A PROGRAMME FOR POSTGRADUATE COURSE (M.Sc.) IN STATISTICS, RGU

Choice Based Credit System (CBCS) for M.Sc. Statistics

(Effective from Academic Year 2021-22)

RAJIV GANDHI UNIVERSITY
RONO HILLS, DOIMUKH
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I. About the Department

The Department of Statistics was established in the year 2020, though the teaching of M.Sc. in Statistics has still to be introduced in the university. At present, the Department is running the postgraduate (M.Sc.) and Ph.D. programmes in Statistics.

The Department imparts rigorous training and exposure to the students in computer education by way of introducing the latest state-of-the-art in the programming language and computer software to enable the students to perform statistical data analysis. The department, at present, is at nascent stage with basic infrastructural facilities. Books related to Statistics curricula have been procured by the university library recently. The department plans to set up a good collection of books in the department library with latest titles in various areas of statistics. The Department also has a vision of setting up computer laboratories with latest computing systems and related equipment in the field of Statistics for the use of students, research scholars and teachers.

II. Introduction to CBCS (Choice Based Credit System) Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective or open elective courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

Definitions:

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in ateachingDepartment/Centreorjointlyundermorethanonesuch Department/Centre.

(ii) 'Course' means a segment of a subject that is part of an Academic Programme. 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission.

(iii) 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(iv) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same Department.

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(v) 'Open Elective' means an elective course which is available for students of all programmes, excluding the students of the same department. Students of other Department will opt these courses subject to fulfilling the eligibility criteria as laid down by the Department offering the course.

(vi) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical is proposed as a separate practical course.

Programme Objectives:

1. To inculcate and develop aptitude to apply statistical tools at a number of data generating fields in real life problems.
2. To train students to handle large data sets and carry out data analysis using software and programming language.
3. To teach a wide range of statistical skills, including problem-solving, project work and presentation so as to enable students to take prominent roles in a wide spectrum of employment and research.

Programme Outcomes:

On successful completion of the course a student will be able to:

1. Gain sound knowledge in theoretical and practical aspects of Statistics.
2. Describe complex statistical ideas to non-statisticians.
3. Handle and analyse large databases with computer skills and use their results and interpretations to make practical suggestions for improvement.
4. Get wide range of job opportunities in industry as well as in government sector.

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M.Sc. Statistics Programme Details

III. M.Sc. Statistics Programme Details:

Programme Structure:

M.Sc. Statistics programme is a two-year course divided into four-semester. A student is required to complete **88** credits for the completion of course and the award of degree.

		Semester	**Semester**
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV

Course Credit Scheme:

Semester	**Core Courses**			**Elective Course**			**Open Elective Course**			**Total Credits**
	No. of Papers	Credits (L+T+P)	**Total Credits**	No. of Papers	Credits (L+T+P)	**Total Credits**	No. of Papers	Credits (L+T+P)	**Total Credits**	
I	5	16+0+4	**20**							**20**
II	5	16+0+4	**20**							**20**
III	4	12+0+4	**16**	1	4+0+0	**4**	1	*	**4**	**24**
IV	2	8+0+4	**12**	2	8+0+0	**8 + 4****				**24**
Total Credits for the Courses			**68**			**16**			**4**	**88**

***** Details are given in the list of open elective courses.

**** Project Work = 4 Credits**

Semester wise Details:

Semester –I					
Number of Core Courses: 5					
Course code	**Course Title**	**Credits in each core course**			
		Theory	Practical	Tutorial	Credits
STATC 101	Statistical Methods	4	0	0	4
STATC 102	Probability Theory	4	0	0	4
STATC 103	Distribution Theory	4	0	0	4
STATC 104	Statistical Inference – I	4	0	0	4
STATP 105	Practical –I	0	4	0	4
Total credits in core courses		**16**	**4**	**0**	**20**
Number of elective courses: 0					
Credits in each course		Theory	Practical	Tutorial	Credits
Total credits in elective courses		0	0	0	**0**
Number of open electives: 0					
Total credits in open elective courses		0	0	0	**0**
Total credits in Semester –I		**16**	**4**	**0**	**20**

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Semester –II

Number of Core courses: 5					
Course code	**Course Title**	**Credits in each core course**			
		Theory	Practical	Tutorial	Credits
STATC 201	Multivariate Analysis	4	0	0	4
STATC 202	Linear Models and Generalized Linear Models	4	0	0	4
STATC 203	Statistical Inference-II	4	0	0	4
STATC 204	Survey Sampling	4	0	0	4
STATP 205	Practical –II	0	4	0	4
Total credits in core courses		**16**	**4**	**0**	**20**
Number of elective courses: 0					
Credits in each course		Theory	Practical	Tutorial	Credits
Total credits in elective courses		0	0	0	**0**
Number of open electives: 0					
Total credits in open elective courses		0	0	0	**0**
Total credits in Semester –II		**16**	**4**	**0**	**20**

Semester –III

Number of Core courses: 4					
Course code	**Course Title**	**Credits in each core course**			
		Theory	Practical	Tutorial	Credits
STATC 301	Stochastic Process and Time Series Analysis	4	0	0	4
STATC 302	Large Sample Theory	4	0	0	4
STATC 303	Design of Experiments	4	0	0	4
STATP 305	Practical –III	0	4	0	4
Total credits in core courses		**12**	**4**	**0**	**16**
Number of elective courses: 1					
		Theory	Practical	Tutorial	Credits
Elective Course 1		4		0	4
Total credits in elective courses		**4**		**0**	**4**
Number of open electives: 1					
Total credits in open elective courses		*	0	0	**4**
Total credits in Semester –III		**16 + ∗**	**4**	**0**	**24**

*M.Sc. Statistics Students shall opt for Open Elective Courses from other departments as per rules and regulations of the university.

Semester –IV

Number of Core courses: 3					
Course code	**Course Title**	**Credits in each core course**			
		Theory	Practical	Tutorial	Credits
STATC 401	Econometrics and Survival Analysis	4	0	0	4
STATC 402	Demography and Statistical Quality Control	4	0	0	4
STATP 405	Practical – IV	0	4	0	4
STATP 406	Practical –V{Project Work (Dissertation)}	0	4	0	4
Total credits in each course		**8**	**8**	**0**	**16**

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Number of elective courses: 2				
	Theory	Practical	Tutorial	Credits
Elective Course 2	4		0	4
Elective Course 3	4		0	4
Total credits in elective courses	**8**		**0**	**8**
Number of open electives: 0				
Total credits in open elective courses	0	0	0	**0**
Total credits in Semester –IV	**16**	**8**	**0**	**24**

List of Elective for Semester-III

Elective Course 1: One optional paper out of the following:		
Course Code: MSTE 304	**Course Title**	**L-T-P**
STATE 304 (i)	Advanced Survey Sampling Theory	4-0-0
STATE 304 (ii)	Operations Research-I	4-0-0
STATE 304 (iii)	Advanced Nonparametric Inference	4-0-0
STATE 304 (iv)	Financial Statistics	4-0-0

List of Elective for Semester-IV

Elective Course II and Elective Course III: Two optional papers out of the following		
Course Code: MSTE 403-404	**Course Title**	**L-T-P**
STATE 403 - 404 (i)	Biostatistics	4-0-0
STATE 403 - 404 (ii)	Statistical Computing	4-0-0
STATE 403 – 404 (iii)	Bayesian inference	4-0-0
STATE 403 – 404 (iv)	Operations Research-II	4-0-0
STATE 403 – 404 (v)	Advanced Design of Experiments	4-0-0
STATE 403 – 404 (vi)	Statistical decision theory	4-0-0
STATE 403 – 404 (vii)	Reliability Theory	4-0-0

List of Open Elective Courses

Any one course out of the following		
Course Code: STATOE 306	**Course Title**	**L-T-P**
STATOE 306 (i)	Data Analysis Using R	4-0-0
STATOE 306 (ii)	Essentials of Survey Sampling and Experimental Designs	4-0-0
STATOE 306 (iii)	Research Methodology	4-0-0
STATOE 306 (v)	Statistics for Research and Management Studies	4-0-0

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Selection of Elective Courses:

For selection of elective courses, a student may choose one course in semester III and two courses in semester IV from the lists of options being offered by the Department.

Teaching:

The department shall follow the academic calendar of the university. The course papers to be taught shall be assigned to the respective faculty members as per the need of the department and as per the ordinance of the university.
There shall be 90 instructional days excluding examination in a semester.

Eligibility for Admissions:

Admission to Post-Graduate Courses in Statistics leading to a Master's Degree in Statistics will be made through an Entrance Test (RGUCET). The eligibility conditions shall be as per as per the decision of the Academic Council of the university and also as per the rules of the university

Number of Seats Available: 10.

Assessment of Students' Performance and Scheme of Examinations:

(i) English shall be the medium of instruction and examination.
(ii) Examinations shall be conducted at the end of each Semester as per the Academic Calendar notified by the University
(iii) Examination/Evaluation: A student will be evaluated as per the ordinance and rules and regulations of the Rajiv Gandhi University.

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SCHEME OF EXAMINATION:

First Year: Semester I (July to December)

		Duration (hrs.)	Internal Assessment	End Semester	Credits L+P
STATC 101:	Statistical Methods	3	20	80	4+0
STATC 102:	Probability Theory	3	20	80	4+0
STATC 103:	Distribution Theory	3	20	80	4+0
STATC 104:	Statistical Inference – I	3	20	80	4+0
STATP 105:	Practical-I	5	20	80	0+4

First Year: Semester II (January to May)

		Duration (hrs.)	Internal Assessment	End Semester	Credits L+P
STATC 201:	Multivariate Analysis	3	20	80	4+0
STATC 202:	Linear Models and Generalized Linear Models	3	20	80	4+0
STATC 203:	Statistical Inference-II	3	20	80	4+0
STATC 204:	Survey Sampling	3	20	80	4+0
STATP 205:	Practical-II	5	20	80	0+4

Second Year: Semester III (July to December)

		Duration (hrs.)	Internal Assessment	End Semester	Credits L+P
STATC 301:	Stochastic Process and Time Series Analysis	3	20	80	4+0
STATC 302:	Large Sample Theory	3	20	80	4+0
STATC 303:	Design of Experiments	3	20	80	4+0
STATE 304:	Any one of the following options: (i) Advanced Survey Sampling Theory (ii) Operations Research-I (iii) Advanced nonparametric Inference (iv) Financial Statistics	3	20	80	4+0
STATP 305:	Practical-III	5	20	80	0+4
STATOE 306:	Any one of the following options: (i) Data Analysis Using R (ii) Essentials of Survey Sampling and Experimental Designs (iii) Research Methodology (iv) Statistics for Research and Management Studies	3	20	80	4*

* Details are given in the list of open elective courses.

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Second Year: Semester IV (January to May)

		Duration (hrs.)	Internal Assessment	End Semester	Credits L+P
STATC401:	Econometrics and Survival Analysis	3	20	80	4+0
STATC402:	Demography and Statistical Quality Control	3	20	80	4+0
STATE 403-404:	Any two of the following options: (i) Biostatistics (ii) Statistical Computing (iii) Bayesian Inference (iv) Operations Research-II (v) Advanced Design of Experiments (vi) Statistical Decision Theory (vii) Reliability Theory	3	20	80	4+0
		3	20	80	4+0
STATP 405:	Practical-IV	5	20	80	0+4
STATP 406:	Practical-V {Project Work (Dissertation)} – 6 Months			100	4

Note 1: Each paper will carry 100 marks including 20 marks earmarked for Internal Assessment and 80 Marks for End semester Examination. The format and modus operandi for the above Internal Assessments will be as per the rules and regulations of the university and as per the ordinance of the university. The conversion of marks to grades (credits) shall be as per the rules and regulations of the university and as per the ordinance of the university.

Pass Percentage, Promotion Criteria:

PASS PERCENTAGE:

Minimum marks for passing the examination in each semester shall be 45% in each paper and 45% in aggregate of a semester.

Note: Examination for courses shall be conducted only in the respective odd and even semesters as per the Scheme of Examinations. Regular as well as Ex-Students shall be permitted to appear/reappear/ improve in courses of odd semesters only at the end of odd semesters and courses of even semesters only at the end of even semesters.

PROMOTION CRITERIA and SPAN PERIOD:

The rules and regulations of the university along with ordinances of the university related to Master programme shall be followed.

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IV: Course Wise Content Details for Master of Statistics

M.Sc. (Statistics) Programme

Semester- I

STATC 101: Statistical Methods

Course Objectives: *The aim of the course is to introduce basic ideas of statistical data and their characteristics.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Understand Different types of data and the art of data handling.*
2. *Techniques of summarization and identification of the salient features of the data through graphical displays and other descriptive measures.*
3. *Characteristics of bivariate and multivariate data and their salient features.*

Module I: Concepts of statistical population and sample. Different types of data. Visual representation of data – line diagram, bar plot, pie chart. Frequency distribution of discrete and continuous variables, column and step diagram, histogram, boxplot and give.

Module II: Measures of central tendency – arithmetic mean, geometric mean, harmonic mean, median, mode. Measures of dispersion – range, standard deviation, mean deviation, quartile deviation, coefficient of variation. Measures of skewness and kurtosis and their relationship.

Module III: Bivariate data, scatter diagram, simple correlation, simple linear and regression, least squares method, fitting polynomial and exponential curves, correlation index and correlation ratio, rank correlation.

Module IV: Multivariate data – Multiple regression, multiple and partial correlations. Different results concerning multiple, partial correlations and regression coefficients.

SUGGESTED READINGS:

1. Gun, A. M., Gupta, M. K. and Dasgupta, B (2013). *Fundamentals of Statistics, Vol I,* World Press.
2. Freedman, D., Pisani, R. and Purves, R. (2007). *Statistics*.
3. Yule G.U. and Kendall M.G (1994): An Introduction to the theory of Statistics. 14thEdn. Universal Book stall, Delhi

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STATC 102: Probability Theory

Course Objectives: *The aim of the course is to pay a special attention to applications of measure theory in the probability theory, understanding of Weak Law of Large Numbers, StrongLawofLargeNumbersandtheCentralLimitTheoremwiththeirapplications.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions.*
2. *Gain the ability to understand the concepts of measurable functions, sequence of random variables, convergence, modes of convergence.*
3. *Learn the concepts of weak and strong laws of large numbers and central limit theorem.*

Module I: Classes of sets, fields, σ -fields, minimal σ -field, Borel σ – field in R^K, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure. Probability of union of k events, conditional probability and Bayes theorem. Combinatorial problems in probability.

Module II: Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability, in the rth mean and in distribution, their relationship. Integration of a measurable function with respect to a measure. Helly-Bray theorem, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem, three series criterion.

Module III: Probability generating function, convolution, moment generating function. Characteristic functions, properties of characteristic functions, uniqueness/inversion/Levy continuity theorems.

Module IV: Markov's, Chebychev's and Kolmogorov's inequalities, Jensen, Liapounov, Holder's and Minkowsky's inequalities, Borel –Cantelli lemma and Borel 0-1law. Kolmogorov's 0-1 law.

Module IV: Concept of Independence, Laws of large numbers, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, strong law of large numbers and Kolmogorov's theorem, Central limit theorem, Lindeberg and Levy and Liapunov forms of CLT.

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SUGGESTED READINGS:

1. Ash, R. B. and Doléans-Dade, C.A. (1999). *Probability and Measure Theory*, Second Edition, Academic Press, New York.
2. Billingsley, P. (2012). *Probability and Measure,* Anniversary Edition, John Wiley & Sons.
3. Bhat, B.R. (1999). *Modern Probability Theory*, 3rd Edition, New Age International Publishers.
4. Capinski, M. and Zastawniah (2001). *Probability through problems*, Springer.
5. Chung, K. L. (1974). *A Course in Probability Theory*, 2nd Edition, Academic Press, New York.
6. Feller, W. (1968). *An Introduction to Probability Theory and its Applications*, Vol. 1, 3rd Edition, John Wiley &Sons.
7. Parzen, E. (1960). *Modern Probability Theory and its Application*. Wiley Eastern Private Ltd.
8. Basu, A. K. (2012). *Measure Theory and Probability*. Prentice Hall of India.

STATC 103: Distribution Theory

Course Objective: *The aim of this course is to provide a thorough theoretical grounding in different type of distributions, non-central distributions, censoring, delta method, robust procedures etc.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Formulate the mathematical/statistical models for real data sets arising in various fields in order to analyse in respect of various useful characteristics of the populations.*
2. *Understand how to use non-central distributions in real life problems.*
3. *Understand the idea and use of multivariate distributions.*
4. *Work with real-life data.*
5.

Module I: Brief review of standard probability distributions theory (discrete and continuous), Weighted distributions, Truncated distributions, Compound distributions, Mixture of distributions, Generalized power series distributions, Exponential family of distributions. Properties of the distributions.

Module II: Chi-square, F and t distributions. Non-central Chi-square, t and F distributions and their properties, Concept of censoring.

Module III: Order statistics-their distributions and properties. Joint and marginal distributions of order statistics. Distribution of range. Tolerance intervals, coverage of (X(r), X(s)).

Module IV: Bivariate normal distribution – marginal and conditional distributions, moment generating function, equi-probability contour. Multivariate normal distribution – marginal and conditional distribution, moment generating function, characteristic function, multiple and partial correlations.

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SUGGESTED READINGS:

1. Arnold, B.C., Balakrishnan, N., and Nagaraja, H.N. (1992). *A First Course in Order Statistics*, John Wiley &Sons.
2. Biswas, S. (1992). *Topics in Statistical Methodology*, Wiley-Blackwell.
3. David,H.A.,andNagaraja,H.N.(2003).*OrderStatistics*,3rdEdn.,JohnWiley&Sons.
4. Dudewicz, E.J. and Mishra, S.N. (1988). *Modern Mathematical Statistics*, Wiley, International Students' Edition.
5. Huber, P.J. (1981). *Robust Statistics*, John Wiley &Sons.
6. Johnson, N.L., Kemp, A. W. andKotz, S. (2005). *Univariate Discrete Distributions*, John Wiley & Sons.
7. Johnson, N.L., Kotz, S. and Balakrishnan, N. (2000). *Continuous Univariate Distributions*, Vol. 1 and 2, John Wiley &Sons.
8. Mukhopadhyay, P. (2015). *Mathematical Statistics*. New Central Book Agency.
9. Rohatgi, V.K. and Saleh, A. K. Md. E. (2005). *An Introduction to Probability and Statistics*, 2nd Edn., John Wiley &Sons.
10. Rohatgi, V.K. (1984). *Statistical Inference*, John Wiley &Sons.
11. Rao, C.R. (1973). *Linear Statistical Inference and Its Applications*, 2nd Edn., John Wiley &Sons.
12. A.M. Gun, M. K. Gupta, B. Dasgupta. *Outline of Statistical Theory. (Volume I)*, World Press.
13. Kotz, S., Balakrishnan, N. and Johnson, N. L. (2000). *Continuous Multivariate Distributions*, John Wiley & Sons.

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STATC104: Statistical Inference-I

Course Objectives: *To make students aware of estimation (point, as well as, interval) and testing (simple, as well as, composite hypotheses) procedures.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Apply various estimation and testing procedures to deal with real life problems.*
2. *Understand Fisher Information, Lower bounds to variance of estimators, MVUE.*
3. *Understand Neyman-Pearson fundamental lemma, UMP test, Interval estimation and confidence interval.*

Module I: Sufficiency, Minimal sufficiency and ancillarity, Completeness. Unbiased estimator, minimum variance unbiased estimator, Cramer-Rao inequality, Fisher Information for one and several parameters models. necessary and sufficient conditions for MVUE (MinimumVariance unbiased estimator), Cramer-Rao inequality, Rao-Blackwell Theorem, Lehmann-Scheffe Theorem. Method of moments, Maximum likelihood estimation, Minimum chi-square method.

Module II: Basics of testing of hypotheses. One-sample t-test, paired t-test, Fisher t-test, test concerning variance of one sample, two samples, and paired sample under normal set-up.

Module III: Neyman-Pearson lemma (Statement only) and its applications, MP and UMP tests. Families of distributions with monotone likelihood ratio and UMP tests.

Module IV: Interval estimation, confidence level, construction of shortest expected length confidence interval, Uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses.

SUGGESTED READINGS:

1. Gun, A. M., Gupta, M. K. and Dasgupta, B (2013). *Fundamentals of Statistics, Vol I,* World Press.
2. Gun, A. M., Gupta, M. K. and Dasgupta, B (2013). *Outline of Statistical Theory, Vol I,* World Press.
3. Bartoszynski, R. and Bugaj, M.N. (2007). *Probability and Statistical Inference*, John Wiley &Sons.
4. Kale, B.K.(1999). *A First Course on Parametric Inference*, Narosa Publishing House.
5. Lehmann, E.L. (1986). *Theory of Point Estimation*, John Wiley &Sons.
6. Lehmann, E.L. (1986). *Testing Statistical Hypotheses*, John Wiley &Sons.
7. Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). *An Introduction to Probability and Statistics*, 2nd Edn., John Wiley &Sons.
8. Casella, G. and Berger, R. L. (2013). *Statistical Inference,* Cengage Learning.

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STATP 105: Practical-I

Review of programming in C/C^{++}: Operators & expressions; Flow control; Conditional Statements – If, If-Else. Loop Structures – For loop. Control statements; Break, Exit and Continue functions. Functions; Arrays; Strings; Pointers; Structures.Loop Structures: While, Do-While, for loop.
Linked Lists; Stacks & Queues. Sorting – Introduction, bubble sort, selection sort, insertion sort, quicksort.

Problems arising from Paper STATC 101, STATC-103 and STAC 104.

SUGGESTED READINGS:

1. Kernighan, B.W. and Ritchie, Dennis M. (1989). *The C Programming Language*, Prentice Hall of India Pvt. Ltd., New Delhi.
2. Gottfried, B.S. and Chhabra, J.K. (2006). *Programming with C*, Tata McGraw Hill Publishing Co. Ltd., New Delhi (SIE).
3. Knuth, D.E. (2002). *The Art of Computer Programming*, Vol. 2/Semi numerical Algorithms, Pearson Education (Asia).
4. Rubinstein, R.Y. (2017). *Simulation and the Monte Carlo Method*, 3rd ed., John Wiley & Sons.
5. Ross, S.M. (2012). *Simulation*, 5th ed., Academic press.
6. Thareja, R.(2014).*Data Structures using C*, Oxford University Press, New Delhi, India.

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Semester- II

STATC 201: Multivariate Analysis

Course Objectives: *The main objective of this course is to introduce students to the analysis of observations on several correlated random variables for a number of individuals. Such analysis becomes necessary in Anthropology, Psychology, Biology, Medicine, Education, Agriculture and Economics when one deals with several variables simultaneously.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Summarize and interpret multivariate data.*
2. *Appreciate the range of multivariate techniques available.*
3. *Understand the link between multivariate techniques and corresponding univariate techniques.*
4. *Use multivariate techniques appropriately and draw appropriate conclusions.*

Module I: Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known.

Module II: Wishart distribution and its properties (without proof). Distribution of sample generalized variance, Hotelling's T^2 statistics, its distribution and properties, Applications in tests on mean vector for one and more multivariate normal populations, Mahalanobis' D^2 Statistics

Module III: Dimension reduction techniques: Principle Component Analysis (PCA), Factor analysis, Canonical correlation.

Module IV: Classification and discrimination procedures for discrimination between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, classification rule based on expected cost of misclassification (ECM), classification into more than two multivariate normal populations, Cluster analysis.

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SUGGESTED READINGS:

1. Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 3rd ed., John Wiley &Sons.
2. Hardle, W. K. and Simar, L. (2015). *Applied Multivariate Statistical Analysis*, 4th Edn., Springer.
3. Johnson, R. A. and Wichern, D. W. (2015). *Applied Multivariate Statistical Analysis*, 6th Edn., Pearson Education India.
4. Izenman, A. J. (2008). *Modern Multivariate Statistical Techniques*. Springer.
5. Kshirsagar, A. M. (1996). *Multivariate Analysis*, 2nd ed., Marcel Dekker.
6. Lawley, D. N. and Maxwell, A. E. (1971). *Factor Analysis as a Statistical Method*, 2nd Edn., London Butterworths.
7. Muirhead, R. J. (1982). *Aspects of Multivariate Statistical Theory*, John Wiley & Sons.
8. Rao, C. R. (1973). *Linear Statistical Inference and its Applications*, 2nd ed., John Wiley &Sons.
9. Srivastava, M. S. and Khatri, C. G. (1979). *An Introduction to Multivariate Statistics*, North Holland.

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STATC 202: Linear Models and Generalised Linear Models

Course Objectives: *The main objective of this course is to introduce students to the analysis of observations on dependent variable on few explanatory variables.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Extend the modelling of a response-predictor relationship to the case where there are more than 2 predictors.*
2. *Identify and classify Gauss Markov models.*
3. *Analyse ANOVA models to test for the differential effects of factors and interaction effects between two factors.*
4. *Deal with testing problems related to regression models.*
5. *Understand the use of concomitant variables in analysing ANOCOVA models.*
6. *Understand the problems arising when the model is not linear and how to tackle that problem.*

Module I: Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss Markov Theorem, Estimation space and Error Space, Estimation of error variance. Tests of General Linear Hypotheses.

Module II: Regression analysis: Hypothesis testing in case of simple and multiple regression models. Different problems in regression analysis – testing equality and parallelism of two regression lines, testing equality and parallelism of k-regression lines and other related problems. Confidence interval of regression coefficient of two parallel regression lines.

Module III: Analysis of variance: Analysis of Variance in one-way classified data – fixed and random effects models. Analysis of two-way classified data (with equal number of observations per cell) for fixed, random and mixed effects models. Analysis of covariance: Analysis of covariance for one-way and two-way classified data with one concomitant variable.

Module IV: Logistic regression, deviance, concept of generalized linear model, link function, Poisson regression and other link functions.

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SUGGESTED READINGS:

1. Scheffe, H, (1999). *Analysis of Variance*, Wiley.
2. Rao, C.R., (1973). *Linear Statistical Inference* and its Applications, Wiley.
3. Agresti, A. (2002). *Categorical Data Analysis*, 2nd ed., John Wiley & Sons.
4. Christensen, R. (1997). *Log-linear Models and Logistic Regression*, 2nd ed., Springer.
5. McCulloch, C.E. and Searle, S.R. (2001). *Generalized, Linear and Mixed Models*, John Wiley & Sons.
6. Mc Cullagh, P. and Nelder, J.A. (1989). *Generalized Linear Models*, 2nd ed., Chapman and Hall.

10/07/2021

STATC203: Statistical Inference-II

Course Objectives: *To make aware the students of parametric, non-parametric and sequential estimation (point, as well as, interval) and testing (simple, as well as, composite hypotheses) procedures.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Apply various parametric, non-parametric and sequential estimation techniques and testing procedures to deal with real life problems.*
2. *Understand Likelihood ratio test.*
3. *Understand UMPU tests, SPRT, OC and ASN.*
4. *Understand non-parametric methods, U-statistics, UMVU estimators.*

Module I: Similar tests, Neyman structure, UMPU tests for composite hypotheses, Invariance tests and UMP invariant tests, Likelihood ratio test, Asymptotic distribution of LRT statistic (statement only).

Module II: Sequential tests-SPRT and its properties, Wald's fundamental identity, OC and ASN functions Sequential estimation.

Module III: Non- parametric methods-estimation and confidence interval, U-statistics and their asymptotic properties, UMVU estimator, nonparametric tests-single sample location, location-cum-symmetry.

Module IV: Linear rank statistics, Kruskal-Wallis test, Asymptotic relative efficiency.

10/07/2021

SUGGESTED READINGS:

1 Gun, A. M., Gupta, M. K. and Dasgupta, B. (2013). Fundamentals of Statistic, Vol I. World Press.

2 Gun, A. M., Gupta, M. K. and Dasgupta, B. (2013). An Outline of Statistical Theory, Vol II. World Press.

3 Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference, Marcel Dekker.

4 Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.

5 Lehmann, E.L. (1986). Theory of Point Estimation, John Wiley & Sons.

6 Lehmann, E.L. (1986). Testing Statistical Hypotheses, John Wiley & Sons.

7 Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.

8 Randles, R.H. and Wolfe, D.S. (1979). Introduction to the Theory of Non-parametric Statistics, John Wiley & Sons.

9 Zacks, S. (1971). Theory of Statistical Inference, John Wiley & Sons.

10 Zacks, Shelemyahu, (1981). Parametric Statistical Inference: Basic Theory and Modern Approaches (International series in nonlinear mathematics), Pergamon Press.

10/07/2021

STATC204: Survey Sampling

Course Objectives: *The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Understand the distinctive features of sampling schemes and its related estimation problems*
2. *Learn about various approaches (design based and model-based) to estimate admissible parameters, with and without replacement sampling scheme, sampling with varying probability of selection.*
3. *Learn about the methods of post–stratification (stratified sampling) and controlled sampling and also double sampling procedure with unequal probability of selection.*
4. *Learn about the applications of sampling methods; systematic, stratified and cluster sampling.*
5. *Understand the cluster and two stage sampling with varying sizes of clusters/first stage units.*
6. *Understand the super population approach to estimation.*
7. *Learn about the randomized response techniques.*

Module I: Basic ideas and distinctive features of sampling, Probability sampling designs, sampling schemes, inclusion probabilities and estimation. Simple random sampling – with and without replacement, stratified random sampling, Non-sampling errors with special reference to non-response.

Module II: Sampling with varying probabilities (unequal probability sampling) with or without replacement: pps, πps and non- πps sampling procedures and estimation based on them, Non- negative variance estimation. Ratio and regression Estimators.

Module III: Two-way stratification, post-stratification, controlled sampling, Estimation based on auxiliary data (involving one or more auxiliary variables) under design-based and model-based approaches, Double (two-phase) sampling with special reference to the selection with unequal probabilities in at least one of the phases.

Module IV: Systematic sampling and its application to structured populations, Cluster sampling (with varying sizes of clusters), Two-stage sampling (with varying sizes of first-stage units), Warner's and Simmons' randomized response techniques for one qualitative sensitive characteristic.

10/07/2021

SUGGESTED READINGS:

1. Chaudhari, A. and Stenger, H. (2005). *Survey Sampling Theory and methods*, 2nd Edn., Chapman and Hall.
2. Chaudhari, A. and Vos, J.W.E. (1988). *Unified Theory and Strategies of Survey Sampling*, North –Holland, Amsterdam.
3. Cochran, W.G. (1977). *Sampling Techniques*, John Wiley & Sons, New York.
4. Hedayat, A.S., and Sinha, B.K. (1991). *Design and Inference in Finite Population Sampling*, Wiley, New York.
5. Levy, P.S. and Lemeshow, S. (2008). *Sampling of Populations-Methods and Applications*, Wiley, New York.
6. Murthy, M.N. (1967). *Sampling Theory and Methods*, Statistical Publishing Society, Calcutta.
7. Raj, D. and Chandhok, P. (1998).*Sample Survey Theory*, Narosa Publishing House.
8. Mukhopadhyay, P. (2009). *Theory and Methods of Survey Sampling*, 2nd Edn., Prentice Hall of India, NewDelhi.
9. Sarndal, C.E., Swensson, B. and Wretman, J.H. (1992). *Model Assisted Survey Sampling*, Springer-Verlag, New York.
10. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). *Sampling Theory of Surveys with Applications*, Iowa State University Press, Iowa, USA.
11. Thompson, S.K. (2002). *Sampling*, John Wiley & Sons, New York.

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STATP 205: Practical-II (Programming in R/python)

Programming in R/python: Operators & expressions; Flow control; Conditional Statements – If, If-Else. Loop Structures – For loop. Control statements; Loop Structures: While, for loop. Functions, writing your own functions.

Problems arising from Paper STATC 201 – STAC 204.

SUGGESTED READINGS:

1. Dalgaard, P. (2002). *Introductory Statistics with R*, Springer.
2. Wickham, H. & Grolemund, G. (2017). *R for Data Science*, O'Reilly.
3. McKinney, W. (2017). *Python for Data Analysis*, O'Reilly.
4. Liang, D.Y. (2017). *Introduction to Programming using Python*, Pearson.

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Semester-III

STATC 301: Stochastic Processes and Time Series Analysis

Course Objectives: *The main objective of this course is to develop awareness for the use of stochastic models for representing random phenomena evolving in time.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Use notions of long-time behaviour including transience, recurrence, and equilibrium in applied situations such as branching processes and random walk.*
2. *Construct transition matrices for Markov dependent behaviour and summarize process information.*
3. *Use selected statistical distributions for modeling various phenomena.*
4. *Understand the principles and objectives of model building based on Markov chains, Poisson processes and Brownian motion.*
5. *Understand the analyses of times series data applicable in many areas.*

Module I: Review of Basic Probability Concepts. Introduction to Stochastic Processes. and Stochastic Exponential Growth Models. Stationary and Evolutionary Processes. Poisson Processes: Poisson distribution and Poisson Process. Arrival, Interarrival and Conditional Arrival Distributions. Nonhomogeneous Processes. Law of Rare Events and Poisson Process. Poisson Point Process. Distributions associated with Poisson Process. Compound Poisson Processes.

Module II: Markov Chains: Transition Probability Matrices, Chapman- Kolmogorov equations, Some Examples and Classification of States, Regular Chains and Stationary Distributions, Periodicity, Limit theorems. Fundamental Matrix. Some Applications. One-dimensional random walks.

Module III: Birth and death processes. Brownian Motion: Limit of Random Walk, Its Defining Characteristics and Peculiarities. Its Variations: Standard Brownian Motion, Brownian Bridge. Some applications.

Module IV: Time series as discrete parameter stochastic process. Auto-covariance and Auto-correlation functions and their properties. Stationary Processes: Moving average (MA) process, Auto-regressive (AR) process, ARMA, ARIMA and SARIMA models. Box-Jenkins models, Discussion (without proof) of estimation of mean, auto-covariance auto-correlation functions under large sample theory. Correlogram and Periodogram analysis. Spectral representation of time series. Forecasting. Exponential smoothing methods.

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SUGGESTED READINGS:

1. Basu, A. K. (2007). *Introduction to Stochastic Process.* Narosa Publishing House
2. Bhat, B.R. (2000). *Stochastic Models- Analysis and Applications*, New Age International Publishers.
3. Feller, William (1968). *An Introduction to Probability Theory and its Applications*, Vol. 1, 3rd Edn., John Wiley & Sons.
4. Karlin, S. and Taylor, H.M. (1975). *A first course in Stochastic Processes*, Second ed. AcademicPress
5. Medhi, J. (1994). *Stochastic Processes*, Seconded Wiley Eastern Ltd.
6. Ross, S. M. (1996). *Stochastic Processes*, John Wiley and Sons, Inc
7. Taylor, H.M. and Karlin, S. (1998). *An Introduction to Stochastic Modelling*, 3rd ed., Academic Press.
8. Shumway, R. H., and Stoffer, D. S. (2011). *Time Series Analysis and Its Applications*, 3rd ed., Springer, New York.
9. Brockwell, P.J. and Daris, R. A. (2002). *Introduction to time Series and Forecasting*, 2nd ed., Springer-Verlag.
10. Fuller, W. A. (1996). *Introduction to Time Series*. Wiley.
11. Gun, A. M., Gupta, M. K. and Dasgupta, B. (2013). Fundamentals of Statistic, Vol II. World Press.

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STATC 302: Large Sample Theory

Course Objectives: *The main objective of this course is to introduce students to inferential aspects when the sample size is large.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Understand different modes of convergence of statistics and their inter-relations.*
2. *Understand the large sample behaviour of different statistics used in inference.*
3. *How to stabilize the variance of a statistic and its usefulness in testing of hypothesis.*
4. *Know about Pearsonian Chi-Square statistic and its uses.*

Module I: Sequence of random variables, Different modes of convergence - Convergence in probability, convergence in distribution, L_p convergence, almost sure convergence; their inter-relations. Slutsky's theorem, Central Limit Theorem (Statement only) and its use in test and confidence interval for binomial proportions, Poisson means, and two sample normal means.

Module II: Standard Errors of Statistics: Derivation and uses of large sample standard error of sample moments, Standard deviation, Coefficient of variation, b1 & b2 (g1 & g2) measures, Correlation coefficient. Asymptotic distribution of sample quantiles.

Module III: Variance Stabilization: Transformation of Statistics, Derivation and use of $\sin^{-1}$, square root, logarithmic & Fisher's Z transformations.

Module IV: Pearsonian $\chi 2$: Large Sample distribution of Pearsonian $\chi 2$ statistic &its uses (goodness of fit, independence, homogeneity). Yates' correction in a 2x2 contingency table. Statement of multivariate CLT and its use, Cramer-Wold device.

SUGGESTED READINGS:

1. Gun, A. M., Gupta, M. K. and Dasgupta, B. (2013): *An Outline of Statistical Theory, Vol I*, World Press.
2. Gun, A. M., Gupta, M. K. and Dasgupta, B. (2013): *Fundamentals of Statistics, Vol I*, World Press.
3. Rohatgi, V.K. and Saleh, A.K.M.E. (2003): *An Introduction to Probability and Statistics*, 2nd Edn, Wiley.
4. Basu, A. K. (2012). *Measure Theory and Probability*, Prentice Hall of India.
5. Serfling, R. J. (2001). *Approximation Theorems of Mathematical Statistics*, Wiley.
6. Lehmann, E. L. (2004). *Elements of Large Sample Theory*, Springer.

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STATC303: Design of Experiments

Course Objectives: *This course provides the students the ability to understand the design and conduct experiments, as well as to analyze and interpret data.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Apply ANOVA for two –way classification, fixed effect models with equal, unequal and proportional number of observations per cell, Random and Mixed effect models with m (>1) observations percell.*
2. *Design and analyse incomplete block designs, understand the concepts of orthogonality, connectedness and balance.*
3. *Understand the concepts of finite fields and finite geometries and apply them in construction of MOLS, balanced incomplete block designs, confounded factorial experiments.*
4. *Identify the effects of different factors and their interactions and analyse factorial experiments.*
5. *Construct complete and partially confounded factorial designs and perform their analysis.*
6. *Apply Split-plot designs and their analysis in practical situations.*

Module I: Basic principles of designs of experiments. Theoretical development of designs like Completely Randomised Design (CRD), Randomised Block design (RBD), Latin Square Design (LSD).

Module II: Incomplete Block Designs. Concepts of Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design. B.I.B designs with and without recovery of interblock information.

Module III: Finite fields. Finite Geometries- Projective geometry and Euclidean geometry. Construction of complete set of mutually orthogonal latin squares. Construction of B.I.B.D. using finite Abelian groups, MOLS, finite geometry and method of differences.

Module IV: Symmetrical factorial experiments (s^m, where s is a prime or a prime power), 2^m and 3^m factorial design, Total confounding and partial confounding. Split-plot experiments, strip plot experiments.

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SUGGESTED READINGS:

1. Gun, A. M., Gupta, M. K. and Dasgupta, B. (2013). Fundamentals of Statistic, Vol II.
2. Chakrabarti, M.C. (1962). *Mathematics of Design and Analysis of Experiments*, Asia Publishing House, Bombay.
3. Dean, A. and Voss, D. (1999). *Design and Analysis of Experiments*, Springer. First Indian Reprint2006.
4. Das, M.N. and Giri, N.C. (1986). *Design and Analysis of Experiments*, Wiley Eastern Limited.
5. Dey, A. (1986). *Theory of Block Designs*, John Wiley &Sons.
6. Hinkelmann, K. and Kempthorne, O. (2005). *Design and Analysis of Experiments*, Vol. 2: Advanced Experimental Design, John Wiley &Sons.
7. John, P.W.M. (1971). *Statistical Design and Analysis of Experiments*, Macmillan Co., New York.
8. Montgomery, D. C. (2005). *Design and Analysis of Experiments*, 6th ed., John Wiley & Sons.
9. Raghavarao, D. and Padgett, L. V. (2005). *Block Designs: Analysis, Combinatorics, and Applications*, World Scientific.
10. Raghavarao, D. (1970). *Construction and Combinatorial Problems in Design of Experiments*, John Wiley & Sons.

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STATP 305 – Practical-III

Group A: Practical problems from paper STATC 301 to STATC 303

Group B: Practical problems from paper STATE 304(i) / STATE 304(ii) / STATE 304(iii) / STATE 304(iv)

At least one question must be opted from the elective course in their practical exam.

SUGGESTED READINGS:

1. Hand, D.J., Daly, F., McConway, K., Lunn, D., & Ostrowski, E. (1993). *A Handbook of Small Data Sets*, CRC Press.
2. Dalgaard, P. (2002). *Introductory Statistics with R*, Springer
3. Liang, D.Y. (2017). *Introduction to Programming using Python*, Pearson.

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Semester-IV

STATC 401: Econometrics and Survival Analysis

Course Objectives: *The objective of this course is to study more advanced topics in econometrics and survival analysis.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Acquire knowledge of various advanced econometric models, estimation methods and related econometric theories.*
2. *Conduct econometric analysis of data.*
3. *Apply statistical techniques to model relationships between variables and make predictions.*
4. *Understand how to analyse survival data.*
5. *Estimation of survival function and related tests.*

Module I: Econometrics: Review of GLM and generalized least squares, GLM with stochastic regressors, Probit and tobit model, Instrumental Variables (I.V): estimation, consistency property, asymptotic variance of I.V estimators.

Module II: Distributed lag models, Polynomial lag models, Almon's lag model, Determination of degree of polynomial and lag length. Adaptive expectation model, Partial adjustment model, Compound Geometric lag model. Methods of estimation.

Module III: Simultaneous-equation models: Identification problems. Restrictions on structural parameters – Rank and Order Condition for identification. Restrictions on variances and covariances. Simultaneous-equation methods: Estimation - Recursive systems, Two Stage Least Squares (2SLS) estimators, Limited Information (Least Variance Ratio) estimators, k- class estimators, Three Stage Least Squares (3SLS) and Full Information Maximum-Likelihood(FIML).

Module IV: Functions of survival time, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function. Different type of censoring viz. right (type I), left, double, interval and number censoring (type II) with real life examples. Estimation of mean survival time and variance of the estimate or for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Acturial and Kaplan –Meier methods. Parametric methods viz. Likelihood Ratio test, Cox's F-test and non-parametric methods viz. Log Rank test, Cox F test for comparing two survival distributions, Cox proportional hazard model.

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SUGGESTED READINGS:

1. Johnston, J. (1984). *Econometric Methods*, McGraw Hill Kogakusha Ltd.
2. Judge, G. G., Hill, R, C., Griffiths, W.E., Lutkepohl, H. and Lee, T. C. (1988). *Introduction to the Theory and Practice of Econometrics*, 2nd ed., John Wiley & Sons.
3. Greene, W.H. (2003). *Econometric Analysis*, 5th ed., Dorling Kindersley (India) Pvt. Ltd., licensees of Pearson Education in South Asia.
4. Kmenta, J. (1986). *Elements of Econometrics*, 2nd ed., MacMillan.
5. Klein, J. P. and Moeschberger, M. L. (2003). *Survival Analysis: Techniques for Censored and Truncated Data.* Springer.
6. Moore, D. F. (2016). *Applied Survival Analysis Using R,* Springer.

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STATC 402: Demography and Statistical Quality Control

Course Objectives: *The main objective of this course is to describe current population trends, in terms of fertility, mortality and population growth and the concepts of Statistical Quality Control, Quality Assurance and Performance Analysis.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Identify principle sources of demographic data and assess their strengths and weaknesses.*
2. *Construct and interpret single-decrement life tables.*
3. *Specify and calculate the principal demographic measures and standardize these measures for comparison and interpretation.*
4. *Identify the components of population change, including the effects of changing birth, death and migration rates, and demonstrate their influences on age structure.*
5. *Do population projection by different methods.*
6. *Describe the DMAIC process (define, measure, analyze, improve, and control).*
7. *Demonstrate to use the methods of statistical process control and to determine when an out-of-control situation has occurred.*
8. *Design and use Cumulative sum chart, tabular Cumulative sum chart and V-mask schemes for detecting small shifts of the mean from goal conditions.*
9. *Choose an appropriate sampling inspection technique.*

Module I: Demography: Measures of morbidity and mortality, description of life table, construction of complete and abridged life tables, Estimation of life table parameters. Basic knowledge of SRS technique. Demographic data management systems in India

Module II: Measures of fertility, models for population growth, intrinsic growth rate, stable population analysis, population projection by component method and using Leslie matrix. Cohort Component Method, Fitting of Logistic growth function (Gompertz and Makeham's method)

Module III: Basic concepts of process monitoring and control, General theory and review of control charts, OC and ARL of control charts, CUSUM charts using V-mask and decision intervals, economic design of $\bar{x}$ chart.

Module IV: Review of sampling inspection techniques, single, double and sequential sampling plans and their properties, methods for estimating (n, c) using large sample. Dodge's continuous sampling inspection plans for inspection by variables for one-sided and two-sided specifications.

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SUGGESTED READINGS:

1. Biswas, S. (1996). *Statistics of Quality Control, Sampling Inspection and Reliability*, New Age International Publishers.
2. Biswas, S. (1988). *Stochastic Processes in Demography and Applications*, Wiley Eastern Ltd.
3. Keyfitz, N. (1971). *Applied Mathematical Demography*, Springer Verlag.
4. Montgomery, D. C. (2005). *Introduction to Statistical Quality Control*, 5th ed., John Wiley &Sons.
5. Spiegelman, M. (1969). *Introduction to Demographic Analysis*, Harvard University Press.
6. Wetherill, G. B. (1977). *Sampling Inspection and Quality Control*, Halsted Press.

STATP 405: Practical-IV

Group A: Practical problems from paper STATC 401 and STATC 402

Group B: Practical problems from paper STATE 403-404(i) / STATE 403-404(ii) / STATE 403-404(iii) / STATE 403-404(iv) / STATE 403-404(v) / STATE 403-404(vi) / STATE 403-404(vii)

At least one question must be opted from the elective course in their practical exam.

SUGGESTED READINGS:

1. Judge,G.G.,Hill,R,C.,Griffiths,W.E.,Lutkepohl,H.andLee,T.C.(1988). *Introduction to the Theory and Practice of Econometrics*, 2nd ed., John Wiley & Sons.
2. Montgomery, D. C. (2005). *Introduction to Statistical Quality Control*, 5th ed., John Wiley &Sons.
3. Gun, A. M., Gupta, M. K. and Dasgupta, B (2013). *Fundamentals of Statistics, Vol II,* World Press.

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STATP 406: **Practical-V {Project Work (Dissertation)}**

The project work shall involve statistical knowledge that the students learned through the four semesters. It is expected but not mandatory that the project work should involve real life data and its analysis. Each student will carry out one project and it will be supervised by one or more faculty.

ELECTIVE COURSES (THIRD SEMESTER)

STATE 304 (i): Advanced Survey Sampling Theory

Course Objectives: *The objective of this course is to provide advanced techniques in survey sampling with practical applications in daily life and to provide accessible statistical tool for applying sampling strategies and methodologies.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Understand the non –existence of uniform estimators and repetitive surveys.*
2. *Apply the re-sampling techniques for variance estimation – independent and dependent random groups.*
3. *Understand the design-based estimation procedures and double sampling technique for stratification.*
4. *Understand the response and non- response techniques; Randomized Response Technique and a technique to predict non observed residue under design and model-based model.*
5. *Understand the model assisted sampling strategies, super population model.*

Module I: Admissibility of Estimators; Non-existence of UMV estimators; Estimation of Median; Sampling on two or more successive occasions (Repetitive surveys); Re-Sampling techniques for variance estimation-independent and dependent random groups, the Jackknife and the Bootstrap.

Module II: Small-area estimation; Design-based conditional approach; Double sampling for stratification.

Module III: Non-sampling errors; Non-response and missing data; Randomized Response Techniques for one quantitative sensitive characteristic. Prediction of non-observed residual under fixed (design-based) and super-population (model-based) approaches.

Module IV: Model-assisted sampling strategies; Different types of Super-population models with optimal strategies based on them; Robustness against model failures.

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SUGGESTED READINGS:

1. Cassel, C.M., Sarndal, C-E and Wretman, J.H. (1977). *Foundations of Inference in Survey Sampling*, John Wiley &Sons.
2. Chaudhari, A. and Stenger, H. (2005). *Survey sampling Theory and Methods*, 2nd ed., Chapman andHall.
3. Hedayat, A.S. and Sinha, B.K. (1991). *Design and Inference in Finite Population Sampling*, John Wiley &Sons.
4. Muhopadhyay, P. (2007). *Survey Sampling*, Nerosa Publishing House, New Delhi.
5. Mukhopadhyay, P. (1996). *Inferential Problems in Survey Sampling*, New Age International (P)Ltd.
6. Levy, P.S. And Lemeshow, S. (2008). *Sampling of Populations-Methods and Applications*, John Wiley & Sons.
7. Sarndal, C.E., Swensson, B. and Wretman, J.H. (1992). *Model Assisted Survey Sampling*, Springer-Verlag.
8. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). *Sampling Theory of Surveys with Applications*, Iowa State University Press, Iowa, USA.
9. Wolter, K.M. (2007). *Introduction to Variance Estimation*, Springer-Verlag.

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STATE 304(ii): Operations Research-I

Course Objectives*: The purpose is to provide deterministic model technique of real-life problems.*

Course Learning Outcomes*:*

1. *How to write a mathematical model on real-life decision-making problem, specially linear model.*
2. *Methods to solve linear programming problems graphically as well as using other methods.*
3. *How to model competitive situations between opponents.*
4. *Problem of resolving allocation of resources to the destinations.*
5. *To develop methods to resolve Queue problems.*

Module I: Two-person games; pure and mixed strategies; existence of solution and uniqueness of value in zero-sum games; finding solution in 2×2, 2×m and m×n games; reduction of game problem to a linear programming problem.

Module II: Linear programming problems (LPP); formulation, Graphical solution of LPP, Simplex procedure, Solution of LPP by simplex method. Artificial variable technique and big M method of solving LPP.

Module III: Allocation Problems: transportation problem (TP); degeneracy in TP; unbalanced TP.

Module IV: Queueing Models: Basic idea of queue. steady-state solutions of (M/M/I) and (M/M/C) Models with associated distributions of queue length and waiting time.

SUGGESTED READINGS:

1. Gross, D., Shortle J.F., Thompson J.M. and Harris, C.M. (2008). *Fundamentals of Queueing Theory,* John Wiley &Sons.
2. Hillier, F.S. and Lieberman, G.J. (2001). *Introduction to Operations Research*, 7th ed., Irwin.
3. Taha, H. A. (2016).*Operations Research: An Introduction*, Tenth Ed. Prentice Hall.
4. Winston, W.L. and Goldberg, J.B. (2004). *Operations Research: Applications and Algorithms*, Thomson Brooks/Cole.
5. Medhi, J. (2003). *Stochastic Models in Queuing Theory*, 2nd Ed., Elsevier Inc.

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STATE 304 (iii): Advanced Nonparametric Inference

Course Objectives: *This course will provide the ability to learn the fundamentals of the most relevant nonparametric techniques for statistical inference.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Understand hypothesis testing problems where the conditions for the traditional parametric inferential tools to be applied are not fulfilled.*
2. *Build nonparametric density estimates.*

Module I: Review of order statistics, Distribution-free statistics over a class, Statistics utilizing counting and ranking, Asymptotic distribution of U- statistics, point and interval estimation for population quantile and scale parameter. Estimators associated with distribution free test statistics, Exact small-sample and asymptotic properties of the Hodges-Lehmann location estimators.

Module II: Nonparametric density estimation, nonparametric regression estimation. Tests based on run, Kolmogorov-Smirnov two sample statistic. Rank order statistics: Correlation between ranks and variate values, one sample, paired sample and two sample problems, distribution properties of linear rank statistics.

Module III: Tests for equality of k independent samples: Kruskal-Wallis one way ANOVA test, Measures of Association for bivariate samples: Kendall's Tau coefficient, Spearman's coefficient of Rank correlation, relations between R and T; E (R), τ and ρ.

Module IV: Measures of association in multiple classifications: Friedman's two-way ANOVA by ranks in a k x n table, the Coefficient of Concordance of k sets of rankings of n objects, the Coefficient of Concordance of k sets of incomplete rankings. Concept of power and robustness, elements of boot strapping.

SUGGESTED READINGS:

1. David, H.A. and Nagaraja, H. N. (2003). *Order Statistics*, Third Edition, John Wiley & Sons.
2. Gibbons, J.D. and Chakraborti, S. (1992). *Nonparametric Statistical Inference*, 3rd ed., Marcel Dekker.
3. Hettmansperger, T.P. (1984).*Statistical inference Based on Ranks*, John Wiley & Sons.
4. Randles, R.H. and Wolfe, D.A. (1979). *Introduction to the Theory of Nonparametric Statistics*, John Wiley & Sons.
5. Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). *An Introduction to Probability and Statistics*, 2nd ed., John Wiley &Sons.

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STATE 304 (iv): Financial Statistics

Course Objectives: *Financial Statistics aims to introduce students to the market tools required for analyzing the financial markets, to model various financial instruments and to find solutions of the problems faced by various players of these markets.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Understand the intricacies of the derivatives markets and analyse them quantitatively.*
2. *Model and analyze the jumps observed in security markets.*
3. *Takeupresearchtobeabletoattempttofillthegapbetweenthemarketsandacademics.*

Module I: Review and Extensions- Assets, Portfolios and Arbitrage, Derivatives, Pricing, Hedging, Greeks, Discrete Time Models, Continuous Time Models, Random walk, Geometric Random Walk, Wiener Process.

Module II: Elements of Stochastic Calculus, Stochastic Differential Equations, Partial Differential Equations, Black- Scholes' PDE, Applications of Martingales in Pricing of Assets, Estimation of Volatility, CRR Model.

Module III: Financial Markets Instruments- Exotic Options, Reflection Principle, Asian Options, Change of Numeraire, Pricing of Exchange Options, Forward Rates Modelling, Forward Vesicek Rates, Interest Rates Derivatives and their Pricing, Default Risk in Bond Markets, Credit Default Swaps.

Module IV: Jump Processes- Poisson Process, Compound Poisson Processes, Stochastic Integrals with Jumps, Itô- Integral with Jumps, Stochastic Differential Equations with Jumps, Girsanov Theorem for Jumps Processes, Lèvy Processes, Pricing and Hedging in Jump Processes.

Suggested Readings:

1. Lamberton, D. and Lepeyre, B. (2008). *Introduction to Stochastic Calculus Applied to Finance,* 2nd ed., Chapman and Hall/CRC Press.
2. Privault, N. (2014). *Stochastic Finance –An Introduction with Market Examples,* Chapman and Hall/CRC. *Financial Mathematics Series,* CRC Press, Boca Raton,2014.
3. Tankov, P. (2010). *Financial Modeling with Lèvy Processes,* e-Book.

10/07/2021

ELECTIVE COURSES (FOURTH SEMESTER)

STATE 403-404 (i): Biostatistics

Course Objectives: *Biostatistics is one area of Applied Statistics that concerns itself with the application of statistical methods to medical, biological, epidemiological and health related problems.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Tackle the challenges associated with the study design and data analysis conducted in the health sciences.*
2. *Use and understand the principal numeric and graphical techniques to display and summarize medical and health related data.*
3. *Understand the basic principles of probability and how they relate to biostatistics.*
4. *Studying the relationship between a vector of covariates x and the rate of occurrence of specific types of failure*
5. *Analyze whether people at high risk of one type of failure are also at high risk for others, even after controlling for covariates.*
6. *Evaluate, from simple data sets, evidence for linkage disequilibrium and disease associations using basic association tests.*
7. *Discuss the wider issues involved in applying association tests to whole genomes.*
8. *Understand the introduction to basic statistics for clinical trials.*

Module I: Analysis of Epidemiologic and Clinical Data: Studying association between a disease and a characteristic: Types of studies in Epidemiology and Clinical Research, Prospective study, Retrospective study, Cross-sectional data, Dichotomous Response and Dichotomous Risk Factor: 2x2 Tables, Expressing relationship between a risk factor and a disease, Inference for relative risk and odds ratio for 2x2 table, Sensitivity, specificity and predictivities. Theory of independent and dependent risks, Bivariate normal dependent risk model. Conditional death density functions.

Module II: Basic biological concepts in genetics, Mendel's law, Hardy- Weinberg equilibrium, random mating, estimation of allele frequency (dominant/co-dominant cases), Approach to equilibrium for X-linked genes, natural selection, mutation, migration, genetic drift, equilibrium when both natural selection and mutation are operative.

Module III: Detection and estimation of linkage inheredity. Genetic association study for qualitative and quantitative trait.

Module IV: Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.

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SUGGESTED READINGS:

1. Thomas, D. C. (2004). *Statistical Methods of Genetic Epidemiology*, Oxford University Press.
2. Ewens, W. J. and Grant, G.R. (2001). *Statistical methods in Bio informatics: An Introduction*, Springer.
3. Ewens, W. J. (1979). *Mathematics of Population Genetics*, Springer Verlag.
4. Elandt Johnson R.C. (1971). *Probability Models and Statistical Methods in Genetics,*
5. John Wiley & Sons.
6. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998). *Fundamentals of Clinical Trials*, Springer Verlag.
7. Li, C.C. (1976). *First Course of Population Genetics,* Boxwood Press.
8. Robert F. Woolson (1987). *Statistical Methods for the analysis of biomedical data*, John Wiley &Sons.

10/07/2021

STATE 403 - 404 (ii): Statistical Computing

Course Objective: *The main objective of this paper is to introduce some advanced statistical computing techniques to extract information, visualization and knowledge about various industries.*

Course Learning Outcome:

After successful completion of this course, student will be:

1. *Equipped with different theoretical methods and practicable techniques to achieve the objectives.*
2. *Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.*

Module I: Random number generation: simulating univariate and multivariate distributions; Simulating stochastic processes. Stochastic differential equations: introduction, Numerical solutions. Monte Carlo Integration; Variance reduction methods.

Module II: Markov Chain Monte Carlo methods: The Metropolis–Hastings Algorithm; Gibbs sampling. EM algorithm. Smoothing with kernels: density estimation, choice of kernels.

Module III: Review of classification methods from multivariate analysis; classification and decision trees. Machine learning - supervised and unsupervised. Introduction to artificial intelligence (basic ideas only). Clustering methods from both statistical and data mining viewpoints; Vector quantization. Unsupervised learning; Supervised learning.

Module IV: Ensemble methods: Bagging, boosting, stacking, random forests. Introduction to high dimension, small sample size problems.

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SUGGESTED READINGS:

1. Bishop,C.M.(1995).*NeuralNetworksforpatternRecognition*,OxfordUniversityPress.
2. Duda, R.O., Hart, P.E. and Strok, D.G. (2000). *Pattern Classification*, 2nd ed., John Wiley &Sons.
3. Hastie, T., Tibshirani, R., Friedman, J. (2008). *The Elements of Statistical Learning: Data Mining, Inference and Prediction*, 2nd ed., Springer.
4. Han, J. and Kamber, M. (2000). *Data Mining: Concepts and Techniques*, Morgan Kaufmann.
5. Haykin, S. (1998). *Neural Networks: A Comprehensive Foundation*, 2nd ed., Prentice Hall.
6. Hand, D., Mannila, H., and Smyth, P.(2001). *Principles of Data Mining*, MIT Press.
7. McLachlan, G.J. and Krishnan, T. (1997). *The EM Algorithms and Extensions*, John Wiley & Sons.
8. Nakhaeizadeh, G. and Taylor G.C., (1997). *Machine Learning and Statistics*, John Wiley & Sons.
9. Pooch, Udo W. and Wall, James A. (1993). *Discrete Event Simulation (A practical approach)*, CRC Press.
10. Rubinstein, R.Y. (1981). *Simulation and the Monte Carlo Method*, John Wiley & Sons.
11. Robert, C.P. & Casella, G. (2004). *Monte Carlo Statistical Methods*, 2nd ed., Springer.
12. Voss, J.(2014).*An introduction to statistical computing: a simulation-based approach*, Wiley series in computational statistics.

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STATE 403 - 404 (iii): Bayesian Inference

Course Objectives*: The objective of this course is to provide the understanding of the fundamentals of Bayesian inference including concept of subjectivity and priors by examining some simple Bayesian models and linear regression in a Bayesian frame work.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Treat "evidence" as value of observations and prescribe methods to deal rationally with it.*
2. *Equip students with skills to carry out and interpret posterior and pre-posterior data-based modeling and analyses.*
3. *Compute probability that the theory in question could produce the observed data.*
4. *Examine some simple Bayesian models and linear regression in a Bayesian framework.*

Module I: Review of Basic Probability Concepts. Comparing Likelihood and Bayesian Approaches, Concept of Inverse Probability and Bayes Theorem. Classes of Prior Distributions. Conjugate Families for One Parameter Exponential Family Models.

Module II: Generalized Maximum Likelihood Estimate. Types of Loss Functions. Bayes estimation under various loss functions. Posterior Risk. Bayesian interval estimation: Credible intervals, HPD intervals, Comparison with classical confidence intervals. Situation specific case studies to conduct posterior analysis.

Module III: Prior and posterior odds. Bayes factor. Lindley's Paradox. Various types of testing hypothesis problems.

Module IV: Predictive density function, Regression Models.

SUGGESTED READINGS:

1. Box, G.E.P. and Tiao, G.C. (1973). *Bayesian Inference in Statistical Analysis*, Addison & Wesley.
2. Leonard, T. and Hsu, J.S.J. (1999*). Bayesian Methods*, Cambridge University Press.
3. Lee, P. M. (1997). *Bayesian Statistics: An Introduction*, Arnold Press.
4. Gelman, A., Carlin, J. B., Stern, H. S., Rubin, D. B. (2004). Bayesian Data Analysis, 2nd Ed. Chapman & Hall/CRC
5. Ghosh, J. K., Delampady, M., Samanta, Tapas (2009). *An introduction to Bayesian analysis—theory and methods*. Springer.
6. Zellner, A. (1996). *Bayesian Analysis in Statistics and Econometrics*, Wiley

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STATE 403-404 (iv): Operations Research-II

Course Objectives: *The main course objective of this paper is to introduce quantitative and model-based techniques for model formulation and effective decision–making.*

Course Learning Outcomes:
After successful completion of this course, student will be able to:

1. *Identify and develop operational research models from the verbal description of the real system.*
2. *Understand the characteristics of different types of decision-making environments and decision-making approaches.*
3. *Understand the mathematical tools that are needed to solve optimization problems.*
4. *Analyze the queueing and inventory situations.*
5. *Understand discrete event simulation and decision analysis with inclusion of modelling based on random events involving uncertainties.*
6. *Conceptualize optimum event management through Network scheduling'.*

Module I: Dynamic Programming: Bellman's principle of optimality; general formulation of dynamic programming; computational methods and applications of dynamic programming.

Module II: Non-Linear Programming: Kuhn-Tucker conditions; Wolfe's and Beale's algorithms for solving quadratic programming problems.

Module III: Integer Programming: Branch and bound algorithm and cutting plane algorithm. Multi-criterion and goal programming.

Module IV: Analytical structure of inventory problems; EOQ formula of Harris; its sensitivity analysis and extensions allowing quantity discounts and shortages; Multi-item inventory subject to constraints.

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SUGGESTED READINGS:

1. Banks J. (1998). *Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice*, John Wiley and Sons.
2. Gross, D., Shortle J.F., Thompson J.M. and Harris, C.M. (2008). *Fundamentals of Queueing Theory*, John Wiley &Sons.
3. Hillier, F.S. and Lieberman, G.J. (2001). *Introduction to Operations Research*, 7th ed., Irwin.
4. Hadley, G. and Whitin, T.M. (1963). *Analysis of Inventory Systems*, Prentice Hall.
5. Ross, S. M. (2013). Simulation, Fifth Ed., Academic Press.
6. Taha, H. A. (2016).*Operations Research: An Introduction*, Tenth Ed. Prentice Hall.
7. Winston, W.L. and Goldberg, J.B. (2004). *Operations Research: Applications and Algorithms*, Thomson Brooks/Cole.

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STATE 403-404 (v): Advanced Design of Experiments

Course Objectives: *The main objective of this course is to equip students to apply experimental design techniques in real world problems and in research.*

Course Learning Outcomes:

After successful completion of this course, student will be able to:

1. *Understand the design and analysis of Partially Balanced Incomplete Block Designs and apply them in situations where balanced designs are not available.*
2. *Construct Hadamard matrices, symmetric and asymmetric orthogonal arrays. Orthogonal arrays are used in industrial setups like automobile industry, computer experiments, cryptography, and quality improvement.*
3. *Understand the concepts in general theory of Fractional Factorial Experiments and Various optimality criteria to obtain optimal designs.*
4. *Apply techniques of Response surface methodology, construct designs for first and second order models, and appreciate the concepts of orthogonality, rotatability and blocking.*
5. *Construct and analyse designs for mixture experiments that are useful in our day-to-day life, food industry, chemical industry, pharmaceutical companies.*
6. *Understand and apply Crossover designs in practical situations.*
7. *Understand the Robust Parameter designs and their use in quality improvement.*

Module I: Partially balanced incomplete block designs, Resolvable and affine resolvable designs, Lattice Designs, Construction of PBIB designs.

Module II: General Theory of Fractional Factorial Experiments, Optimal designs- Various optimality criteria, Symmetric and asymmetric orthogonal arrays and their constructions.

Module III: Response surface designs for first and second order models, concepts of orthogonality, rotatability and blocking.

Module IV: Mixture Experiments–models and designs, Cross-over designs, Robust Parameter designs.

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SUGGESTED READINGS:

1. Bose, M. and Dey, A. (2009). *Optimal Crossover Designs*, World Scientific.
2. Cornell, John A. (2002*). Experiments with Mixtures*, John Wiley & Sons.
3. Dey, A. and Mukerjee, R. (1999). *Fractional Factorial Plans*, John Wiley & Sons.
4. Das, M. N. and Giri, N. C. (1986). *Design and Analysis of Experiments*, Wiley Eastern Limited.
5. Dey, A. (1986). *Theory of Block Designs*, John Wiley & Sons.
6. Hinkelmann, K. and Kempthorne, O. (2005). *Design and Analysis of Experiments*, Vol. II: Advanced Experimental Design, John Wiley & Sons.
7. Hedayat, A. S., Sloane, N. J.A. and Stufken, J. (1999). *Orthogonal Arrays: Theory and Applications*, Springer.
8. Jones, B. and Kenward, M.G. (2003). *Design and Analysis of Cross-over Trials*. Chapman & Hall/CRC Press.
9. Montgomery, D. C. (2005). *Design and Analysis of Experiments*, Sixth Edition, John Wiley &Sons.
10. Myers, R. H. and Montgomery, D. C. (2002). *Response Surface Methodology: Process and Product Optimization using Designed Experiments*, John Wiley & Sons.
11. Raghavarao, D. (1970). *Construction and Combinatorial Problems in Design of Experiments*, John Wiley &Sons.
12. Wu, C. F. J. and Hamada, M. (2000). *Experiments: Planning, Analysis and Parameter Design Optimization*, John Wiley & Sons.

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STATC 403-404 (vi): Statistical Decision Theory

***Course Objectives**: To enhance the decision-making knowledge under deterministic and stochastic situation.*

***Course Learning Outcomes**:*

1. *Application of loss-function*
2. *Problems using the minimax theorem.*
3. *How to define decision rules in real life problems*

Module I: Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles. Concept of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

Module II: Supporting and separating hyperplane theorems, minimax theorem of for finite parameter s pace, minimax estimators of Normal and Poisson means, admissibility of minimax rules.

Module III: Invariant decision rules – location parameter problems, invariance and minimaxity, admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations.

Module IV: Sufficient statistics essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

SUGGESTED READINGS:

1. Berger, J.O. (1985): *Statistical Decision Theory and Bayesian Analysis*, 2nd Edition. Springer Verlag.
2. Ferguson, T.S. (1967): *Mathematical Statistics – A Decision Theoretic Approach*, Academic Press.
3. Rohatgi, V.K. (1988): *An Introduction to Probability and Mathematical Statistics*, Wiley Eastern, New Delhi.

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STATC 403-404 (vii): Reliability Theory

Course Objectives: *To enhance the knowledge of reliability theory with reference to the real-life problems.*

Course Learning outcomes*:*

- *Explaining the concept of reliability with reference to real life using examples. Comparing exponential distribution with other distributions.*
- *Explaining the concept of Structure functions, coherent structure; reliability bounds of parallel and series structures using inclusion and exclusion methods.*
- *Obtaining its probability of occurrence of number of renewals in a random interval in terms of Laplace transform; Enumerating the mean time to failure and reliability of the system.*
- *Explaining the concept of censoring and its importance in life testing. Estimation of the mean lifetimes and properties of the estimator when a number of systems are put on test under failure censored scheme with exponential failure time distribution.*

Module I: Concept and Measures, notion of Ageing, Hazard rate, IFR and DFR distributions and related Theorems.

Module II: Structure Function, Coherent Systems, Component and Systems, Reliability of Coherent Systems. Life distributions (Exponential, Gamma, Weibull etc.), Stress- Strength Model.

Module III: Replacement and Maintenance Policies, System Reliability under Markovian setup (Series, Parallel and Multistate systems), Repairable Systems and their Availability.

Module IV: Life Testing Problems, Censoring and Truncated cases, Estimation of Average Life, Discussion of different procedure followed in life testing Experiments related to Exponential, Weibull and Gamma Distributions.

SUGGESTED READINGS:

1. Barlow, R.E, Proschan, F. (1980).*Statistical Theory of Reliability and Life Testing*, Holt, Rinehart and Winston.
2. Barlow, R.E, Proschan, F. (1996). *Mathematical Theory of Reliability*, SIAM, Philadelphia, PA.
3. Lawless, J. F (2003). *Statistical Models and Methods for Lifetime Data*, 2nd Ed., John Wiley.
4. Bain L.J and Engelhardt (1991) *Statistical Analysis of Reliability and Life Testing Models*, Marcel Dekker.
5. Nelson W. (1982) *Applied Life Data Analysis*, John Wiley.
6. Natvig, Bent (2011). *Multistate Systems Reliability Theory with Applications*, Wiley.

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OPEN ELECTIVE COURSES (For Other Disciplines)

STATOE 306 (i): Data Analysis Using R

Course Objectives:

The main objectives of this course are:

1. *To learn the principles and methods of data analysis.*
2. *To provide a basic understanding of methods of analyzing data from different fields.*
3. *To learn R software.*

Course Learning Outcomes:

After successful completion of this course, the students will be able to:

1. *Carry out data analysis using R software.*
2. *Effectively visualize and summarize the data.*
3. *Interpret the results of statistical analysis.*

Module I: Introduction to R: Installing R. R data structures: vectors, matrices, array, data frames, factors, lists. Creating datasets in R, Importing and exporting dataset, annotating datasets.
Graphs: Creating and saving graphs, customizing symbols, lines, colors and axes, combining multiple graphs into one, bar plots, boxplot and dot plots, pie chart, stem and leaf display, histogram and kernel density plots.
Data management: Manipulating dates and missing values, understanding data type conversion,creatingandrecodingvariables,sorting,mergingandsub-settingdatasets.
Mathematical and statistical functions, character functions, looping and conditional statements, user defined functions.

Module II: Basic statistics: Descriptive statistics, frequency and contingency tables, outlier detection, testing of normality, basics of statistical inference in order to understand hypothesis testing, p-value and confidence intervals.
Parametric and Nonparametrictests: Tests for population mean and variance for two or more populations, tests for independence and measures of association.

Module III: **Correlation**: Correlations between quantitative variables and their associated significance tests. **Regression Analysis**: Fitting simple and multiple regression models, forward, backward and stepwise regression, polynomial regression, regression diagnostics to assess the statistical assumptions, methods for modifying the data to meet these assumptions more closely, selecting a final regression model from many competing models.

Module IV: **ANOVA**: Fitting and interpreting ANOVA type models, evaluating model assumptions, basic experimental designs: CRD, RBD, LSD and factorial experimental designs.

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SUGGESTED READINGS:

1. Kabacoff, R.I. (2015). *R in Action: Data Analysis and Graphics in R*, 2nd ed., Manning Publications.
2. Davies, T. M. (2016). *The Book of R: A First Course in Programming and Statistics*, No Starch Press, San Francisco.
3. Crawley, M.J. (2013). *The R Book*, 2nd ed., John Wiley.
4. Field, A., Miles, J. and Field, Z. (2012).*Discovering Statistics using R*, Sage, Los Angeles.
5. Dalgaard, P. (2008). *Introductory Statistics with R*. Springer.

STATOE 306 (ii): Essentials of Survey Sampling and Experimental Designs

Course Objectives:

The main objectives of this course are:

1. *To learn the methods of conducting a sample survey.*
2. *To learn how to design and conduct an experiment.*
3. *To analyse and interpret the results of a designed experiment.*

Course Learning Outcomes:

After completing this course, the students will be able to:

1. *Plan and conduct a sample survey.*
2. *Choose a proper sampling design for conducting a sample survey.*
3. *Understand the need of a designed experiment.*
4. *Understand basic designs and apply them in their area of study.*
5. *Analyse and interpret the results.*

Module I: Population and sample, survey process, survey design, frame, different types of data collection methods, advantages and disadvantages, online surveys, designing survey questions and questionnaires, ordering of questions, open verses closed questions, errors in sample survey, planning a survey.

Detection and correction of errors in survey data: Non-response and its effect, methods to reduce non response, correction techniques, imputation techniques and their effects on the properties of estimator.

Module II: Random number tables, methods of sample selection and estimation with their properties – simple random sampling (with and without replacement), stratified sampling, cluster sampling, ratio and regression estimation and selection with probability proportional to sizes.

Module III: Gauss Markov linear model, estimable functions, least squares estimators and their properties, regression analysis, ANOVA and ANOCOVA.

Module IV: Basic concepts, basic principles, uniformity trial, error control, determination of optimal plot size, simple and complex (or factorial) experiments, Design and Analysis of Experiments: Basic designs, missing plot techniques, balanced incomplete block designs, split plot designs.

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SUGGESTED READINGS:

1. Bethlehem, J. (2009). *Applied Survey Methods: A Statistical Perspective*, John Wiley, New Jersey.
2. Cochran, W.G. (2011). *Sampling Techniques*, 3rd ed., Wiley Eastern John Wiley and Sons.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005). *Fundamentals of Statistics*, Vol. II, 8th ed., World Press, Kolkata.
4. Montgomery, D.C. (2001). *Designs and Analysis of Experiments*, John Wiley and Sons, New York.
5. Murthy M.N. (1977). *Sampling Theory & Statistical Methods*, Statistical Pub. Society, Calcutta.
6. Mukhopadhyay, P. (1998). *Theory and Methods of Survey Sampling*, Prentice Hall of India.
7. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C. (1984). *Sampling Theory of Surveys with Applications*, Lowa State University Press, Lowa, USA.
8. Scheaffer, R.L., Mendenhall, W., Ott, R.L. and Gerow, K. (2012). *Elementary Survey Sampling*, 7th ed., Cengage Learning.

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STATOE 306 (iii): Research Methodology

Course Objectives*: To understand some basic concepts of research and its methodologies.*

Course learning outcomes*:*

1. *Identify appropriate research topics.*
2. *Select and define appropriate research problems and parameters.*
3. *Prepare a project proposal (to undertake a project).*
4. *Organize and conduct research in a more appropriate manner.*
5. *Write a research report and thesis.*

Module I: Concept and definitions, variables and hypotheses, theory and facts, formulation of research problems, development of research methodology and research methods-collection of data, statistical techniques used, evaluation and accuracy of results, developments of knowledge-approaches, rationalistic mode, scientific mode. Identification of problem, formulation of hypotheses, imagination in the formulation of scientific law, recognition of a problem area and identifying the relative questions.

Module II: Steps in research process-

A. Conceptual phase-formulation of the research problem, literature review, developing the hypothesis.
B. Research design, Empirical phase- preparing the research design, determination of sample size, collection of data.
C. Analytical phase- analysis of data, hypothesis testing, generalization and interpretations, writing up, conclusions.

Module III: Types of variables- independent, dependent and control variables.
Measurements - concept and level of measurement, scaling technique, validity and reliability of a measurement.

Module IV: Types of data and methods of collection of data, pre-testing, pilot survey, longitudinal survey, prospective and retrospective surveys, sampling and non-sampling errors, sampling unit and sampling frame, population and sample, scrutinizing of data, estimation of coverage and errors in data collection, revisits.

SUGGESTED READINGS:

1. Kothari, C.R. (1985).*Research Methodology: Methods and Techniques*, Wiley Eastern.
2. Dominowski, R.L. (1980).*Research Methods*, Prentice Hall Inc., New Jersey.
3. Mishra, R.P. (1980). *Research Methodology*, Handbook Concept Publishing Company, New Delhi.
4. IIPS (1996).*Research Methodology*, IIPS, Mumbai.

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STATOE 306 (iv): Statistics for Research and Management Studies

Course Objectives: *The main objectives of this course are:*

1. *To learn statistical techniques useful for research work.*
2. *To understand the quantitative methods used in business and management studies.*

Course Learning Outcomes:

After completing this course, the students will be able to:

1. *Know different types of data produced in their area of study.*
2. *Create, manage, visualize, and summarize data sets.*
3. *Use and understand the inferential procedures.*
4. *Apply suitable sampling design.*
5. *Apply regression techniques.*
6. *Get an understanding of multivariate techniques.*
7. *Apply suitable statistical techniques to analyse the data and interpret the results.*

Module I: Data types, scale of measurement, creating and managing datasets, importing and exporting data, data cleaning. Summarizing data: Frequency and probability distributions, measures of central tendency, measures of dispersion, skewness and kurtosis. Correlation and regression, Measures of association, Cross tabulation. Visualizing data: Histogram, bar chart, pie chart, stem and leaf display, scatter plot, box and whisker plot.

Module II: Inference: Population and sample, parameter and statistic, estimates and estimators, estimation of parameters, type I and type II errors, p-value, statistical hypotheses, testing of hypothesis, inferences based on sample. Tests based on sampling distributions: Z, t, χ^2 and F, Sample size determination.

Sampling Techniques: Simple random sampling, Stratified random sampling, Two-stage sampling.

Module III: ANOVA for one-way and two-way classification. Idea of ANOCOVA, analysis of basic designs, analysis of 2 level factorial experiments. Simple and multiple regression, logistic regression.

Module IV: Idea of multivariate data, Variance-Covariance matrix **Note:** Data analysis and applications of the methods are to be carried out using a statistical package like Excel/R/SPSS/MINITAB/MATLAB or any other principal component analysis, factor analysis, discriminant analysis, cluster analysis.

10/07/2021

SUGGESTED READINGS:

1. Raghavarao, D. (1988). *Exploring Statistics*, Markel Dekker, New York.
2. Taylor, J.K. and Cihon, C. (2004). *Statistical Techniques for Data Analysis*, 2nd ed., Chapman & Hall.
3. Judd, C. M., McClelland, G. H. and Ryan, C.S. (2009). *Data Analysis: A Model Comparison Approach*, 2nd ed., Routledge, New York.
4. Montgomery, D.C. (2001). *Design and Analysis of Experiments*, 5th ed., John Wiley, New York.
5. Field, A., Miles, J. and Field, Z. (2012). *Discovering Statistics using R*, Sage, Los Angeles.
6. Agresti, A. (2015). *Foundations of Linear and Generalized Linear Models*, John Wiley, New Jersey.
7. DeGroot, M.H. and Schervish, M.J. (2012). *Probability and Statistics*, 4th ed., Pearson Education.
8. Rice, J.A. (1995). *Mathematical Statistics and Data Analysis*, 2nd ed., Duxbury Press.
9. Cochran, W.G. (2011*). Sampling Techniques*, 3rd ed., Wiley Eastern John Wiley & Sons.
10. Everitt, B.S. (2005). *An R and S-Plus Companion to Multivariate Analysis*, Springer-Verlag, London.
11. Stevens, J.P. (2009). *Applied Multivariate Statistics for the Social Sciences*, Routledge.

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Prof. Aditya Chattopadhyay, External Member	Department of Statistics, University of Calcutta, Kolkata
Prof. Indranil Mukhopadhyay, External Member	Indian Statistical Institute, Kolkata
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Dr. Pankaj Kumar	Department of Zoology, RGU
Dr. Anup Kumar Das	Department of Economics, RGU

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