HSNC UNIVERSITY, MUMBAI

Board of Faculty of Science & Technology

Board of Studies in the Subjects of Statistics and Data Science & Business Analytics

1) **Name of Chairperson/Co-Chairperson/Coordinator:-**

   a) Dr Asha Jindal, Associate Professor and Head, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai –400 020. Email ID- asha.jindal@kccollege.edu.in Mobile no- 9821235627

2) **Two to five teachers each having minimum five years teaching experience amongst the full time teachers of the Departments, in the relevant subject.**

   a) **Dr. S. B. Muley,** Assistant Professor, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID sakharam.muley@kccollege.edu.in , Mobile No- 9323817918

   b) **Mrs. Pratiksha Kadam,** Assistant Professor, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID pratiksha.kadam@kccollege.edu.in , Mobile No- 7507162816

   c) **Ms. Shailaja Rane,** Assistant Professor, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID shailaja.rane@kccollege.edu.in, Mobile No- 7506986359

3) **One Professor / Associate Professor from other Universities or professor / Associate Professor from colleges managed by Parent Body;**

   a) **Dr Anjum Ara Ahmed;** I/C Principal, Rizvi College, Mumbai. Email ID **anjumahmed8@gmail.com, Mobile No-** 8451046220

4) **Four external experts from Industry / Research / eminent scholar in the field relevant to the subject nominated by the Parent Body;**

a. **Prof. Suresh Kumar Sharma,** Professor, Department of Statistics, Panjab University, Chandigarh. Email ID ssharma643@yahoo.co.in, **Mobile No**-9815911381

b. **Mr Mukesh Jain,** Chief Technological Officer, Capgemini. Email ID mdjain@hotmail.com, **Mobile No**-7972637347.

c. **Dr Santosh Gite,** Associate Professor, Dept. of Statistics, University of Mumbai, Mumbai. Email ID santgite@yahoo.com, **Mobile No-** 9167157717.

d. **Mr Prashant Kumar Nair,** Director, Geo Spatial Analytics Global Lead, Intelligent Analytics, Nielsen Connect, Email ID prashantkumar.nair@nielsen.com , **Mobile No**-9833747057.

5. Top rankers of the Final Year Graduate and Final Year Post Graduate examination of previous year of the concerned subject as invitee members for discussions on framing or revision of syllabus of that subject or group of subjects for one year.

a) **Ms. Mohaddasah Patel** (undergraduate student 18-19) Email Id- mohaddasah.98@gmail.com ; Mobile no- 9833781878

b) **Ms. Divya Srivastava** (undergraduate student18-19) Email ID- divyasrivastav20@gmail.com ; Mobile no- 8879240305

Part –I

Outline of Choice Based Credit System as outlined by University Grants Commission:

R. ** : The Definitions Of The Key Terms Used In The Choice Based Credit System And Grading System Introduced From TheAcademicYear2020-2021AreAs Under:**

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a core course.

2. **Elective Course:** Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

   2.1 **Discipline Specific Elective (DSE) Course:** Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

   2.2 **Dissertation/Project:** An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of adiscipline specific elective paper.

   2.3 **Generic Elective (GE) Course:** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
   P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. **Choice Base Credit System :** CBCS allows students to choose inter-disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students.

4. **Honours Program :** To enhance employability and entrepreneurship abilities among the learners, through aligning Inter Disciplinary / Intra Disciplinary courses with Degree Program. Honours Program will have
40 additional credits to be undertaken by the learner across three years essentially in Inter / Intra Disciplinary course.

   A learner who joins Regular Undergraduate Program will have to opt for Honours Program in the first year of the Program. However, the credits for honours, though divided across three years can be completed within three years to become eligible for award of honours Degree.

5. **Program:** A Program is a set of course that are linked together in an academically meaningful way and generally ends with the award of a Degree Certificate depending on the level of knowledge attained and the total duration of study, B.Sc. Programs.

6. **Course:** A 'course' is essentially a constituent of a 'program' and may be conceived of as a composite of several learning topics taken from a certain knowledge domain, at a certain level. All the learning topics included in a course must necessarily have academic coherence, i.e. there must be a common thread linking the various components of a course. A number of linked courses considered together are in practice, a 'program'.

7. **Bridge Course:** Bridge course is visualized as Pre semester preparation by the learner before commencement of regular lectures. For each semester the topics, whose knowledge is considered as essential for effective and seamless learning of topics of the Semester, will be specified. The Bridge Course can be conducted in online mode. The Online content can be created for the Bridge Course Topics.

8. **Module and Unit:** A course which is generally an independent entity having its own separate identity, is also often referred to as a 'Module' in today's parlance, especially when we refer to a 'modular curricular structure'. A module may be studied in conjunction with other learning modules or studied independently. A topic within a course is treated as a Unit. Each course should have exactly 3 Units.

9. **Self-Learning: 20% of the topics will be marked for Self-Learning.** Topics for Self-Learning are to be learned independently by the student, in a time-bound manner, using online and offline resources including online lectures, videos, library, discussion forums, fieldwork, internships etc.

   Evaluative sessions (physical/online), equivalent to the credit allocation of the Self Learning topics, shall be conducted, preferably, every week for each course. Learners are to be evaluated real time during evaluative sessions. The purpose of evaluative sessions is to assess the level of the students' learning achieved

in the topics earmarked for Self-Learning.

The teacher's role in these evaluative sessions will be that of a Moderator and Mentor, who will guide and navigate the discussions in the sessions, and offer concluding remarks, with proper reasoning on the aspects which may have been missed by the students, in the course of the Self-Learning process.

The modes to evaluate self-learning can be a combination of the various methods such as written reports, handouts with gaps and MCQs, objective tests, case studies and Peer learning. Groups can be formed to present self-learning topics to peer groups, followed by Question and Answer sessions and open discussion. The marking scheme for Self Learning will be defined under Examination and Teaching.

The topics stipulated for self-learning can be increased or reduced as per the recommendations of the Board of Studies and Academic Council from time to time. All decisions regarding evaluation need to be taken and communicated to the stakeholders preferably before the commencement of a semester. Some exceptions may be made inexigencies, like the current situation arising from the lockdown, but such ad hoc decisions are tobe kept to the minimum possible.

10. **Credit Point:** Credit Point refers to the 'Workload' of a learner and is an index of the number of learning hours deemed for a certain segment of learning. These learning hours may include a variety of learning activities like reading, reflecting, discussing, attending lectures / counseling sessions, watching especially prepared videos, writing assignments, preparing for examinations, etc. Credits assigned for a single course always pay attention to how many hours it would take for a learner to complete a single course successfully. A single course should have, by and large a course may be assigned anywhere between 2 to 8 credit points wherein 1 credit is construed as corresponding to approximately 30 to 40 learning hours.

11. **Credit Completion and Credit Accumulation:** Credit completion or Credit acquisition shall be considered to take place after the learner has successfully cleared all the evaluation criteria with respect to a single course. Thus, a learner who successfully completes a 4 CP (Credit Point) course may be considered to have collected or acquired 4 credits. learner level of performance above the minimum prescribed level (viz. grades / marks obtained) has no bearing on the number of credits collected or acquired. A learner keeps on adding more and more credits as he completes successfully more and more courses. Thus the learner 'accumulates' course wise credits.

12. **Credit Bank:** A Credit Bank in simple terms refers to stored and dynamically updated information regarding the number of Credits obtained by any given learner along with details regarding the course/s for which Credit has been given, the course-level, nature, etc. In addition, all the information regarding the number of Credits transferred to different programs or credit exemptions given may also be stored with the individual's history.

13. **Credit Transfer:** (performance transfer) When a learner successfully completes a program, he/she is allowed to transfer his/her past performance to another academic program having some common courses and Performance transfer is said to have taken place.

14. **Course Exemption:** Occasionally, when two academic programs offered by a single university or by more than one university, may have some common or equivalent course-content, the learner who has already completed one of these academic programs is allowed to skip these 'equivalent' courses while registering for the new program. The Learner is 'exempted' from 'relearning' the common or equivalent content area and from re-appearing for the concerned examinations. It is thus taken for granted that the learner has already collected in the past the credits corresponding to the exempted courses.

Part-II

O*** The fees for transfer of credits or performance will be based on number of credits that a learner has to complete for award of the degree.**

The Scheme of Teaching and Examination:

The performance of the learners shall be evaluated in two components: Internal Assessment with 40% marks by way of continuous evaluation and by Semester End Examination with 60% marks by conducting the theory examination.

INTERNAL ASSESSMENT:- It is defined as the assessment of the learners on the basis of continuous evaluation as envisaged in the credit based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

A). Internal Assessment – 40% **40 marks**

Practical's (internal Components of the Practical Course)

1. For Theory Courses

Sr. No.	Particulars	Marks
1	**ONE** class test / online examination to be conducted in the given semester	15 Marks
2	One assignment based on curriculum (to be assessed by the teacher Concerned	10 Marks
3	Self-Learning Evaluation	10 Marks
4	Active participation in routine class instructional deliveries	05 Marks

2. For Courses with Practicals

Each practical course can be conducted out of 50 marks with 20 marks for internal and 30 marks for external

Practical's (Internal component of the Practical Course)

Sr. No	Evaluation type	Marks
1	Two Best Practicals /Assignments/Presentation /Preparation of models/ Exhibits **Or** One Assignment/ project/presentation to be assessed by teacher concerned	10
2	Journal	05
3	Viva	05

The semester end examination (external component) of 60 % for each course will be as follows:

i) **Duration** – **2 Hours** ii) **Theory Question**

Paper Pattern:-

1. There shall be four questions each of 15 marks. On each unit there will be one question and the fourth one will be based on entire syllabus.
2. All questions shall be compulsory with internal choice within the questions. (Each question will be of 20 to 23 marks with options.)
3. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depend on the weightage of the topic.

The marks will be given for all examinations and they will be converted into grade (quality) points. The semester-end, final grade sheets and transcripts will have only credits, grades, grade points, SGPA and CGPA.

3. Project and Assignment:

- Project or Assignment, which can in the following forms
  - Case Studies
  - Videos
  - Blogs
  - Research paper (Presented in Seminar/Conference)
  - Field Visit Report
  - Presentations related to the subject (Moot Court, Youth Parliament, etc.)
  - Internships (Exposition of theory into practice)
  - Open Book Test
  - any other innovative methods adopted with the prior approval of Director Board of Examination and Evaluation.

4.Self-Learning Evaluation

- **20% OF THE TOPICS OF CURRICULUM ARE LEARNED BY THE STUDENT THROUGH SELF LEARNING USING ONLINE / OFFLINE ACADEMIC RESOURSE SPECIFIED IN THE CURRICULUM.**

- **HENCE 20% OF THE LECTURES SHALL BE ALLOCATED FOR EVALUATION OF STUDENTS ON SELF LEARNING TOPICS**

- The identified topics in the syllabus shall be learnt independently by the students in a time bound manner preferably from online resources. Evaluative sessions shall be conducted by the teachers and will carry 10 Marks.

  CLUB The self-learning topics into 3-4 GROUPS OF TOPICS ONLY FOR EVALUATION.

- **PRESCRIBE TIME DURATION (IN DAYS) FOR COMPLETION OF EACH GROUP OF TOPIC AND EARMARK SELF LEARNING EVALUATION LECTURES IN THE TIMETABLE. HENCE EACH GROUP OF TOPIC CAN BE ASSIGNED 3 REGULAR LECTURES FOR THIS EVALUATION FOR ENTIRE CLASS**

3 Sub Topics

Each evaluative session shall carry 3 Marks (3 x 3 Units = 9 Marks). Students who participate in all evaluative sessions shall be awarded 1 additional Mark.

4 Sub Topics

Each evaluative session shall carry 2.5 Marks (2.5 x 4 Units = 10 Marks)

- **EVALUATION OF SELF LEARNING TOPICS CAN COMMENCE IN REGULAR LECTURES ASSIGNED FOR SELF LEARNING EVALUATION IN THE TIMETABLE**

3 Evaluative sessions

Each evaluative session shall carry 3 Marks (3 x 3 = 9 Marks).
Students who participate in all evaluative sessions shall be awarded 1 additional Mark.

4 Evaluative sessions

Each evaluative session shall carry 2.5 Marks (2.5 x 4 = 10

Marks). <u>Methods for Evaluation of Self-learning topics:</u>

- Seminars/presentation (PPT or poster), followed by Q&A – Objective questions /Quiz / Framing of MCQ questions.
- Debates
- Group discussion
- You-Tube videos (Marks shall be based on the quality and viewership)
- Improvisation of videos
- Role Play followed by question-answers

TEACHERS CAN FRAME OTHER METHODS OF EVALUATION ALSO PROVIDED THAT THE METHOD, DULY APPROVED BY THE COLLEGE EXAMINATION COMMITTEE, IS NOTIFIED TO THE STUDENTS AT LEAST 7 DAYS BEFORE THE COMMENCEMENT OF THE EVALUATION SESSION AND IS FORWARDED FOR INFORMATION AND NECESSARY ACTION AT LEAT 3 DAYS BEFORE THE COMMENCEMENT OF THE EVALUATION SESSION

- Viva Voce
- Any other innovative method

SEMESTER END EXAMINATION: - It is defined as the examination of the learners on the basis of performance in the semester end theory / writtenexaminations.

B. Semester End Examination- 60 % ***60 Marks***

1) Duration – These examinations shall be of 2 Hours duration.
2) Question Paper Pattern: -
   i. There shall be four questions each of 15 marks.
   ii. All questions shall be compulsory with internal choice within the questions.
   iii. Question may be sub-divided into sub-questions a, b, c, d & e only and the allocation of marks depends on the weightage of the topic.

THE MARKS OF THE INTERNAL ASSESSMENT SHOULD NOT BE DISCLOSED TO THE STUDENTS TILL THE RESULTS OF THE CORRESPONDING SEMESTER IS DECLARED.

HSNC University Mumbai

(2020-2021)

Ordinances and Regulations

With Respect to

Choice Based Credit System

(CBCS)

For the Programmes Under

The Faculty of Science and Technology

For the Course

Statistics

Curriculum – First Year Postgraduate Programmes

Semester-I and Semester -II

2020-2021

Statistics
Part 1- Preamble

M. Sc. Statistics program is of minimum 96 credits cover four semesters. Statistics is the language of the uncertainties riddled modern information age. Statistics facilitates the choice making process by quantifying the element of chance or uncertainties. The program 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, in academics and other government and non-government organizations. The program has some unique features like independent projects, number of elective courses and extensive computer training of statistical computations including standard software packages like SPSS, SAS, MINITAB, R and PYTHON. Due to Cluster University, the department got the academic autonomy and it's been utilized to add the new and need based elective courses. The independent project work is one among the important components of this program. The syllabus of the first year (two semesters) covers most of the core courses. In the second year of the syllabus, there are six core courses, six optional courses and one project. The syllabus has been framed to possess a decent balance of theory, methods and applications of statistics. It is possible for the students to study basic courses from other disciplines like economics, life sciences, computer science and Information Technology in place of optional/electives. The thrust of the course is to prepare students to enter into a promising career after post graduation, as also provide to them a platform for pursuing higher studies resulting in doctorate degrees.

1. **Course Objective:** The main objectives of the course are-
   - Make students realize measuring certainty involved into uncertainty in happening of events with accuracy and precision
   - Acquaint students in understanding behaviour of the data using probability distributions.
   - To provide a systematic account of Neyman-Pearson, theory of testing and closely related theory of point estimation and confidence sets, together with their applications
   - Make students realize about understanding and importance of the data
   - Acquaint students in understanding behaviour of the data
   - Make students realize about understanding and importance of the Hypothesis and Statistical Sample Tests in decision drawing.
   - Develop an understanding and application of statistical concepts and skills in the sciences and social sciences.

   To think analytically, creatively and critically in developing robust, extensible and highly maintainable technological solutions to simple and complex problems related to human, technology and environmental factors.

Semester I

Course Code: MS-FST-101- Probability and Measure Theory

Objective: This course will lay the foundation to probability theory and Statistical modeling of outcomes of real life random experiments through various Statistical distributions.

Course Code: MS-FST-102-Theory of Estimation and Testing of Hypotheses

Objective: The objective of the course is to provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications.

Course Code: MS-FST-103-Linear Models:

Objective: Techniques of linear Models useful in various Statistics courses will be covered in this course. After learning this course, the students will be well equipped to apply these techniques in many major Statistics courses like Linear Inference, Multivariate Analysis and Operations Research etc.

Course Code: MS-FST-104-Computational Statistics using R & Python

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

Semester II

Course Code: MS-FST-201-Stochastic Process:
Objective: The main objective of this course is to apprise the students about the existence of several stochastic processes in real life situations and to equip them with the techniques to study their statistical behaviour as a sequence of dependent random variables.

Course Code: MS-FST-202-Multivariate Analysis:
Objective: The course deals with the statistical estimation and testing problems when the underlying structure is not univariate but multivariate in nature. Various multivariate techniques (estimation and testing) required to handle two or more correlated response variables, will be discussed under multivariate normal setting. One sample, two sample and c-sample multivariate normal mean vector testing problems will be discussed.

Course Code: MS-FST-203-Sample Surveys and Official Statistics:
Objective: The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits, demerits and comparisons in appropriate practical situations, (iii) role of various statistical organizations in national development.

Course Code: MS-FST-204-Regression Techniques:

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

2. Process adopted for curriculum designing.

The department has conducted multiple meetings with academician, industry experts. After discussion with them, the changes in the syllabus were introduced with the view that students need to learn the core concepts in detail.

3. Salient features, how it has been made more relevant:

After discussion and interaction with the members of BOS and understanding the requirement of the industries certain changes in the syllabus are introduced. Seminars, Interaction with Industry Experts, Field Visits and upcoming technologies like Contingencies, FOSS R/ Python, Data Science etc. have been added keeping the upcoming trends in the field of Statistics.

4. Learning Outcomes:

It is expected to improvise the theoretical as well as application based soft skills for the students and make them Market ready for Jobs and Higher Research & Development.

Part 2- The Scheme of Teaching and Examination is as under:
Semester – I Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Statistics**)			MS-FST-101,MS-FST-102, MS-FST-103,MS-FSP-101,MS-FSTP-102,MS-FSTP-103	
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course		
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)			MS-FST-104 and MS-FSTP-104	
	Skill Enhancement Courses (SEC)				

First Year Semester I Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Tot al Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	MS-FST-101	Probability and Measure Theory	4	20% *	4	0	0	4	10	20	10	60	100
2	MS-FST-102	Theory of Estimation and Testing of Hypotheses	4	20% *	4	0	0	4	10	20	10	60	100
3	MS-FST-103	Linear Models	4	20% *	4	0	0	4	10	20	10	60	100
4	MS-FST-104	Computational Statistics using R and Python	4	20% *	4	0	0	4	10	20	10	60	100
5	MS-FSTP-101	**Practical based on** MS-FST-101					2	2			10 (J + V)	40	50
6	MS-FSTP-102	**Practical based on** MS-FST-102					2	2			10 (J + V)	40	50
7	MS-FSTP-103	**Practical based on** MS-FST-103					2	2			10 (J + V)	40	50
8	MS-FSTP-104	**Practical based on** MS-FST-104					2	2			10 (J + V)	40	50
	Total Hours / Credit							24	Total Marks				600

***One to two lectures to be taken for CONTINUOUS self -learning Evaluation.**

I Year Semester – I Units – Topics – Teaching Hours

S. N	Subject Code	Subject Unit Title		Hours/Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MS-FST-101	I	Basics of Measure Theory.	15	60 H	4	100 (60+40)
		II	Basics of Probability.	15			
		III	Random Variables.	15			
		IV	Distribution Theory.	15			
2	MS-FST-102	I	Introduction to Estimation and Inequalities.	15	60 H	4	100 (60+40)
		II	Methods of Estimation.	15			
		III	Introduction to Testing of Hypothesis.	15			
		IV	Interval Estimation.	15			
3	MS-FST-103	I	Introduction to Linear Algebra	15	60 H	4	100 (60+40)
		II	Gauss-Markoff Model	15			
		III	Analysis of Variance: One way, Two Way and Fixed Effect Models	15			
		IV	Analysis of Variance: Random, Mixed Effect Models and ANCOVA	15			
4	MS-FST-104	I	Introduction to R	15	60 H	4	100 (60+40)
		II	Introduction to Python	15			
		III	Data Handling using R and Python	15			
		IV	Statistical Computing using R and Python	15			
5	MS-FSTP-101		Practical based on MS-FST-101	30	120 H	2	50
6	MS-FSTP-102		Practical based on MS-FST-102	30		2	50
7	MS-FSTP-103		Practical based on MS-FST-103	30		2	50
8	MS-FSTP-104		Practical based on MS-FST-104	30		2	50
			TOTAL			24	600

- **Lecture Duration = 1 hours**
- **One Credit = 15 hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA-Project Assessment, AT- Attendance

Part -3 Detailed Scheme Theory

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

Course Code: MS-FST-101
Title of the paper: **Probability and Measure Theory**

Unit	Content	No. of Hours
1	**Basics of Measure Theory:** 1.1 Review of Sequence and series, limit, limit inferior, limit superior, monotone sequence, convergence of sequence, infinite series, Power series. 1.2 Function, limit of a function, left and right hand limit, continuity, uniform continuity, derivative, mean values theorems, Taylor series expansion, intermediate forms. 1.3 Introduction to Riemann integration, integrable functions, fundamental theorem on calculus, mean value theorems of integral calculus	15
2	**Basics of Probability:** 2.1. Sets, classes of sets, algebra of sets, limits of sequence of sets 2.2. field, sigma-field, Borel field, minimal field, 2.3. definitions: random experiment, sample space, event. Measure, measureable sets, non-measurable sets, Probability space, probability definitions 2.4. Bonferroni's inequality, Booles' inequality, continuity theorem.	**15**
3	**Random Variables:** 3.1. Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability. 3.2. Combinatorial problems. Product sample spaces, conditional probability, Bayes' formula. 3.3. Random variables (discrete and continuous), Distribution Function and its properties, expectation (its properties) and variance. Moments, Bivariate random variable, joint, marginal and conditional pmfs and pdfs, correlation coefficient, conditional expectation. 3.4. Functions of random variables and their distributions using Jacobian of transformation and other tools. Probability Integral transformation. Markov, Chebyshev and Jensen inequalities.	**15**
4	**Distribution Theory:** **4.1.** Moment generating, Characteristic and probability generating functions **4.2.** Discrete Distributions: Bernoulli, Binomial, Poisson, Hyper-geometric, geometric, negative binomial and uniform. **4.3.** Continuous Distributions: Uniform, normal, exponential, gamma, Beta, Cauchy, Weibull, Pareto, Chi-square, Laplace and Lognormal. Bivariate normal and multinomial distributions. **4.4.** Convergence in distribution. De-Moivre-Laplace and Lindeberg-Levy forms of Central Limit Theorem.	**15**

Self-Learning topics (Unit wise)

Unit	Topics
2	2.1 Sets, classes of sets, algebra of sets, limits of sequence of sets 2.2 field, sigma-field.
2	2.4 Bonferroni's inequality, Booles' inequality
3	3.1 Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability.
	3.2 conditional probability, Bayes' formula.
	3.3 Random variables (discrete and continuous), Distribution Function and its properties, expectation (its properties) and variance. Moments, Bivariate random variable, joint, marginal and conditional pmfs and pdfs, correlation coefficient
	3.4 Functions of random variables and their distributions using Jacobian of transformation and other tools. Markov, Chebyshev.

Online Resources

1. 'Measure Theory' by Prof. E. K. Narayanan from IISc Bangalore available on the Swayam portal
   https://nptel.ac.in/courses/111/108/111108135/
2. 'Measure theory' by Prof. Inder Kumar Rana from IIT Bombay available on the Swayam portal
   https://nptel.ac.in/courses/111/101/111101100/
3. 'Probability and Statistics' by Prof. Somesh Kumar from IIT Kharagpur available on the Swayam portal
   https://nptel.ac.in/courses/111/105/111105090/

   for unit II and unit III
4. 'Introduction to Probability in Computing' by Prof.John Augustine from IIT Madras available on the Swayam portal
   https://nptel.ac.in/courses/106/106/106106176/
5. 'Advanced Topics in Probability and Random Processes ' by Prof. P. K. Bora from IIT Guwahati available on the Swayam portal
   https://nptel.ac.in/courses/108/103/108103112/

Course Code: MS-FST-102

Title of the paper: Theory of Estimation and Testing of Hypotheses

Unit	Content	No. of Hours
1	**Introduction to Estimation and Inequalities:** 1.1. **Estimation:** Introduction to the problem of estimation. Concepts of unbiasedness, sufficiency, consistency, efficiency, completeness. 1.2. Unbiased estimation: Minimum and uniformly minimum variance unbiased estimation, Rao-Blackwell and Lehmann-Scheffe theorems. 1.3. Ancillary statistic, Basu's theorem and its applications. Fisher information measure. 1.4. Cramer- Rao inequality. Chapman-Robin inequality.	15
2	**Methods of Estimation** 2.1. method of moments, maximum likelihood estimation, minimum chi-square method, method of scoring. 2.2. Basic ideas of Bayes and Minimax estimators.	15

3	**Introduction to Testing of Hypothesis** 3.1. **Tests of Hypotheses**: Concepts of critical regions, test functions, two kinds of errors, size function, power function, level of significance. 3.2. MP and UMP tests in a class of size α tests. Neyman - Pearson Lemma, MP test for simple null against simple alternative hypothesis. 3.3. UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper or lower end depends on the parameter and to distributions with MLR property. Non-existence of UMP test for simple null against two-sided alternatives in one parameter exponential family. 3.4. Likelihood Ratio Tests. Wald's SPRT with prescribed errors of two types.	15
4	**Interval estimation:** **4.1** Confidence interval, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval. **4.2** Uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses. **4.3** Tests of hypotheses and interval estimation viewed as decision problems with given loss functions.	15

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1. Introduction to the problem of estimation. Concepts of unbiasedness, sufficiency, consistency, efficiency, completeness. 1.2. Unbiased estimation: Minimum and uniformly minimum variance unbiased estimation
2	2.1 method of moments, maximum likelihood estimation.

Online Resources

1. 'Probability and Statistics' by Prof. Somesh Kumar from IIT Kharagpur available on the Swayam portal
   https://nptel.ac.in/courses/111/105/111105090/

   for unit I and Unit II
2. 'Statistical Inference' by Prof. Somesh Kumar from IIT Kharagpur
   https://nptel.ac.in/courses/111105043/
3. 'Introduction to Statistical Hypothesis Testing' by Prof. Arun Tangirala from IIT Madras available on the Swayam portal
   https://nptel.ac.in/courses/103/106/103106120/

Course Code: MS-FST-103
Title of the paper: **Linear Models**

Unit	Content	No. of Hours
1	**Introduction to Linear Algebra** 1.1. Basic operations ,Vector Spaces, Linear dependence and independence, 1.2. Determinants of Matrices: Definition, Properties and applications of determinants for 3rd and Higher order, Inverse of matrix ,Trace of matrix, Partition of matrix, Rank of matrix, echelon forms, canonical form, generalized inverse, Solving linear equations. 1.3. Characteristic roots and characteristic vectors, properties of characteristics roots , Idempotent matrix, Quadratic forms, positive and Positive semi definite matrix	15
2	**The Gauss-Markoff Model:** 2.1. Linear parametric function and its estimability, Gauss markoff theorem. 2.2. Interval estimates and test of hypothesis, fundamental theorems on conditional error ss, Test of $\Lambda\beta=d$, generalized least squares	15
3	**Analysis of Variance: One way, Two Way and Fixed Effect Models** 3.1. One –way classification model 3.2. Checking assumptions of ANOVA Model 3.3. Simultaneous Confidence Intervals: Scheffe's, Bonferroni and Turkey's interval. 3.4. Two – way classification model with and without interaction effect, one observation per cell and r observations per cell. Tukey's test for non additivity. 3.5. Two – way classification model with and without interaction effect with unequal number of observations per cell.	15
4	**Analysis of Variance: Random, Mixed Effect Models and ANCOVA** **4.1** Analysis of variance with random and Mixed effect models: Estimation and testing of variance components in one-way, two-way and multiway classification models. ANOVA method. **4.2** Analysis of Covariance: Model, BLUE, ANOCOVA table, testing of hypothesis, use of ANOCOVA for missing observation.	15

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1. Basic operations ,Vector Spaces, Linear dependence and independence, 1.2. Determinants of Matrices: Definition, Properties and applications of determinants for 3rd and Higher order, Inverse of matrix ,Trace of matrix, Partition of matrix, Rank of matrix, echelon forms, canonical form, generalized inverse, Solving linear equations.

Online Resources

1. 'Linear Algebra' by Prof. Pranav Haridas from Kerala School of Mathematics available on the Swayam portal
   https://nptel.ac.in/courses/111/106/111106135/
2. 'Basic Linear Algebra' by Prof. I. K .Rana from IIT Bombay available on the Swayam portal
   https://nptel.ac.in/courses/111/101/111101115/

Course Code: MS-FST-104

Title of the paper: Computational Statistics using R & Python

Unit	Content	No. of Hours
1	**Introduction to R:** 1.1. Downloading and installation of R; http://www.r-project.org. Setting of working directory, Entering and manipulating data in R, 1.2. Basic classes of objects (character, numeric, integer, complex, logical), Vectors and their attributes (names, length, type), Arrays and Data types (matrices, frames, list), Combining data (cbind, rbind). 1.3. Matrix operations (addition, subtraction, multiplication, determinant, diagonal, trace, rank), Generating sequences, function repeats, component extraction (for vectors, matrices, list, frames). 1.4. Creating factors, installing packages and library, importing data from other sources (Excel and SPSS). Data input/output functions. Introduction to dplyr and data.table packages	15
2	**Introduction to Python:** 2.1. Python Setup, Python Arithmetic, Basic Data Types, Variables, Lists, Tuples and Strings, Dictionaries and sets. 2.2. Numpy arrays: Creating arrays crating n-dimensional arrays using np.array and array operations(indexing and slicing, transpose, mathematical operations) 2.3. Pandas data frames: Creating series and data frames and Operations on series and data frames 2.4. Reading and writing data: From and to Excel and CSV files 2.5. Control statements: if, if-else, if-elif, while loop, for loop 2.6. Defining functions: def statement 2.7. Text data operations: len, upper, lower, slice, replace	15
3	**Data Handling using R and Python:** 3.1. Data Manipulation: Selecting random N rows, removing duplicate row(s), dropping a variable(s), Renaming variable(s), sub-setting data, creating a new variable(s), selecting of random fraction of row(s), appending of row(s) and column(s), simulation of variables. 3.2. Data Processing: Data import and export, setting working directory, checking structure of Data, Changing type of variable 3.3. Data Visualisation: Simple bar diagram, subdivided bar diagram, multiple bar diagram, pie diagram, Box plot for one and more variables, histogram, frequency polygon, scatter plot eg plot(), correlation plot using R (ggplot) and Python.	15
4	**Statistical Computing using R and Python:** **4.1** Descriptive Statistics: Mean, Median, Mode, Standard Deviation, Variance, Coefficient of Variation, Quantiles. Positional Averages, Skewness, Kurtosis, Correlation, Curve Fitting and Regression. **4.2** Some Probability Distributions: Generating random samples from Binomial, Poisson, Normal, Exponential, and computing p.d.f., c.d.f. and inverse c.d.f.'s from these distributions.	15

Self-Learning topics (Unit wise)

Unit	Topics
4	4.1 Descriptive Statistics: mean, median, mode, standard deviation, variance, coefficient of variation, skewness, kurtosis, quantiles. Positional Averages, Skewness, Kurtosis, Correlation, Curve Fitting and Regression. 4.2 computing p.d.f.

Online Resources

1. 'Introduction to R Software' by Prof. Shalabh from IIT Kanpur available on the Swayam portal
   https://nptel.ac.in/courses/111/104/111104100/
   for unit 4
2. 'Descriptive Statistics with R Software' by Prof. Shalabh from IIT Kanpur available on the Swayam portal
   https://nptel.ac.in/courses/111/104/111104120/
3. 'Introduction to R' by Santu Ghosh from Rajiv Gandhi University of Health Sciences available on the Swayam portal
   http://ugcmoocs.inflibnet.ac.in/ugcmoocs/view_module_pg.php/1851
4. 'Data Analytics with Python' by Prof. A. Ramesh from IIT Roorkee available on the Swayam portal
   https://nptel.ac.in/courses/106/107/106107220/
   for unit 4

Part -4 Detailed Scheme Practical

Practical of Semester I — Total Credit: 08

Paper Code	Title	No. of Hours
MS-FSTP-101	1. Probability 2. Moment Generating and Characteristic Function 3. Probability Generating Function 4. Random Variables and Transformation 5. Inequalities 6. Discrete probability distributions 7. Continuous probability distributions 8. Central Limit Theorem	02 Hours per Practical per Batch*
MS-FSTP-102	1. Methods of Estimation. 2. Uniform Minimum Variance Unbiased Estimation 3. Lower bounds for variance 4. Consistency 5. Bayes' Estimation 6. Introduction to Testing of Hypothesis 7. MP test and UMP test-I 8. MP test and UMP test-II 9. Likelihood Ratio Tests 10. Wald's SPRT 11. Interval Estimation	
MS-FSTP-	1. Matrix Theory-I (Determinant, Rank of Matrix, Inverse of	

103	matrix) 2. Matrix Theory-II (Generalized Inverse, Simultaneous Linear Equations, Characteristics roots & Characteristics Vectors) 3. Linear Model-I 4. Linear Model-II 5. Techniques for Checking Assumptions of ANOVA 6. One way classification model 7. Two way Classification Model -I 8. Two way Classification Model-II 9. Random Effect Models 10. Analysis of Covariance	
MS-FSTP-104	1. Introduction to R and Python 2. Elementary calculation using R and Python 3. Data processing and Manipulation using R and Python 4. Matrix operations using R and Python 5. Visualization using R and Python –I 6. Visualization using R and Python –II 7. Measures of Central Tendency, Dispersion , Skewness and Kurtosis	

Part 5- The Scheme of Teaching and Examination is as under:
First Year Semester – II
Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Statistics**)			MS-FST-201,MS-FST-202, MS-FSP-201,MS-FSTP-202	
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course	MS-FST-203, MS-FSTP-203	
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)			MS-FST-204, MS-FSTP-204	
	Skill Enhancement Courses (SEC)				

Detail Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Tot al Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	MS-FST-201	Stochastic Process	4	20% *	4	0	0	4	10	20	10	60	100
2	MS-FST-202	Multivariate Analysis	4	20% *	4	0	0	4	10	20	10	60	100
3	MS-FST-203	Sample Surveys and Official Statistics	4	20% *	4	0	0	4	10	20	10	60	100
4	MS-FST-204	Regression Techniques	4	20% *	4	0	0	4	10	20	10	60	100
5	MS-FSTP-201	**Practical based on** MS-FST-201					2	2			10 (J+V)	40	50
6	MS-FSTP-202	**Practical based on** MS-FST-202					2	2			10 (J+V)	40	50
7	MS-FSTP-203	**Practical based on** MS-FST-203					2	2			10 (J+V)	40	50
8	MS-FSTP-204	**Practical based on** MS-FST-204					2	2			10 (J+V)	40	50
	Total Hours / Credit							24	Total Marks				600

***One to two lectures to be taken for CONTINUOUS self -learning evaluation.**

First Year Semester – II Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MS-FST-201	I	Basics of Stochastic Process	15	60 H	4	100 (60+40)
		II	Advanced study of Stochastic Process-1	15			
		III	Advanced study of Stochastic Process-2	15			
		IV	Poisson Process and Renewal Process	15			
2	MS-FST-202	I	Introduction to Multivariate Distribution	15	60 H	4	100 (60+40)
		II	Hotelling's T2, Regression and MANOVA	15			
		III	Discriminant Analysis and its Application	15			
		IV	Advanced Multivariate Techniques	15			
3	MS-FST-203	I	Basic Sample Designs	15	60 H	4	100 (60+40)
		II	Advance Sample Designs-1	15			
		III	Advance Sample Designs-2	15			
		IV	Official Statistics	15			
4	MS-FST-204	I	Multiple Linear Regression	15	60 H	4	100 (60+40)
		II	Regression Diagnostics	15			
		III	Advanced Regression Models and Generalized Linear Models	15			
		IV	Non Linear Regression	15			
5	MS-FSTP-201		Practical based on MS-FST-201	30	120 H	2	50
6	MS-FSTP-202		Practical based on MS-FST-202	30		2	50
7	MS-FSTP-203		Practical based on MS-FST-203	30		2	50
8	MS-FSTP-204		Practical based on MS-FST-204	30		2	50
			TOTAL			24	600

- **Lecture Duration – 1 hour**
- **One Credit =15 Classroom hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA- Project Assessment, AT- Attendance

Part -6 - Detailed Scheme Theory

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

Course Code: MS-FST-201
Title of Paper: **Stochastic Process**

Unit	Content	No. of Hours
1	**Basics of Stochastic Process** 1.1 Notion of stochastic processes, Markov chain, one step transition probabilities, Chapman-Kolmogorov equations, evaluation of higher step transition probabilities, Classification of states, periodicity of a Markov chain, 1.2 Concept of closed class, minimal closed class, stationary distribution. Some examples such as gamblers ruin problem and one dimensional random walk. 1.3 Concept of absorption probabilities, Use of these to compute probability of winning the game by a gambler having initial capital 'a'.	15
2	**Advanced study of Stochastic Process-1** 2.1 Branching process, classification of states, identification of criticality parameter, extinction probability, relationship between criticality parameter and extinction probability of the process, Expression for mean and variance of the process. 2.2 Extinction probability, Some epidemiological applications, Introduction to Markov chain in continuous time, concept of intensity rate, relationship between intensity matrix and transition probability matrix. 2.3 Kolmogorov's forward and backward equations	**15**
3	**Advanced study of Stochastic Process-2** 3.1 Introduction to birth process, birth and death process, linear birth and death process, 3.2 Growth model with immigration and related results, Expression for mean and variance of a birth process and, birth and death process, Applications of these processes.	**15**
4	**Poisson Process and Renewal Process** 4.1 Poisson process, two definitions and their equivalence, Distribution of inter arrival times, conditional joint distribution of inter arrival times. Compound Poisson process, Some applications. 4.2 Introduction to renewal process, relationship with Poisson process, key and elementary renewal theorems associated with renewal processes, Some applications.	**15**

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1 Notion of stochastic processes, Markov chain, one step transition probabilities, Chapman-Kolmogorov equations, evaluation of higher step transition probabilities, Classification of states, periodicity of a Markov chain, 1.2 Concept of closed class, minimal closed class, stationary distribution. Some examples such as gamblers ruin problem and one dimensional random walk.

Online Resources

1. 'Introduction to Probability Theory and Stochastic Processes' by Prof. S Dhramaraja from IIT Delhi available on the Swayam portal https://nptel.ac.in/courses/111/102/111102111/
2. 'Stochastic Processes' by Prof. Dharmaraja from IIT Delhi and Prof. N. Selvaraju from IIT Gowahati available on the Swayam portal https://nptel.ac.in/courses/111/102/111102098/# for unit 1.
3. 'Introduction to Stochastic Processes' by Prof. Manjesh hanawal from IIT Bombay available on the Swayam portal https://nptel.ac.in/courses/110/101/110101141/

Course Code: MS-FST-202
Title of Paper: **Multivariate Analysis**

Unit	Content	No. of Hours
1	**Introduction to Multivariate distributions** 1.1 Multivariate normal distribution: definition, conditional & marginal distributions, characteristic function. 1.2 Random sample from multivariate normal distribution. Maximum likelihood estimators of parameters. 1.3 Distributions of sample mean vector and variance-covariance matrix and their independence. 1.4 Null Distribution of partial and multiple correlation coefficients and Interval Estimation and Application in Testing.	15
2	**Hotelling's T^2, Regression and MANOVA** 2.1 Hotelling's T^2 distribution and its applications. 2.2 Wishart distribution and its properties. 2.3 Multivariate Analysis of Variance (MANOVA) for one way and two way.	15
3	**Discriminant analysis and its Application** 3.1 Discriminant Analysis and Classification of a discriminant procedure for discriminating between two multivariate normal populations. 3.2 Sample discriminant function and tests associated with discriminant functions, probabilities of misclassification and their estimation.	15
4	**Advanced Multivariate Techniques** 4.1 Principal Component analysis: Estimation of Linear Functions and their extraction using Orthogonal Rotation. 4.2 Factor Analysis: KMO and Bartlett Test and their significance (without derivation), Scree Plot and other methods of Extraction 4.3 Cluster analysis: **Hierarchical Optimization Methods:** Agglomerative Schedule based on linkage Method (Single, Complete and Average), Ward's Method, Centroid Method. **K-Mean Optimization Methods:** Sequential Threshold, Parallel Threshold, Optimizing Partitioning.	15

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1. Multivariate normal distribution: definition 1.2. Random sample from multivariate normal distribution.
2	2.4 Multivariate Analysis of Variance (MANOVA) for one way.
4	4.1 Principal Component analysis. 4.2 Factor Analysis

Online Resources

1. 'Applied Multivariate Statistical Modeling' by Prof. J. Maiti from IIT Kharagpur available on the Swayam portal
   https://nptel.ac.in/courses/111/105/111105091/

   for unit I, II, III.
2. 'Applied Multivariate Analysis' by Prof. Amit Mitra and Prof. Sharmishtha Mitra from IIT Kanpur
   https://nptel.ac.in/courses/111104024/

Course Code: MS-FST-203

Title of paper: Sample Surveys and Official Statistics

Unit	Content	No. of Hours
1	**Basic Sample Designs** 1.1 Sample Surveys: Introduction to usual notations used in sampling. 1.2 Basic finite population sampling techniques: SRSWR, SRSWOR, stratified, systematic and related results on estimation of population mean/ total. 1.3 Relative precision of different sampling techniques. Allocation problem in stratified sampling. 1.4 Determination of Sample size (SRSWR & SRSWOR).	15
2	**Advance Sample Designs-1** 2.1 Ratio and regression estimators based on SRSWOR method of sampling. 2.2 Two-stage sampling with equal size of first stage units. 2.3 Double sampling for ratio and regression methods of estimation. 2.4 Cluster sampling - equal clusters.	15
3	**Advance Sample Designs-2** 3.1 Unequal probability sampling: PPS WR/WOR methods [cumulative total, Lahiri's schemes] and related estimators of a finite population mean [Thompson-Horwitz, Yates and Grundy estimator, Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2].	15
4	**Official Statistics**	15

	4.1 Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. 4.2 Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. 4.3 Government of India's Principal publications containing data on the topics such as population, industry and finance.	

Self-Learning topics (Unit wise)

Unit	Topics
2.1	Ratio and regression estimators based on SRSWOR method of sampling
3	PPS WR/WOR methods, Thompson-Horwitz estimators for a general sample size and Murthy's estimator for a sample of size 2

Online Resources

"Sampling Theory" **Swayam Prabha Course, Channel 16, MOE, GOI by Prof. Shalabh, IIT Kanpur** Source: https://www.youtube.com/playlist?list=PLqMl6r3x6BUTP4XPysDab-RrLAt4_PP6E

Course Code: MS-FST-204

Title of paper: Regression Techniques

Unit	Content	No. of Hours
1	**Multiple Linear Regression** **1.1** Partial and multiple correlations, standard Gauss Markov setup, least squares (LS) estimation, variance-covariance of LS estimators, estimation of error variance, regression analysis with correlated observations, LS estimation with restriction on parameters.; properties of least squares residuals; forward, backward and stepwise regression; different methods for subset selection.	15
2	**Regression Diagnostics** 2.1 Lack of fit (linearity): diagnostics and test, Model building. Heteroscedasticity: consequences, diagnostics, tests (including Breusch-Pagan test and White's test) and efficient estimation. 2.2 Autocorrelation: consequences, diagnostics, tests (including Durbin-Watson test, Breusch-Godfrey LM test) and efficient estimation. 2.3 Collinearity: consequences, diagnostics and strategies (including ridge & shrinkage regression). 2.4 Discordant outlier and influential observations: diagnostics and strategies.	15
3	**Advanced Regression Models and Generalized Linear Models** 3.1 Dummy Variables, Polynomial Regression Model 3.2 Orthogonal Polynomial, Log-Linear models. 3.3 Introduction to Generalized Linear Models (GLMs), illustration with logit and probit analysis.	15
4	**Non Linear Regression**	15

	4.1 Linearization transforms, their uses & limitations, examination of nonlinearity, initial estimates. 4.2 Iterative procedures for NLS, grid search, Newton-Raphson, steepest descent, Marquardt's methods.	

Self-Learning topics (Unit wise)

Unit	Topics
3	3.1 Dummy Variables, Polynomial Regression Model 3.3 Introduction to Generalized Linear Models (GLMs)
4	4.1 Non Linear Regression (NLS): Linearization transforms, their uses & limitations, examination of nonlinearity, initial estimates.

Online Resources

1. 'Linear Regression Analysis and Forecasting' by Prof. Shalabh from IIT Kanpur available on the Swayam portal
   https://nptel.ac.in/courses/111/104/111104098/
2. 'Regression Analysis' by Prof. Soumen Maity from IISER Pune available on the Swayam portal
   https://nptel.ac.in/courses/111/105/111105042/
   for unit III and IV.
3. 'Linear Regression Analysis' by Prof. Shalabh from IIT Kanpur
   https://nptel.ac.in/courses/111104074/

Part – 7- Detailed Scheme Practical

Practical of Semester II Total Credit: 08

Paper Code	Title	No. of Hours
MS-FSTP-201	1. Simulation of Markov chain and estimating the stationary distribution of ergodic Markov chain. 2. Simulation of branching process and estimating its mean and variance. 3. Simulation of Poisson and related processes. 4. Generating birth-death process and its limiting distribution.	02 Hours per Practical per Batch*
MS-FSTP-202	1. Multivariate Normal Distribution 2. Hoteling T^2 3. Multivariate Regression 4. Multiple and Partial Correlation Coeficient 5. Multivariate Analysis of Variance (MANOVA) 6. Discriminant Analysis 7. Principal Component Analysis 8. Factor Analysis 9. Cluster Analysis	
MS-	1. Simple random sampling	

FSTP-203	2. Stratified random sampling. 3. Systematic random sampling 4. Determination of Sample Size 5. Ratio and Regression methods of Estimation. 6. Cluster sampling. 7. Two-stage and Two-phase sampling. 8. Varying Probability Sampling	
MS-FSTP-204	1. Multiple linear Regression: Assumption Checking, Multicolliearity, Selection methods. 2. Regression Diagnostics 3. Ridge Regression 4. Orthogonal Polynomials 5. Fitting of Log Linear Model 6. Non Linear Regression.	

*Batch Size of 10 students

References:

Semester – I

Course Code: MS-FST-101:

1) Apostol, T. M. (1974): Mathematical Analysis. 2nd edition, Narosa Publishing house
2) Bartle G. and Sherbet, D. R. (2000): Introduction to Real Analysis. 3rd edition. Wiley
3) Kumar, A and Kumaresan S. (2015): A Basic course in Real analysis. CRC Press.
4) Malik, S. C. and Arora, S. (2017): Mathematical Analysis. 5th edition. New age International Publishers.
5) Rudin, W. (1976): Principles of Mathematical Analysis. 3rd edition. McGraw-Hill.
6) Bhat B.R. (1999): Modern Probability Theory: An Introductory test book. 3rd edition. New Age International.
7) Bhat B.R. : Modern Probability Theory, New Age International.
8) Rohatgi V.K. & Saleh A.K. Md. Ehasanes (2001) - An Introduction to Probability and Statistics. Wiley
9) Chandra, T. and Gangopadhyay, S. (2017): Fundamentals of Probability Theory. Narosa Publishing House.
10) Ross, S. M. (2014): Introduction to Probability Models. 11th edition. Elsevier.
11) Johnson, N. L., Kotz S. and Balakrishnan, N (2005): Univariate Discrete Distributions. Wiley.
12) Johnson, N. L., Kotz S. and Balakrishnan, N (2004): Continuous Univariate Distributions. Volume-I. Wiley.
13) Johnson, N. L., Kotz S. and Balakrishnan, N (2004): Continuous Univariate Distributions. Volume-II. Wiley.
14) Probability-A Graduate Course, Gut, A., Springer

Course Code: MS-FST-102:

1) Rohatgi, V. K. and Saleh, A.K. M.E.: An Introduction to Probability Theory and Mathematical Statistics,
2) Rao, C.R.: Linear Statistical Inference and its Applications.
3) Lehmann, E.L.: Theory of Point Estimation (Student Edition).
4) Goon, A.M., Gupta, M.K.: An Outline of Statistical Theory
5) Kale, B.K.: A first Course on Parametric Inference
6) Dudewicz, E.J. and Mishra, S.N.: Modern Mathematical Statistics
7) Lehmann, E.L.: Testing Statistical hypotheses (Student Edition).
8) Ferguson, T.S.: Mathematical Statistics.
9) Zacks, S.: Theory of Statistical Inference

Course Code: MS-FST-103:

1) Hohn Franz E : Elementary Matrix Algebra
2) Searle S.R. : Matrix Algebra useful for Statistics
3) Kshirsagar A.M. : A course in Linear Models
4) Wang S. GUI and Chow S.C. : Advanced Linear Models.
5) Healy M. J. R. : Matrices for Statistics
6) Shantinarayan : Textbook of Matrices
7) Finney D, J:- Statistical methods in biological assays.
8) Graybill F.A.:- An introduction to linear statistical models Vol. I.
9) Rao C.R.:- Linear statistical inference and its applications.
10) Searle S.R.:- Linear models.
11) Scheffe H.:- Analysis of variance.

Course Code: MS-FST-104:

1) **Zuur**, Alain**, Ieno**, Elena N., **Meesters**, Erik: A Beginner's Guide to R, Springer
2) Torsten Hothorn, Brian S. Everitt: A Handbook of Statistical Analyses using R, Chapman and Hall/CRC Press, 3rd Edition
3) Pierre-Andre Cornillon, Arnaud Guyader, Francois Husson, Nicolas Jegou, Julie Josse, Maela Kloareg, Eric Matzner-Lober, Laurent Rouvière: R for Statistics, Chapman and Hall/CRC
4) Mark Lutz: Programming Python, O'Reilly Media, 4th Edition
5) Wes McKinney: Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, O'Reilly Media, 2nd Edition
6) Kenneth A. Lambert: The Fundamentals of Python: First Programs, 2011, Cengage Learning
7) Asha Jindal(Ed): Analyzing and Visualizing Data with R Software, Shailja Prakashan and K.C.College, 2018.
8) Asha Jindal(Ed): Analyzing and Visualizing Data using Free Open Source Software: Python Programming with Case Studies, Shailja Prakashan and K. C. College, 2020.

Semester II

Course Code: MS-FST-201:

1) Bhat B.R.: Stochastic Models: Analysis and Applications.
2) Medhi, J.: Stochastic Processes
3) Pinsky M. A. and Karlin, S.: An Introduction to Stochastic Modeling.
4) Ross, S.: Introduction to Probability Models
5) Feller, W.: An Introduction to Probability Theory and its Applications.
6) Hoel, P.G. Port, S.C. & Stone, C.J.: Introduction to Stochastic Processes.
7) Karlin, S & Taylor, H.M.: A First Course in Stochastic Processes (Second. Edition).
8) Serfozo, R.: Basics of Applied Stochastic Processes.

Course Code: MS-FST-202:

1) Johnson Richard A and Wichern D.W.(1998) : Applied Multivariate Statistical Analysis (4th Edition)
2) Johnson Richard A and Wichern D.W. : Applied Multivariate Statistical Methods
3) Anderson T.W.(1958) : An Introduction to Multivariate Statistical Analysis.John Wiley & Sons
4) Dillon William R & Goldstein Mathew (1984) : Multivariate Analysis : Methods and Applications.
5) Giri Narayan C. (1995) : Multivariate Statistical Analysis.
6) Kshirsagar A. M. (1979) : Multivariate Analysis ,Marcel Dekker Inc. New York.
7) Hardle Wolfgang & Hlavka : Multivarite Statistics : Exercise & Solutions
8) Parimal Mukhopadhyay: Multivariate Statistical Analysis.
9) Srivastava, M. S. (2002): Methods of Multivariate Statistics. John Wiley.

Course Code: MS-FST-203:

1) Cochran W.G.: sampling techniques.
2) Raj, d and chandak: sampling theory.
3) Murthy, m.n.: sampling theory & methods.
4) Mukhopadhyay, p.: Theory and methods of survey sampling.
5) Sukhatme et. Al.: sampling theory of surveys with applications.
6) Bansal A.:Survey Sampling
7) Arijit Chaudhuri :Modern Survey Sampling
8) Guide to current indian official statistics, central statistical office, goi, new delhi. http://mospi.nic.in/

Course Code: MS-FST-204:

1) Thomas P. Ryan, Modern Regression Methods.
2) Douglas C. Montgomery, Introduction to Linear Regression Analysis.
3) David A. Belsley, Edwin Kuh and Roy E. Welsch, Regression Diagnostics: Identifying Influential Data and Source of Collinearity.
4) Peter J. Rousseeuw and Annick M. Leroy, Robust Regression and Outlier Detection.

5) P. McCullagh and John A. Nelder. Generalized linear models.
6) Pagan, A. and A. Ullah, Nonparametric Econometrics.
7) Kshirsagar A.M.: A course in Linear Models
8) Draper N.R & Smith H: Applied Regression Analysis.
9) Song GUI Wang and S.C Chow: Advanced Linear Models.
10) Damodar *Gujarati*: *Basic Econometrics*
11) *George A. F. Seber, Alan J. Lee: Linear Regression Analysis*
12) *Chaterjee and Price: Regression Analysis with examples*
13) *Applied Logistic Regression, David W. Hosmer and Stanley Lemeshow, Wiley*
14) Ratkowsky, D. A. (1983). Nonlinear Regression Modelling,
15) Seber, G. E. F. and Wild, C. J. (1989). Nonlinear Regression.