loss function, Risk function, admissibility Minimax rule, Bays rule, Structure of Bay's rule, Construction of a Minimax rule, point and interval estimation as decision problem

UNIT-V

Four short notes, one from each unit will be asked. Students have to answer any two.

Reference :

1. Kale, B.K. (1999): A first Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi V. (1988): An Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd. New.Delhi (Student Edition)
3. Lehmann, E.L.(1986)-(Latest): Theory of point Estimation (Student Edition).
4. Lehmann, E.L.(1986): Testing Statistical hypotheses (Student Edition).
5. Rao, C. R. (1973): Linear Statistical Inference.
6. Zacks, S. (1971): Theory of Statistical Inference, John Wiley and Sons, New York.
7. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics. Wiley Series in Prob. Math. Stat., John Wiley and Sons, New York (International Student Edition)
8. Ferguson, T.S. (1996). A course on Large Sample Theory. Chapman and Hall, London.
9. Ferguson, T.S. (1967) : Mathematical Statistics, Academic Press.

PAPER   - III
OPERATIONS RESEARCH- I

UNIT-I

Definition and scope of Operational research ; phases in Operations Research ; models and their solutions ; decision-making under uncertainty and risk, use of different criteria ; The structure and formation of a linear programming problem, Graphical and simplex procedure, Two phase methods, and Charne's M method with artificial variables ; duality theorem .

UNIT -II

Transportation and assignment problems , Routing and traveling salesman problem .

UNIT -III

Inventory problems – Deterministic models of inventory , Economic Lot size formula ,instantaneous production case ,finite production rates situation ,cases when shortages are allowed /not allowed .Stochastic inventory models – a single period model with no set up cost.

UNIT -IV

Basic characteristics of queuing systems, Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue-length and waiting time. M/G/1 queue and Pollazcek Khinchine result. Steady-state solutions of M/Ek/1 and Ek/M/1 queues, Machine interference problem. Transient solution of M/M/1 queue .

Decision-making in the face of competition, two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in 2x2, 2xm and mxn games. Non-zero sum games, co-operative and competitive games, equilibrium solutions and their existence in bi-matrix games. Nash equilibrium solution. ;

UNIT V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Taha H.A. (1982) Operational Research : An Introduction ; Macmillan.
2. Hillier F.S. and Leiberman G.J. (1962) Introduction to Operations Research ; Holden Day.
3. Kanti Swarup, Gupta, P.K. and Singh M.M. (1985) Operations Research ; Sultan Chand& Sons.
4. Philips D.T., Ravindran A. and Solberg J. Operations Research, Principles and Practice.
5. Churchman C.W., Ackoff R.L. and Arnoff E.L.(1957) Introduction to Operations Research ; John Wiley.
6. Kleinrock L. (1975) Queueing Systems, vol. 1, Theory ; John Wiley
7. Saaty T. L. (1961) Elements of Queueing Theory with Applications ; McGraw Hill
10. Hadley G.and Whiting T.M. (1963) Analysis of Inventory Systems ; Prentice Hall
11. Starr M.K. and Miller D.W. (1962) Inventory Control-Theory and Practice; Prentice Hall
12 . Mckinsey J.C.C. (1952) Introduction to the Theory of Games ; McGraw Hill
13. Wagner H.M. (1973) Principles of O.R. with Applications to Managerial Decisions ; Prentice Hall
14. Gross, D. and Harris, C. M. (1974) Fundamentals of Queueing Theory ; John Wiley

PAPER   - IV
STATISTICAL QUALITY CONTROL

UNIT-I

Basic concept of process monitoring and control, process capability and process optimization. General theory and review of control charts for attribute and variable data ; O.C. and A.R.L. of control charts, control by gauging.

UNIT-II

Moving average and exponentially weighted moving average charts ; Cu-sum charts using V-masks and decision intervals ; Economic design of X-bar chart. Capability indices Cp, Cpk and Cpm ; estimation, confidence intervals and tests of hypotheses relating to capability indices for Normally distributed characteristics.
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UNIT-III

Acceptance sampling plans for attribute inspection ; single, double and sequential sampling plans and their properties ; Bayesian sampling plan.

UNIT-IV

Plans for inspection by variables for one-sided and two-sided specifications ; Continuous sampling plans of Dodge type and Wald-Wolfiwitz type and their properties. Use of Design of Experiments in SPC ; factorial experiments, fractional factorial designs, construction of such designs and analysis of data. Multivariate quality control ; use of control ellipsoid and of utility

UNIT V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Montgomery, D.C. (1985) Introduction to Statistical Quality Control ; Wiley
2. Ott, E.R. (1975) Process Quality Control ; McGraw Hill

3. Wetherill, G.B. (1977) Sampling Inspection and Quality Control ; Halsted Press
4. Wetherill, G.B. and Brown, D.W. (1991) Statistical Process Control, Theory and Practice ; Chapman and Hall.
5. Duncan, A. J.(1986): Quality Control and Industrial Statistics. 5th ed., Richard D. Ervin, Homewood, Illiions.
6. Ekambaram, S.K. (1963): The Statistical basis of quality control charts. Asia Publishing House, London.
7. Grant, E.L. & Leavenworth, R.S. (1988): Statistical Quality Control. 6th ed., McGraw-Hill Book Co., New York.
8. Bowker, A.H. & Goode, H.P. (1952): Sampling inspection by variables. McGraw-Hill Book Co., New York.
9. Schilling, E.G. (1982): Acceptance sampling in quality control. Marcel Dekker, Inc., New York.

Lab Course - I	:	**Practical based on courses I and II**
Lab Course - II	:	**Practical based on courses III and IV**

FOURTH SEMESTER

Paper	**–I**	:	**Design of Experiments**
Paper	**- II**	:	**Inference II**
Paper	**- III**	:	**Operations Research II**
Paper	**- IV**	:	**Reliability and Life Testing**
Lab Course		:	**Practical based on courses I, II and III**
Project Work			

PAPER - I
DESIGN OF EXPERIMENTS

UNIT I

Introduction to design of experiments, Principle of design of experiments, Completely randomized design, Randomized block design, Latin square design. Missing plot technique - general theory and applications, efficiency of designs.

UNIT II

Graeco Latin Square design, Cross-over designs, Analysis of covariance: Applications to standard designs with one concomitant variable, Testing the homogeneity of a group of regression coefficients. Split plot and split block experiments, efficiency of whole plot and sub plot treatments, merits and demerits of split plot experiments in comparison to factorial experiments.

UNIT III

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects ; 2^2 and 2^3 factorial experiments; Contrast, Yates method of getting treatment totals, Complete and partial confounding. 2^n experiment with 2^k blocks per replicate, 3^2 experiment.

UNIT IV

General block design and its information matrix. criteria for connectedness, balance and   orthogonality, BIBD- Analysis with intrablock information and interlock information. Response surface experiments; first order designs and orthogonal designs.

UNIT-V

Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Aloke Dey (1986) :Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999) : Design and Analysis of Experiments, Springer.
3. Das, M.N. and Giri, N.(1979) : Design and Analysis of Experiments, Wiley Eastern
4. Giri, N. (1986) : Analysis of Variance, South Asian Publishers
5. John, P.W.M. (1971) : Statistical Design and Analysis of Experiments, Macmillan.
6. Joshi, D.D. (1987) : Linear Estimation and Design of Experiments, Wiley eastern.
7. Montgromery, C.D.(1976): Design and Analysis of Experiments, Wiley, New York.
8. Pearce, S.C. (1984): Design of Experiments, Wiley, New York.

PAPER -II
INFERENCE - II

UNIT- I

 Test of Hypothesis*:* Concepts of critical regions, Test functions, two kinds of errors. Size function, power function, level, M. P. and U,M.P. Test, Neyman Pearson Lemma, M.P. test for simple null against simple alternative hypothesis ,UMP test for simple null hypothesis against one sided alternatives in one parameter exponential family .Unbiased test, UNIFORMELY most powerful unbiased test ,Type "A" critical region or locally most powerful unbiased test. Generalized form of Neyman Pearson lemma,

UNIT- II

Composite Hypothesis and similar regions, similar regions and complete sufficient statistics, Construction of most powerful similar regions, Unbiased critical regions, optimum regions and Sufficient Statistics. Likelihood ratio test, properties of likelihood ratio test, Likelihood ratio test for the mean of normal population, LR test for equality of means and variances of two and several normal populations.

UNIT- III

 Sequential analysis: Wald's sequential probability ratio test (SPRT) with prescribed errors of two types, OC and ASN functions of SPRT. Efficiency of SPRT.

UNIT -IV

Non parametric test, Rank test, Wilcoxon test, Median test, Sign test, Mann-Whitney U test, Wald-Wolfowitz run test, Kolomogorov-Smirnov test, One sample location problem, chi-square test of goodness of fit.

UNIT-V

Four short notes, one from each unit will be asked. Students have to answer any two.

References :
1. Kale, B.K. (1999): A first Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi V. (1988): An Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd. New.Delhi (Student Edition)
3. Lehmann, E.L.(1986)-(Latest): Theory of point Estimation (Student Edition).
4. Lehmann, E.L.(1986): Testing Statistical hypotheses (Student Edition).
5. Rao, C. R. (1973): Linear Statistical Inference.
6. Zacks, S. (1971): Theory of Statistical Inference, John Wiley and Sons, New York.
7. Gibbons,J.D.(1985) : Nonparametric statistical inference 2nd Ed.,Marcel dekker,Inc.
8. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics. Wiley Series in Prob. Math. Stat., John Wiley and Sons, New York (International Student Edition)
9. Ferguson, T.S. (1996). A course on Large Sample Theory. Chapman and Hall, London.
10. Ferguson, T.S. (1967) : Mathematical Statistics, Academic Press.

PAPER –III
OPERATIONS RESEARCH II

UNIT- I
Repllacement problems : Replacement of items that fails and those that deteriorate ,group and individual replacement policies

UNIT -II
Network analysis,-Shortest Path Problem, Project planning and control with PERT and CPM

UNIT -III
Integer programming-Branch and Bound technique. Dynamic programming , Deterministic and Probabilistic Dynamic programming: decision tree and Bellman's Principle of optimality, models of dynamic programming,

UNIT -IV
Quadratic programming ,Kuhn-Tucker conditions for quadratic programming problem, Wolf's modified simplex method, Beale's method.
Goal Programming simulation :Monte Carlo method.

UNIT- V
Four short notes, one from each unit will be asked. Students have to answer any two.

REFERENCES
1. Taha H.A. (1982) Operational Research : An Introduction ; Macmillan.
2. Hillier F.S. and Leiberman G.J. (1962) Introduction to Operations Research ; Holden Day.
3. Kanti Swarup, Gupta, P.K. and Singh M.M. (1985) Operations Research ; Sultan Chand& Sons.
4. Philips D.T., Ravindran A. and Solberg J. Operations Research, Principles and Practice.

5. Churchman C.W., Ackoff   R.L. and Arnoff   E.L.(1957): Introduction to Operations Research   ; John Wiley.

PAPER   - IV
RELIABILITY AND LIFE TESTING

UNIT -I
Reliability concepts and measures ; reliability function ; hazard rate ; 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 ; common life distributions-exponential, Weibull, gamma etc. Estimation of parameters and tests in these models. Notions of ageing ; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals ; loss of memory property of the exponential distribution ; closures or these classes under formation of coherent systems, convolutions and mixtures.

UNIT -III
Univariate shock models and life distributions arising out of them ; bivariate shock models ; common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items .

UNIT -IV
Stress-strength reliability and its estimation. Maintainability and availability, Maintenance and replacement policies ; availability of repairable systems ; modeling of a repairable system by a non-homogeneous Poisson process. Reliability growth models; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs NHPP with repairable systems. Basic ideas of accelerated life testing.

UNIT- V
Four short notes, one from each unit will be asked. Students have to answer any two.

References
1. Barlow R.E. and Prochan F.(1985) ,Statistical theory of reliability and life testing ,Rinehart and Winston
2.Lawless J.F. (1982) ,Statistical Models and Methods of Life time data ; John Wiley .
3.Bain L.J. and Engelhardt (1991) ;statistical Analysis of Reliability and Life testing Models ,Marcel Dekker.
4.Nelson ,W (1982) ;Applied Life data analysis ; john Wiley .
5.Zacks S.;Reliability Theory ,Springer.

Lab Course   :   **Practical based on courses I, II and III**
Project Work