KANNUR UNIVERSITY

(Abstract)

M.Sc Statistics Programme- Scheme , Syllabus and Pattern of Question papers (Ist and IInd semester only) under Choice Based Credit and Semester System (Outcome Based Education system- OBE) in Affiliated Colleges -Implemented with effect from 2023 admissions - Orders issued.

ACADEMIC C SECTION

ACAD/ACAD C4/16916/2023 Dated: 22.08.2023

Read:-1. U.O No. Acad C2/429/2017 Dated 08.09.2020
2. U. O No. Acad C1/21246/2019 Dated 07.12.2020
3 . U.O. No. Acad/C1/21246/2019 dated 16.02.2023 ,
4. U.O. No. Acad/C1/21246/2019 dated 20.04.2023
5. Minutes of the meeting of the CSMC & Conveners of Adhoc committee held on 15.06.2023
6. U.O. No. Acad/C1/21246/2019 dated 09.08.2023
7. Minutes of the Meeting of the Adhoc committee for MSc Statistics programme held on 10.08.2023
8. Syllabus of submitted by the Convenor, Adhoc committee for MSc Statistics Programme vide e-mail dated 11.08.2023

ORDER

1. A Curriculum Syllabus Monitoring Committee comprising the members of Syndicate was constituted for the Syllabus revision of U G & PG Programmes in Affiliated Colleges, vide paper read (1) above and as per the recommendation of this Committee in its meeting held on 20.11.2020, constitute a sub Committee to prepare the Regulation for PG programmes in Affiliated Colleges vide paper read (2) above.

2. As the reconstitution of Board of Studies of the University is under consideration of the Hon'ble Chancellor, considering the exigency of the matter, Ad hoc Committees were constituted vide paper read (3) above, & it has been modified vide paper read (4) above to revise the Curriculum and Syllabus of PG Programmes in Affiliated Colleges w.e.f 2023-24 academic year.

3. The combined meeting of the Curriculum Syllabus Monitoring Committee & Conveners of Ad hoc committee held on 15.06.2023 at syndicate room discussed in detail the draft Regulation, prepared by the Curriculum Syllabus Monitoring Committee, for the PG programmes under Choice Based Credit and Semester System to be implemented in Affiliated Colleges w.e.f 2023 admission and proposed the different phases of Syllabus revision process such as subject wise workshop , vide paper read (5) above.

4. Revised Regulation for PG programmes under Choice Based Credit and Semester System (in OBE- Outcome Based Education System) was approved by the Vice Chancellor on 05.08.2023 and implemented w.e.f 2023 admission vide paper read (6) above.

5. Subsequently, as per the paper read (7) above, the Ad hoc committee for M.Sc Statistics programme finalized the Scheme, Syllabus and Pattern of question papers of Ist & IInd semester M.Sc Statistics programme to be implemented w.e.f 2023 admission

6. As per the paper read (8) above, the Convener, Ad hoc committee for M.Sc Statistics submitted the finalized copy of the Scheme, Syllabus and Pattern of question papers of Ist & IInd semester M.Sc Statistics programme for implementation w.e.f 2023 admission

7. The Vice Chancellor after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1) Chapter III of Kannur University Act, 1996 and all other enabling provisions read together with, **accorded sanction to implement Scheme, Syllabus and Patten of Question Papers of Ist & IInd semester M.Sc Statistics programme under Choice Based Credit and Semester System (in OBE- Outcome Based Education System) in Affiliated**

Colleges under the University w.e.f 2023 admission , *subject to report to the Academic Council.*

8. The Scheme, Syllabus and Pattern of question papers of Ist and IInd semester M.Sc Statistics programme under Choice Based Credit and Semester System (in OBE- Outcome Based Education System) in Affiliated Colleges under the University w.e.f 2023 admission is uploaded in the University website.

9. Orders are issued accordingly.

Sd/-
Sajesh Kottambrath
Assistant Registrar1
For REGISTRAR

To:
1. Principals of Affiliated Colleges offering MSc Statistics Programme
2. Convener, Curriculum Syllabus Monitoring Committee.
3. Convener, Ad hoc Committee for MSc Statistics Programme

Copy To:
1. The Examination Branch (Through PA to CE)
2. PS to VC / PA to PVC / PA to R/PA to F.O
3. DR / AR 1 (Acad) /All sections of Academic Branch/Computer Programmer
4. SF / DF /FC
5. IT Centre (for uploading on the website)

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY
CIVIL STATION P.O.
KANNUR
Pin-670 002
THAVAKKARA

KANNUR UNIVERSITY

M. Sc. Statistics Syllabus

(Effective from 2023 admission)

(I and II Semester)

Choice Based Credit and Semester System For Post Graduate Programmes in Affiliated Colleges

(OBE – Outcome Based Education – System)

(KUCBCSSPG 2023)

PREFACE

Kannur University introduced Outcome Based Education (OBE) in the curriculum for under graduate students in 2019. Expanding OBE to the Postgraduate curriculum and syllabus from the academic year 2023 onwards demonstrates the university's commitment to further improving the learning experience for its students across different academic levels. This move is to enhance the academic rigour and relevance of the Postgraduate programmes, better preparing the students for their future careers and challenges.

The syllabi of the M.Sc programme in Statistics offered in the affiliated colleges of Kannur University under the semester system were revised in light of the decision of the Syndicate of Kannur University, Curriculum Syllabus Monitoring Committee and the PG Board of studies. The Ad hoc committee (Statistics) formed by Kannur University as per order number Acad/C1/21246/2019 dated 16/02/2023 has prepared the revised curriculum and syllabus for M.Sc Statistics programme to be implemented from 2023 admission onwards.

The Ad hoc Committee acknowledges the support of Dr. M. Kumaran, Retired Principal and former HoD of Statistics, Nehru Arts and Science College Kanhangad, Dr. K Radhakrishnan Nair, Principal, Sree Narayana College Periye and Prof. (Dr.) C Baburaj, Principal, Govt. Brennan College Thalassery as experts and teachers of affiliated colleges who participated in the workshops held on 1st July 2023 and 7th July 2023.

The Ad hoc Committee for Revision of M.Sc Statistics Curriculum/Syllabus for the academic Year 2023-24:

1. Dr. Rekha P (Convenor), Assistant Professor,
   Department of Statistics, Nehru Arts and Science College Kanhangad.
2. Shyma S G, Associate Professor,
   Department of Statistics, Government Arts College, Kozhikode.

3. Sabu P. J, Assistant Professor,

Department of Statistics, Government Brennen College, Thalassery, Kannur.

4. Dr. Rejeesh C. John, Associate Professor,

Department of Statistics, Nirmalagiri College, Kuthuparamba, Kannur

5. Dr. Girish V, Assistant Professor,

Department of Statistics, NAM College, Kallikkandy, Kannur.

6. Suresh Kumar R, Assistant Professor,

Department of Statistics, Government College Kasaragod.

7. Dr. Girish Babu M, Assistant Professor, Department of Statistics,

CHMKM Government Arts & Science College, Koduvally, Kozhikode.

8. Dr. Sebastian George, Associate Professor, Department of Statistical Sciences,

Mangattuparamba Campus, Kannur University.

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1. Mission Statements:

- To produce and disseminate new knowledge and to find novel avenues for application of such knowledge.
- To adopt critical pedagogic practices which uphold scientific temper, the uncompromised spirit of enquiry and the right to dissent.
- To uphold democratic, multicultural, secular, environmental and gender sensitive values as the foundational principles of higher education and to cater to the modern notions of equity, social justice and merit in all educational endeavours.
- To affiliate colleges and other institutions of higher learning and to monitor academic, ethical, administrative and infrastructural standards in such institutions.
- To build stronger community networks based on the values and principles of higher education and to ensure the region's intellectual integration with national vision and international standards.
- To associate with the local self-governing bodies and other statutory as well as non-governmental organizations for continuing education and also for building public awareness on important social, cultural and other policy issues.

2. Outcome Based Education (OBE)

Outcome based education is an educational methodology where each aspect of education is organized around a set of goals (outcomes). Students should achieve their goal by the end of the educational process. Throughout the educational experience, all students should be able to achieve their goals. It focuses on measuring student performance through outcomes.

The OBE model aims to maximize student learning outcomes by developing their knowledge and skills.

The key to success in outcome-based education is clarity, for both teachers and students to understand what's expected of them. Outcome-based education aims to create a clear expectation of results that students must achieve. Here, the outcome includes skills, knowledge and attitude. In addition to understanding what's expected, outcome-based education also encourages transparency. The basic principle of outcome-based education is that students must meet a specific standard to graduate. Hence, no curve grading is used in outcome-based education and instead, teachers are free to experiment with any methodology they feel is best.

3. **Programme:** Programme means a programme of study comprising of Core Course, Elective Course, Open Course and MOOC course as applicable.

4. Post Graduate Programme in Statistics

(Syllabus under KUCBCSSPG 2023 (OBE))

Master of Science in Statistics is a Post Graduate level programme that emphasizes both theory and modern applications of Statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics. The program consists of a comprehensive curriculum that includes a combination of core courses, elective courses and an extensive computer training of data analysis including standard software packages such as R, PYTHON and SAS etc. The independent project work is one of the important components of this program.

5. **Duration of the Programme**: The duration of M.Sc Statistics Programme shall be four semesters with 18 weeks in a semester consisting of 90 working days including examination days distributed over a period of two academic years in compliance with hours of instruction stipulated by UGC.

6. **Eligibility for Admission**: Candidates who have successfully completed any of the following three degree programmes are eligible for admission to M.Sc Statistics Programme, as per the existing University/Government orders.

    - B.Sc. Degree with Statistics or Applied Statistics as the Core Course (Main) with not less than 50% marks or equivalent grade excluding subsidiaries /complementary.

    - B.Sc Degree with Statistics and Mathematics double main and B.Sc. Degree with Mathematics as Core Course (Main) and Statistics as one of the complementary Courses (Subsidiary) with not less than 55% marks or equivalent grade.

    The index score for preparing the rank list shall be calculated on the basis of the marks/grade points of Main (Core Courses) and Subsidiaries (Complementary courses) scored by the candidates in the B. Sc degree programme. **A weightage of 6% shall be added to the third index mark of B.Sc. Statistics degree holders before computing the final index.**

7. **Programme Outcomes (POs):** Program outcomes can be defined as the objectives achieved at the end of any specialization or discipline. These attributes are mapped while a student is doing graduation and determined when they get a degree.

    PO 1: Advanced Knowledge and Skills: Post graduate courses aim to provide students with in-depth knowledge and advanced skills related to their chosen field. The best

outcome would be to acquire a comprehensive understanding of the subject matter and develop specialized expertise.

PO 2: Research and Analytical Abilities: Postgraduate programs often emphasize research and analytical thinking. The ability to conduct independent research, analyze complex problems, and propose innovative solutions is highly valued.

PO 3: Critical Thinking and Problem-Solving Skills: Developing critical thinking skills is crucial for postgraduate students. Being able to evaluate information critically, identify patterns and solve problems creatively are important outcomes of these programs.

PO 4: Effective Communication Skills: Strong communication skills, both written and verbal are essential in various professional settings. Post graduate programs should focus on enhancing communication abilities to effectively convey ideas, present research findings and engage in academic discussions.

PO 5: **Ethical and Professional Standards:** Graduates should uphold ethical and professional standards relevant to their field. Understanding and adhering to professional ethics and practices are important outcomes of postgraduate education.

PO 6: Career Readiness: Postgraduate programs should equip students with the necessary skills and knowledge to succeed in their chosen careers. This includes practical skills, industry-specific knowledge and an understanding of the job market and its requirements.

PO7: Networking and Collaboration: Building a professional network and collaborating with peers and experts in the field are valuable outcomes. These connections can lead to opportunities for research collaborations, internships and employment prospects.

PO 8: Lifelong Learning: Postgraduate education should instil a passion for lifelong learning. The ability to adapt to new developments in the field, pursue further education and stay updated with emerging trends is a desirable outcome.

8. Programme Specific Outcomes (PSOs): Program Specific Outcomes can be defined as the objectives achieved at the end of successful completion of the MSc Statistics programme.

PSO – 1: Understand theoretical aspects of various statistical methods and its applications.

PSO – 2: Acquire the working knowledge of handling large data sets and carry out data analysis using various statistical software and programming languages.

PSO –3: Expertise to use databases and make meaningful interpretations of the results.

PSO –4: Communicate effectively complex statistical ideas to people working in diverse spheres of academics and organizational set ups.

PSO - 5: Make unique contribution for the development of discipline by addressing complex and challenging problems in emerging areas of the discipline.

PSO–6: Get wide range of job opportunities in industry as well as in government sector.

PSO – 7: Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in statistical sciences.

PSO - 8: Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges.

PSO -9: Enable to conduct statistical survey and preparing the tools for the analysis and interpretation of the data

9. Course Outcomes (COs): Course outcomes are the objectives that are achieved at the end of any semester/year. For instance, if a student is studying a particular course, then, the outcomes would be concluded on the basis of the marks or grades achieved in theory and practical lessons. The COs are set at the beginning of the study of each course.

10. Automated Question Bank System

The evaluation process shall be based on the revised Bloom's Taxonomy. Hence the syllabus shall be defined and designed in view of the scheme of the said taxonomy.

11. Structure of the Programme: The total credits for the programme is 80. Core courses have a total credit of 64, elective have12 credits and an open elective has 4 credits. Core course is a course that every student admitted to the programme must successfully completes to receive the degree and cannot be substituted by any other course. An elective Course is a Course which can be substituted by an equivalent course from the subject. The Programme includes 16 Core Courses, 3 Elective Courses and an open elective course. Each semester carries 20 credits each.

11.1 Core Course: Core course means a compulsory course in a subject related to a particular postgraduate programme. The M.Sc Statistics Programme includes 16 Core Courses including theory courses, practicals, project evaluation and viva voce.

11.2. Elective Course: Elective course means an optional course to be selected by a student out of such courses offered in the same Department.

11.3. Open Elective Course (Multidisciplinary): Open elective course means an elective course which is available for students of all departments including students of the same department. Students of other departments may opt for these courses subject to fulfilling eligibility criteria as laid down by the department offering the course.

12. CREDIT AND MARK DISTRIBUTION FOR M.Sc STATISTICS

Semester	Course Code	Course	Marks			Credit
			Internal	External	Total	
I	MSSTA01C01	Course 1. 1	15	60	75	4
	MSSTA01C02	Course 1. 2	15	60	75	4
	MSSTA01C03	Course 1. 3	15	60	75	4
	MSSTA01C04	Course 1. 4	15	60	75	4
	MSSTA01C05	Course 1. 5	15	60	75	4
Total			**75**	**300**	**375**	**20**
II	MSSTA02C06	Course 2. 1	15	60	75	4
	MSSTA02C07	Course 2. 2	15	60	75	4
	MSSTA02C08	Course 2. 3	15	60	75	4
	MSSTA02C09	Course 2. 4	15	60	75	4
	MSSTA02C10	Course 2. 5	15	60	75	4
Total			**75**	**300**	**375**	**20**
III	MSSTA03C11	Course 3. 1	15	60	75	4
	MSSTA03C12	Course 3. 2	15	60	75	4
	MSSTA03E01	Course3. 3	15	60	75	4
	MSSTA03O01	Course 3. 4	15	60	75	4
	MSSTA03C13	Course 3. 5	15	60	75	4
Total			**75**	**300**	**375**	**20**
IV	MSSTA04E02	Course 4. 1	15	60	75	4
	MSSTA04E03	Course 4. 2	15	60	75	4
	MSSTA04C14	Course 4. 3	15	60	75	4
	MSSTA04C15	Course 4. 4	20	100	120	6
	MSSTA04C16	Course 4. 5	10	20	30	2
Total			**75**	**300**	**375**	**20**
Grand Total			**300**	**1200**	**1500**	**80**

Course Code	Course Title	Hours per Week	Credits	Marks
I Semester (Total Credits: 20)				
MSSTA01C01	Measure and Probability	5	4	75
MSSTA01C02	Mathematical Methods for Statistics	5	4	75
MSSTA01C03	Distribution Theory	5	4	75
MSSTA01C04	Sampling Methods and Applications	5	4	75
MSSTA01C05	Data Analytics Using R -I (Practical)	5	4	75
II Semester (Total Credits: 20)				
MSSTA02C06	Stochastic Processes	5	4	75
MSSTA02C07	Estimation Theory	5	4	75
MSSTA02C08	Regression Methods	5	4	75
MSSTA02C09	Design and Analysis of Experiments	5	4	75
MSSTA02C10	Data Analytics Using R – II (Practical)	5	4	75
III Semester (Total Credits: 20)				
MSSTA03C11	Multivariate Analysis	5	4	75
MSSTA03C12	Testing of Hypotheses	5	4	75
MSSTA03E01	Elective -I	5	4	75
MSSTA03O01	Open Elective (Multi Disciplinary)	5	4	75
MSSTA03C13	Data Analytics Using Python (Practical)	5	4	75
IV Semester (Total Credits:20)				
MSSTA04E02	Elective - II	5	4	75
MSSTA04E03	Elective–III	5	4	75
MSSTA04C14	Data Analytics Using SAS (Practical)	5	4	75
MSSTA04C15	Project Work	10	6	120
MSSTA04C16	Viva Voce	0	2	30

13. Course Evaluation:

The evaluation scheme for each course shall contain two parts

(1) Continuous Evaluation (CE)

(2) End Semester Evaluation (ESE)

20 % weightage shall be given to the Continuous Evaluation (CE) and 80% weightage shall be for the End Semester Evaluation (ESE)

13. 1 Continuous Evaluation (CE):

20 % of the total marks in each course are for continuous assessment. The continuous evaluation shall be based on a pre determined transparent system. The component wise division of the 20 % CE mark is as follows.

13.1.1 Components of CE (Theory)

	Component	% of Internal Marks
a	Two Test Papers	40
b	Assignment	20
c	Seminar	20
d	Viva Voce	20

13.1.2 Components of CE (Practical)

	Component	% of Internal Marks
a	Two Test Papers	60
b	Lab skill	20
c	Record	20

13.2 End Semester Evaluation (ESE): The End Semester Evaluation in Core courses and Elective Courses shall be made based on examinations for each course conducted by Controller of Examinations, as per the common norms under the PG Regulation (KUCBCSS-PG 2023).

13. 2. 1 Components of ESE (Practical)

	Component	**% of marks**
a	Theories and Concepts	40
b	Utilizing computational methods to find solutions.	40
c	Conclusion/Interpretation	20

The End Semester Evaluation in practical courses shall be conducted by two examiners (one internal and one external) appointed by the University. *Candidate shall be permitted to appear for the ESE of a Practical Course only if she/he has submitted the Record certified by the concerned Head of the Department.*

13. 2. 2 Evaluation process using Revised Bloom's Taxonomy

There are six levels of cognitive learning according to the revised version of Bloom's Taxonomy. Each level is conceptually different. The six levels are remembering, understanding, applying, analysing, evaluating and creating. These levels can be helpful in developing learning outcomes.

(i) **Remember:** Definition: retrieve, recall or recognize relevant knowledge from long-term memory. Appropriate learning outcome verbs for this level include: *cite,define,describe,identify,label,list,match,name,outline,quote,recall,report,reproduce,retrieve,show,state,tabulate,and tell.*

(ii) Understand: Definition: demonstrate comprehension through one or more forms of explanation. Appropriate learning outcome verbs for this level include: *abstract,arrange,articulate,associate,categorize,clarify,classify,compare,compute,conclude,contrast,defend,diagram,differentiate,discuss,distinguish,estimate,exemplify,explain,extend,extrapolate,generalize,give examples of, illustrate, infer, interpolate, interpret, match, outline, paraphrase, predict, rearrange, reorder, rephrase, represent, restate, summarize, transform and translate.*

(iii) Apply: Definition: Use information or a skill in a new situation Appropriate learning outcome verb for this level include: *apply, calculate, carry out, classify, complete, compute, demonstrate, dramatize, employ, examine, execute, experiment generalize, illustrate, implement, infer, interpret, manipulate, modify, operate, organize, outline, predict, solve, transfer, translate and use.*

(iv) Analyze: Definition: break material into its constituent parts and determine how the parts relate to one another and/or to an overall structure or purpose Appropriate learning outcome verbs for this level include: *analyse, arrange, break down, categorize, classify, compare, connect, contrast, deconstruct, detect, diagram, differentiate, discriminate, distinguish, divide, explain, identify, integrate, inventory, order, organize, relate, separate and structure.*

(v) Evaluate: Definition: make judgments based on criteria and standards Appropriate learning outcome verbs for this level include: *appraise, apprise, argue, assess, compare, conclude, consider, contrast, convince, criticize, critique, decide, determine, discriminate, evaluate, grade,*

judge, justify, measure, rank, rate, recommend, review, score, select, standardize, support, test and validate.

(vi) Create: Definitions: put elements together to form a new coherent or functional whole; reorganize elements into a new pattern or structure. Appropriate learning outcome verbs for this level include: *arrange,assemble,build,collect,combine,compile,compose,constitute,construct,create,design,develop,devise,formulate,generate,hypothesize,integrate,invent,make,manage,modify,organize,perform,plan,prepare,produce,propose,rearrange,reconstruct,reorganize,revise,rewrite,specify,synthesize,and write.*

14. Question Paper Pattern

The pattern of question papers for theory papers will be as follows

Part	**Marks of each question**	**Total Marks**	**Number of questions to be answered**	**Number of questions in the question paper**	**Type of questions (Level –Revised Bloom's Taxonomy)**
A	3	15	5	6	1. Remember 2. Understand
B	6	18	3	5	5. Evaluate 6. Create
C	9	27	3	5	3. Apply 4. Analyze
Total		**60**	**11**	**16**	

The distribution of questions will be as follows

Distribution of Questions				
Units	Unit 1	Unit 2	Unit 3	Unit 4
Number of Questions	4	4	4	4

15. Minimum Grade for a Pass:

A candidate securing not less than 40% of aggregate marks of a course with not less than 40% in End Semester Evaluation(ESE)shall be declared to have passed in that course. A minimum of grade point 4with letter grade E is needed for the successful completion of a course. The candidates who fail in theory unit shall reappear for theory unit only, and the marks secured by them in practical unit, if passed in practicals, will be retained. A candidate who fails to secure a minimum for a pass in a course will be permitted to write the same examination along with the next batch. For the successful completion of a semester, a candidate should pass all courses.

Syllabi of Courses Offered in Semester I

MSSTA01C01-Measure and Probability (4 Credits)

Course Outcomes:

CO 1: Understand the concepts of Sigma field, Borel field and different types of measures.

CO2: Understand the concept of measurable function and distribution function.

CO3: Understand the concept of basic inequalities, characteristic function and its properties

CO4: Understand Lebesgue integration and its properties.

Unit 1: Class of sets, fields and sigma fields, Borel class and Borel fields in one and higher dimensions. Limits of sequence of sets, monotone sequence of sets. Set function, additive and sub-additive set functions. Measure, axioms of measure, measure space, different types of measures-Counting measure, probability measure, properties, probability space, continuity theorem, extension of probability measure, Caratheodory extension theorem(*), Lebesgue- Stieltjes measure. Product space and product measure, Fubini's theorem (*), Conditional probability measure and independence of events. (24 marks)

Unit 2: Measurable function, Random variables, simple, non-negative and arbitrary random variables, Inverse function and properties. Sequence of random variables and limit. Distribution function, decomposition of distribution function, vector valued random variables and its distribution function, induced probability space of a random variable. (24 marks)

Unit 3: Inequalities involving moments-Holder and Jensen inequalities, Cr-inequality, basic inequality, Markov inequality, Liapounov's inequality. Independence of events, classes of events, Independence of random variables, Kolmogorov's 0-1 law, Borel –Cantelli Lemma. Characteristic function -definition, properties, Inversion theorem, characteristic function and moments, Taylor's series for characteristic functions, Bochner's theorem (*). (24 marks)

Unit 4: Lebesgue integration and properties (*), Monotone convergence theorem, Fatou'slemma (*), Dominated convergence theorem, Lebesgue-Stieltjes integral, Expectation as Lebesgue-Stieltjes integral. Absolute continuity of a measure with respect to another measure, Radon-Nikodym theorem (*) and its applications. Lebesgue decomposition theorem.

(21 marks)

* *Without proof*

Book for Study

1. Basu, A. K. (1999). Measure Theory and probability, Prentice Hall of India, Pvt. Lt. , New Delhi
2. Bhat B. R. (2014) Modern Probability theory (An introductory text book), Fourth edition, New Age International

Books for Reference:

1. Jain, P. K & Gupta. (2011). Lebesgue Measure and Integration, New Age International
2. Rao, C. R (2002). Linear Statistical Inference and its Applications, John Wley & Sons.
3. Billingsley, P. (1995). Probability and Measure, 3rdEd. , John Wiley, New York
4. Chung, K. L. (2001). A Course in Probability Theory, Third Ed. , Academic Press, London
5. Gut, Allan (2005),Probability: A Graduate Course. Springer, New York
6. Laha R. G. and Rohatgi V. K. (1979) Probability theory, John Wiley.
7. Loeve M. (1977) Probability Theory, Fourth edition, Springer-Verlag.
8. Rohatgi V. K. and SalehM. (2015) An introduction to Probability and Statistics, Third edition,Wiley.

MSSTA01C02-Mathematical Methods for Statistics (4 Credits)

Course Outcomes:

CO 1: Understand the concepts and solve problems of limits and continuity of functions.

CO 2: Learn real valued functions and Riemann Stieltjes integral.

CO 3: Understand the ideas of vector spaces and linear transformations.

CO 4: Handle various types of matrix and its applications.

CO 5: Do calculations to regarding the inverse, eigen values and eigen vectors of matrices.

CO 6: Understand the concepts of quadratic forms and its application.

Unit 1: Sequence and series, continuity and differentiability of functions of single and several variables, Lagrangian multiplier method of optimization, Uniform continuity, Sequence of functions and uniform convergence, Reimann -Steltjes integrals and properties. (24 marks)

Unit 2: Linear vector space and sub spaces, dependence and independence, basis and dimensions, orthogonal vectors, orthogonal basis, Gram-Schmidt orthogonalisation, linear transformation and orthogonal transformation, Linear equations, solution of system of linear equations, Rank and inverse of a matrix. Partition of a Matrix, Inverse of a partitioned matrix, Generalized inverse and its properties. Reflexive g-inverse. Properties of M-P g-inverse, Computation of g inverse and M-P g inverse. (24 marks)

Unit3: Matrices with special structures: Diagonal, triangular, symmetric, skew symmetric, hermitian, skew hermitian, orthogonal, idempotent, Nilpotent and unitary matrices. Eigen values, Rank-Nullity theorem, characteristic roots and vectors, Cayley- Hamilton theorem, minimal polynomial, characteristic subspace of a matrix, Characteristic roots of some special types of matrices, Algebraic and geometric multiplicity of a characteristic root, Diagonal forms, triangular forms, Jordan canonical form, similarity and spectral decomposition of real symmetric matrices. (24 marks)

Unit 4: Quadratic forms, rank and signature, Inner product, positive definite and non negative definite matrices, classification of quadratic forms, Reduction of quadratic forms: canonical and orthogonal reduction. Derivative of quadratic forms. Similarity and spectral decomposition of real symmetric matrices. (21 marks)

Books for Study:

1. Mathai, A. M. Linear Algebra Part I, II & III, Centre for Mathematical Sciences
2. S. C Malik and Savitha Arora, Mathematical Analysis
3. Stephen H. Friedberg, Arnold J. Insel, Linear Algebra, 4th edition

Books for Reference:

1. Biswas, S. Introduction to the theory of Matrices
2. Shanti Narayanan,Text book of Matrices
3. Bapat, R. B. (2011). Linear Algebra and Linear Models. Springer and Hindustan Book Agency.
4. Bartle, R. G. ,& Sherbert, D. R. (2000). *Introduction to real analysis*. John Wiley & Sons, Inc.
5. Gilbert Strang (2014) Linear Algebra and its Applications,15th Re-Printing edition, Cengage Learning.
6. Hoffman K. and Kunze R. (2014) Linear Algebra, Second edition, Phi Learning.
7. Pringle & Rayner,M. . Generalised inverse of matrices with application to Statistics, Griffin, Londons
8. Rao A. R and Bhimasankaram P (2002) Linear Algebra, Second edition, Springer
9. Rudin,W. (1976). *Principles of mathematical analysis* (Vol. 3). New York: Mc Graw-hill.
10. Searle, S. R. and Khuri,A. I. (2017). Matrix Algebra Useful for Statistics, 2nd Ed. , JohnWiley, New York.
11. Trench W. F. (2012). Introduction to Real Analysis, E-book.
12. Yau, D. (2013). A First Course in Analysis,World Scientific

MSSTA01C03 – Distribution Theory (4 Credits)

Course Outcomes:

CO 1: Understand the concepts such as pgf, convolution, factorial moments etc.

CO 2: Understand the concepts of truncation and censoring of distributions.

CO 3: Understand the concepts and problems related sampling distributions.

CO 4: Understand the different modes of convergence and the relations between them.

CO 5: Understand the laws of large numbers and central limit theorems.

CO 6: Understand the concept of order statistics and the distributions of order statistics

Unit1: Discrete distributions: pgf, convolution, distribution of random sum of random variables, factorial moments, simple properties and applications of the following distributions- Power series, Logarithmic series and their particular cases, multinomial, hyper geometric. Generation of random samples from various distributions. (21 marks)

Unit 2: Continuous distributions: Pareto, Lognormal, Logistic, Weibull and Laplace distributions; Convolution of distributions, compound and mixture distributions, functions of random variables, random vectors and transformations, censoring and truncation of distributions. Sampling distributions: Joint distributions of mean and variance from normal population, Chi-square, t and F distributions (central and non-central without derivation) and their properties and applications. (24 marks)

Unit 3: Different modes of convergence- convergence in probability, almost sure convergence, convergence in rth mean, convergence in distribution, relationships among different forms of convergence, Slutsky's theorem, Helly Bray theorem and Helly Bray lemma (statements only),Continuity theorem joint characteristic functions – applications. Infinitely divisible distributions, Definition, elementary properties and examples, Conditional expectation and properties. (24 marks)

Unit 4: Law of large numbers (LLN), WLLN and SLLN-Khinchin's weak law of large numbers, Kolmogrov's strong law of large numbers I and II (*), Kolmogorov's three series theorem (*), Law of iterated logarithm and Glivenko –Cantelli Lemma (Concepts and statements only), Central Limit theorem (CLT)- CLT as a generalization of law of large numbers, Lindberg –Levy form, Liapounov's form (*), Lindberg-Feller form (*). Standard errors of means (Concept only), moments and that of a function of statistics in large samples. Order statistics, the distributions and properties, asymptotic distribution of sample median and range. (24 marks)

**Without Proof*

Books for Study

1. Balakrishnan, N. & Rao, C. R. (2003). Handbook of Statistics, Vol. XVI, Elsevier.
2. Johnson, Kotz and Balakrishnan. (2000). Distributions in Statistics, Vol. 1, 2 & 3, JohnWiley.
3. Rohatgi, V. K. (1976). An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons.

Books for Reference

1. Kendall, M. G and Stuart, A. (1977). The Advanced Theory of Statistics, Vol. 1,
2. Ord, J. K. Families of frequency distributions, Charles Griffin & Co.
3. Rao, C. R (2002). Linear Statistical Inference and its Applications, John Wley & Sons.
4. Karian, Z. A & Dudewicz, E. J. (2010). Fitting of Statistical distributions with R, Crc Press

MSSTA01C04- Sampling Methods and Applications (4 Credits)

Course Outcomes:

CO 1: Understand the concepts of probability and non-probability sampling.

CO 2: Understand different sampling procedures.

CO3: Understand the estimation methods of the population parameters for attributes and variables.

CO 4: Understand various scheme of sampling with varying probabilities

CO 5: Understand the use of auxiliary information for the estimation of population parameters.

Unit1: Planning and execution of survey sampling-Sampling and non sampling errors, SRSWOR and SRSWR- Estimation of population mean and variance, estimation of their standard errors, estimation of population proportion and sample size. Quota sampling, systematic sampling-method of selection, estimation of population mean and variance, comparison of systematic sampling with SRS. (24 marks)

Unit 2: Stratified sampling- Estimation of population mean and variance, proportional, Neyman's and optimum allocations, comparison of stratified sampling with srs and systematic sampling.

Cluster sampling- with equal and unequal cluster size, estimation of their mean and variance. Two stage sampling with equal first stage units, estimation of its mean and variance. Concept of double sampling. Multistage and multiphase sampling. (24 marks)

Unit 3: Sampling with varying probabilities- pps sampling with and without replacement, Midzuno scheme of sampling, ordered and unordered estimators- Desraj's ordered estimator, Horvitz-Thompson and Yates-Grundy estimators. Murthy's unordered estimator. (21 marks)

Unit 4: Ratio and regression estimators, bias of ratio estimator, approximate variance of ratio estimator, comparison of ratio estimator with mean per unit, unbiased ratio estimator. Linear regression estimator, bias of regression estimator, approximate variance of regression estimator, comparison of regression estimator with mean per unit and ratio estimator. Ratio and regression estimation in stratified sampling. Gibbs sampling. (24 marks)

Books for Study

1. Cochran,W. G. (1992). Sampling Techniques, Wiley Eastern, New York
2. Desraj. (1979). Sampling Theory,Tata Mc Graw Hill
3. Singh, D and Chowdhary, F. S. (1986). Theory and Analysis of Sample Survey Designs, New Age International, New Delhi.

Books for Reference

1. Hansen, Hurwitz & Madow. (1993). Sample Survey Methods and Theory
2. Murthy, M. N. Sampling Theory and Methods
3. Som, K. S. & Som, R. K. (1976). Practical sampling techniques, CrcPress
4. Gupta and Kapoor (2010). Fundamentals of Applied Statistics. Sulthan Chand & Sons.
5. Parimal Mukopadhyay. (2008). Theory & methods of survey sampling, Prentice Hall of India, New Delhi.

MSSTA01C05 - Data Analytics using R -I (Practical)

Course Outcomes:

CO 1: Understand how to read data, data frame, data types, loops, matrix operations and simultaneous equation solving.

CO 2: Draw high-end graphs using various graphical parameters.

CO3: Compute descriptive statistics and fit simple models.

CO4: Define, Calculate, Implement Probability and Probability Distributions to solve a wide variety of problems.

CO 5: Compute inverse, g-inverse, M-P inverse of matrix and solve system of linear equations.

CO 6: Learn to determine sample size in various sampling schemes.

CO 7: Learn to select samples and estimate population parameters using different type of sampling methods.

Unit 1: R language Essentials: Expressions and objects, Assignments, creating vectors, vectorised arithmetic, creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection; examples. R Programming: conditional statements – if and if else; loops – for, while, do-while; functions – built-in and user defined; Data entry – reading from text file, data editor; examples. Descriptive Statistics and Graphics: Obtaining summary statistics; generating tables; Bar plots, Pie charts, Box plots, Histogram; exercises. (20 marks)

Unit 2: Distribution Theory- Plotting of probability distributions and sampling distributions, P-P plot, Q-Q Plot. Simulation of random numbers. Fitting of discrete and continuous distributions. Chi Square goodness of fit. lm and glm functions. Analysis of variance using lm function. Test for correlation and regression coefficients. (20 marks)

Unit 3: Calculation of rank and determinant of higher order matrix and powers of a matrix. Determine equivalent canonical form by using elementary row and column operations. Calculation of inverses of symmetric matrices of higher order by partitioning method. Calculation of Inverse, Moore-Penrose inverse and g-inverse. Calculation of eigen values and eigen vectors. Solution of simultaneous system of equations. Spectral decomposition.

(20 marks)

Unit 4: Sampling theory-Implementation of numerical problems using R. Use of statistical packages in survey sampling. Computations using the survey package. Use of other related packages in sampling theory. Writing user defined functions for various computations in sampling theory and using different sampling methods. (20 marks)

Book for Study:

1. Introductory Statistics with R by Peter Dalgaard, Springer, 2nd edition, 2008. Johnson,
2. Rizzo, M. L. (2007). Statistical Computing with R, CRC Press
3. Bruce, P. and Bruce, A. (2017). Practical Statistics for Data Scientists, O'Reilly Media.

Books for Reference:

1. An Introduction to R by W. N. Venables, D. M. Smith and the R Core Team
2. Norman Matloff (2011) The Art of R Programming - A Tour of Statistical Software Design, No Starch Press, San Francisco
3. Crawley, M,J. (2012). The R Book, 2nd Edition. John Wiley & Sons.

Practical is to be done using computer. The question paper for the external examination will be set by the external examiners in consultation with the chairman. The practical will be valued on the same day the examination is carried out and the mark sheet will be given to the chairman on the same day.

Syllabi of Courses Offered in Semester II

MSSTA02C06 - Stochastic Processes (4 Credits)

Course Outcomes:

CO1: Understand the concepts of Stochastic processes and conceive the concepts of Markov chains, classification of its states and limiting probabilities.

CO 2: Understand the concept of random walk process and branching process.

CO 3: Understand continuous time Markov chains, Poisson processes and its generalizations.

CO 4: Understand various queuing models and the concept of renewal process.

Unit 1: Introduction to Stochastic Processes, time and state space, classification of stochastic Processes with examples, Processes with stationary independent increments, Weak and strong stationary processes, Markov Processes, Martingales, Wiener Processes, Gaussian Processes (definitions and examples). Markov Chains, transition probabilities, stationary transition probabilities, transition probability matrix, n-step transition probabilities, Chapman Kolmogorov equations, classification of states, ergodic chains, stationary distributions, absorption probabilities, occupation times. (24 marks)

Unit 2: Random walk and gambler's ruin problem, Branching processes- discrete time branching processes, offspring distribution and probability of extinction. (21 marks)

Unit 3: Continuous time discrete state space Markov processes, Chapman Kolmogorov equations, Poisson processes, compound Poisson processes, pure birth process, Yule process, birth and death processes, Kolmogorov forward and backward differential equations.

(24 marks)

Unit 4: Introduction to queueing theory, characteristics of queueing processes, Markovian queueing models, steady state solutions of the M/M/1 model, waiting time distributions, Little's formula, M/M/1 queues with limited waiting space, M/M/c queueing models. Renewal processes, renewal equation, renewal theorems (continuous case only), delayed renewal process. (24 marks)

Books for Study:

1. Medhi, J. (2009). Stochastic Processes, New Age International

2. Karlin, S & Taylor, H. E. (1975). A First Course in Stochastic Processes, Academic Press

Books for Reference:

1. Ross, S. M. (2008). Stochastic Processes,Wiley India Pvt. Ltd.

2. Cinlar. Introduction to Stochastic Processes

2. Cox, D. R. (1962). Renewal Theory, Methuen & Co.

3. Doob, J. L. Stochastic Processes.

4. Feller, W. (1991). An Introduction to Probability Theory and Applications, John Wiley

5 Bhat, U. N. (2002). Elements of Applied Stochastic Processes, 3rd edition,Wiley Interscience

6. Gross, D. and Harris, C. M. (1985). Fundamentals of Queueing Theory, 2nd Edition, John Wiley and Sons,New York.

7. Kleinrock, L. (1976). Queueing Systems,Vol. 1 & 2,Wiley-Interscience.

MSSTA02C07 – Estimation Theory (4 Credits)

Course Outcomes:

CO 1: Understand the difference between Classical and Bayesian inference.

CO 2: Understand the basics of point and interval estimation.

CO 3: Understand different methods of estimation - MME, MLE, Minimum and modified minimum chi-square and method of least squares.

CO 4: Understand consistency, sufficiency, unbiasedness, CAN and BAN estimators.

CO 5: Quantify information in statistic using Fisher Information.

CO 6: Design basic elements of Bayesian inference and calculate Bayes estimators of parameters of standard distributions.

Unit 1: The problem of point estimation, desirable properties of an estimator - unbiasedness, consistency, efficiency and sufficiency. Fisher - Neyman factorization theorem, minimal sufficiency, completeness, exponential families, ancillary statistics, Basu's theorem.

(21 marks)

Unit 2: Methods of estimation - methods of moments, method of maximum likelihood and their properties, minimum chi-square, modified minimum chi-square, method of least squares, method of minimum variance. Comparison of the methods and their characteristics.

(24 marks)

Unit 3: Minimum Variance Bound Estimator (M. V. B. E)- Cramer - Rao bound, Distributions admitting M. V. B estimators. Fisher's information measure in a random sample and statistics. Minimum Variance Unbiased Estimator (M. V. U. E) - Rao- Blackwell theorem, comparison of M. V. B. E and M. V. U. E,U. M. V. U. E and their characterisation, Lehmann- Scheffe theorem, CAN and BAN estimators (Definition only). (24 marks)

Unit 4: Interval Estimation - Confidence interval, shortest confidence and unbiased confidence intervals, confidence intervals for large samples. Basics of Bayesian estimation: Loss and risk functions, prior and posterior distributions, minimax estimators, Bayes theore, Bayes risk, Bayes principle, Bayes estimators. (24 marks)

Books for study

1. Rohatgi,V. K. (1976). An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons.

2. Lehmann, E. (1983). Theory of Point Estimation, John Wiley, New York.

Books for Reference

1. Berger, J. O. (2013). Statistical decision theory and Bayesian analysis. Springer Science & Business Media.

2. Casella, G. , & Berger,R. L. (2021). Statistical inference. Cengage Learning.

3. Deshmukh S. R. and Kulkarni M. G. (2021). Asymptotic Statistical Inference - A Basic Course Using R,Springer.

4. Kale B. K. and Muralidharan (2015): Parametric Inference, An Introduction, Alpha Science International Limited.

5. Kendall,W. G. & Stuart,A. (1977). The Advanced Theory of Statistics,Vol. 2.

6. Mukhopadhyay,P. (2006). Mathematical Statistics. Books and Allied (P) Ltd. , Kolkatta.

7. Rao, C. R(2003). Linear Statistical Inference and its Applications, John Wley& Sons

8. Srivastava, M. K. ,Khan, A. H. ,& Srivastava, N. (2014). Statistical Inference: Theory of Estimation. PHI Learning Pvt. Ltd.

9. Mood, A. M and Graybill, F. A. (2009). Introduction to the theory of Statistics, Tata Mc Graw Hill.

10. Kale, B. K. (2005). A First Course on Parametric Inference, 2nd edition, Narosa

MSSTA02C08—Regression Methods (4 Credits)

Course Outcomes:

CO1: Understand the least square estimation and its properties and able to develop regression models.

CO2: Student will able to do the test on significance of the model and goodness of fit.

CO3: Understand the violation of regression assumptions, diagnosis and remedies.

CO4: Understand various regression models including logistic regression models and simultaneous equation models.

Unit 1: Least square estimation- properties of least square estimates- unbiased estimation of $\sigma 2$- distribution theory- maximum likelihood estimation- estimation with linear restriction- design matrix of less than full rank- generalized least square.

(24 marks)

Unit 2: Hypothesis testing; likelihood ratio test- F test- multiple correlation coefficient- confidence intervals and regions. Simultaneous interval estimation- confidence bands for the regression surface- prediction intervals and band for the response.

(24 marks)

Unit 3: Bias- incorrect variance matrix- effect of outliers- diagnosis and remedies: residuals and hat matrix diagonals- non constant variance and serial correlations- departures from normality- detecting and dealing with outliers- diagnosing collinearity, ridge regression and principal component regression.

(24 marks)

Unit 4: The straight line- weighted least square for the straight line- polynomials in one variable. Generalized linear model, Logistic regression, Poisson regression (concept only), Variable selection criteria. (24 marks)

Books for Study:

1. Draper, N. R and Smith, H(1988). Applied Regression Analysis,3rd edition. John Wiley & Sons Inc, New York.

2. Seber,G. A. F. and Lee,A. J(2003). Linear Regression Analysis,2nd edition,Wiley Intersciences, New Jersey.

Books for Reference:

1. Abraham,B and Ledolter,J(2005). Introduction to Regression Modeling,Duxbury Press

2. Montgomery,D. C,Peck,F. A and Vining,G(2003). Introduction to Linear Regression Analysis,3rd edition,John Wiley and Sons,New York.

3. Rao,C. R(2002). Linear Statistical Inference and its Applications,John Wiley & Sons,New York.

4. Searls,S. R (1997). Linear Models,Wiley,Paper back edition,Wiley Intersciences,New Jersey.

5. Sengupta,D and Jammalamadaka,S. R((2003). Linear Models: An Integrated Approach, World Scientific

MSSTA02C09-Design and Analysis of Experiments (4 Credits)

Course Outcomes:

CO 1: Understand ANOVA for one way and two-way classification.

CO 2: Understand the layout and analysis of standard designs and compare them.

CO 3: Identify the effects of different factors and their interactions and analyse factorial experiments.

CO 4: Construct complete and partially confounded factorial designs and perform their analysis.

CO 5: Understand the concept of fractional replication.

CO 6: Design and analyse incomplete block designs, split plot and strip plot designs.

CO 7: Understand the concepts of orthogonality, connectedness and also to understand ANCOVA in RBD and LSD.

Unit1: Linear estimation, Review of Gauss- Markoffsetup, Gauss-Markoff theorem, Principles of experimentation, uniformity of trials. One way and two way classification models. Standard designs - CRD, RBD, LSD and Graeco Latin Square Design. Comparison of designs. Construction of orthogonal LSD, missing plot analysis in RBD and LSD.

(24 marks)

Unit2: Factorial experiments- 2^n and 3^n experiments, total and partial confounding in symmetrical factorial designs. Concept of fractional replication. (24 marks)

Unit 3: Split plot and strip plot designs, BIBD and PBIBD with only two associate classes, intra and inter block analysis of BIBD. Missing plot analysis in BIBD. (24 marks)

Unit4: Connectedness and orthogonality of designs. ANCOVA in RBD and LSD. Mixed plot analysis. Optimality criteria for experimental design , estimation of residual effects.

(21 marks)

Books for Study

1. Das, M. N & Giri, N. C. (2002). Design and Analysis of Experiments, 2nd edition, New Age International Pvt. Ltd. , New Delhi.
2. Douglas, G. Montgomery. (1976). Design and Analysis of Experiments, John Wiley & Sons.

Books for Reference

1. Joshi, D. D. (1987). Linear estimation and Design of experiments, Wiley Eastern Ltd.
2. Cochran, W. G & Cox, G. M. (1957). Experimental Designs, Wiley International.
3. Federer, W. T. (1963). Experimental Design-Theory & Applications.
4. Giri, N. Analysis of variance.
5. Henry Sheffe. (1999). The Analysis of variance, Wiley Interscience.
6. Parimal Mukopadhyaya. Applied Statistics.

MSSTA02C10 - Data Analytics using R - II (Practical)

The practical is based on the following core courses in the second semester:

MSSTA02C06 - Stochastic Processes
MSSTA02C07 - Estimation Theory
MSSTA02C08 - Regression Methods
MSSTA02C09 - Design and Analysis of Experiments

Practical is to be done using computer. The question paper for the external examination will be set by the external examiners in consultation with the chairman. The practical will be valued on the same day the examination is carried out and the mark sheet will be given to the chairman on the same day.

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