॥ सा विद्या या विमुक्तये ॥

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

'ज्ञानतीर्थ', विष्णुपुरी, नांदेड – ४३१ ६०६ (महाराष्ट्र राज्य) भारत

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

'Dnyanteerth', Vishnupuri, Nanded - 431 606 (Maharashtra State) INDIA

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

Established on 17th September, 1994, Recognized By the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'B++' grade

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विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत राष्ट्रीय शैक्षणिक धोरण २०२० नुसार पदव्यूत्तर द्वितीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२४–२५ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, या विद्यापीठा अंतर्गत येणा–या सर्व संलग्नित महाविद्यालयामध्ये शैक्षणिक वर्ष २०२४–२५ पासून राष्ट्रीय शैक्षणिक धोरणानुसार पदव्यूत्तर द्वितीय वर्षाचे अभ्यासक्रम लागू करण्याच्या दृष्टीकोनातून विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत येणा–या अभ्यासमंडळांनी तयार केलेल्या पदव्यूत्तर द्वितीय वर्षाच्या अभ्यासक्रमांना मा. विद्यापरिषदेने दिनांक १५ मे २०२४ रोजी संपन्न झालेल्या बैठकीतील विषय क्रमांक १५/५९–२०२४ च्या ठरावाअन्वये मान्यता प्रदान केली आहे. त्यानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील खालील एम. एस्सी द्वितीय वर्षाचे अभ्यासक्रम (Syllabus) लागू करण्यात येत आहेत.

1) M. Sc. II year Biotechnology (Affiliated College)
2) M. Sc. II year Biotechnology (Campus)
3) M. Sc. II year Bioinformatics (Sub Campus Latur)
4) M. Sc. II year Bioinformatics (Affiliated College)
5) M. Sc. II year Clinical Research (Affiliated College)
6) M. Sc. II year Botany (Campus)
7) M. Sc. II year Herbal Medicine
8) M. Sc. II year Boany (Affiliated College)
9) M. Sc. II year Geology (Campus)
10) M. Sc. II year Dairy Science
11) M. Sc. II year Electronics
12) M. Sc. II year Environmental Science
13) M. Sc. II year Environmental Science (Campus)
14) M. Sc. II year Geography (Campus)
15) M. Sc. II year Applied Mathematics
16) M. Sc. II year Mathematics
17) M. Sc. II year Mathematics (Campus)
18) M. Sc. II year Microbiology
19) M. Sc. II year Microbiology (Campus)
20) M. Sc. II year Statistics
21) M. Sc. II year Statistics (Campus)

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी, ही विनंती.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.:शै–१/एनइपी/विवत्रंविपदवी/२०२४–२५/१०९
दिनांक १२.०६.२०२४

डॉ. सरिता लोसरवार
सहा.कुलसचिव
शैक्षणिक (१–अभ्यासमंडळ) विभाग

प्रत : १) मा. आधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मुंल्यमापन मंडळ, प्रस्तुत विद्यापीठ.
३) मा. प्राचार्य, सर्व संबधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.
४) मा. संचालक, सर्व संकुले परिसर व उपपरिसर, प्रस्तुत विद्यापीठ
५) सिस्टीम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ. याना देवून कळविण्यात येते की, सदर परिपत्रक संकेतस्थळावर प्रसिध्द करण्यात यावे.

SWAMI RAMANAND TEERTH

MARATHWADA UNIVERSITY, NANDED - 431 606

(Structure and Syllabus of Two Years Multidisciplinary Master Degree Program with Multiple Entry and Exit Option)

(University Campus)

TWO YEARS MASTER DEGREE PROGRAMME IN SCIENCE

Subject: STATISTICS

Under the Faculty of
Science and Technology

Effective from Academic Year 2024 – 2025
(As per NEP-2020)

From the Desk of the Dean, Faculty of Science and Technology

Swami Ramanand Teerth Marathwada University, Nanded, enduring to its vision statement "***Enlightened Student: A Source of Immense Power***", is trying hard consistently to enrich the quality of science education in its jurisdiction by implementing several quality initiatives. Revision and updating curriculum to meet the standard of the courses at national and international level, implementing innovative methods of teaching-learning, improvisation in the examination and evaluation processes are some of the important measures that enabled the University to achieve ***the 3Es, the equity, the efficiency*** and ***the excellence*** in higher education of this region. To overcome the difficulty of comparing the performances of the graduating students and also to provide mobility to them to join other institutions the University has adopted the cumulative grade point average (CGPA) system in the year 2014-2015. Further, following the suggestions by the UGC and looking at the better employability, entrepreneurship possibilities and to enhance the latent skills of the stakeholders the University has adopted the Choice Based Credit System (CBCS) in the year 2018-2019 at graduate and post-graduate level. This provided flexibility to the students to choose courses of their own interests. To encourage the students to opt the world-class courses offered on the online platforms like, NPTEL, SWAYM, and other MOOCS platforms the University has implemented the credit transfer policy approved by its Academic Council and also has made a provision of reimbursing registration fees of the successful students completing such courses.

SRTM University has been producing a good number of high calibre graduates; however, it is necessary to ensure that our aspiring students are able to pursue the right education. Like the engineering students, the youngsters pursuing science education need to be equipped and trained as per the requirements of the R&D institutes and industries. This would become possible only when the students undergo studies with an updated and evolving curriculum to match global scenario.

Higher education is a dynamic process and in the present era the stakeholders need to be educated and trained in view of the self-employment and self-sustaining skills like start-ups. Revision of the curriculum alone is not the measure for bringing reforms in the higher education, but invite several other initiatives. Establishing industry-institute linkages and initiating internship, on job training for the graduates in reputed industries are some of the important steps that the University would like to take in the coming time. As a result, revision of the curriculum was the need of the hour and such an opportunity was provided by the New Education Policy 2020. National Education Policy 2020 (NEP 2020) aims at equipping students with knowledge, skills, values, leadership qualities and initiates them for lifelong learning. As a result the students will acquire expertise in specialized areas of interest, kindle their intellectual curiosity and scientific temper, and create imaginative individuals.

The curriculum given in this document has been developed following the guidelines of NEP-2020 and is crucial as well as challenging due to the reason that it is a transition from general science based to the discipline-specific-based curriculum. All the recommendations of the ***Sukanu Samiti*** given in the **NEP Curriculum Framework-2023** have been followed, keeping the disciplinary approach with rigor and depth, appropriate to the comprehension level of learners. All the Board of Studies (BoS) under the Faculty of Science and Technology of this university have put in their tremendous efforts in making this curriculum of international standard. They have taken care of maintaining logical sequencing of the subject matter with proper placement of concepts with their linkages for better understanding of the students. We take this opportunity to congratulate the Chairman(s) and all the members of various Boards of Studies for their immense contributions in preparing the revised curriculum for the benefits of the stakeholders in line with the guidelines of the **Government of Maharashtra regarding NEP-2020**. We also acknowledge the suggestions and contributions of the academic and industry experts of various disciplines.

We are sure that the adoption of the revised curriculum will be advantageous for the students to enhance their skills and employability. Introduction of the mandatory ***On Job Training, Internship program*** for science background students is praise worthy and certainly help the students to imbibe firsthand work experience, team work management. These initiatives will also help the students to inculcate the workmanship spirit and explore the possibilities of setting up of their own enterprises.

Dr. M. K. Patil
Dean
Faculty of Science and Technology

Preamble:

The education in India, in general is expanding manifolds. It is the challenge to ensure its quality to stakeholders to meet this challenge the issue of quality needs to be addressed and taken forward in systematic manner. For this we statistician tried to modify our subject curriculum according to National Education Policy (NEP) 2020 to explore future brightness of stakeholders.

M. A. / M. Sc. Statistics programme is of minimum 88 credits spread over four semesters. The programme emphasizes both theory and 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 has some unique features such as independent projects, number of elective courses, extensive computer training of statistical computations including standard software packages such as MATLAB, MINITAB, R, Python, TORA and SPSS. The department has the academic autonomy and it has been utilized to add the new and need based elective courses. The independent project work is one of the important components of this program. In this syllabus core courses, electives and open electives are offered. The syllabus has been framed to have a good balance of theory, methods and applications of statistics. It is possible for the students to study basic courses from other disciplines such as economics, life sciences, computer science and mathematics in place of electives. This programme requires basic of data types, organization of data and tabulation of data, Graphical representation, data transformation, distribution theory, and sampling methodology.

A course with SSTAC, SSTAE, STATPC and STATOE indicates First letter S-Sci, next three letters STA-Major/DSE-Elective, fourth letter C-Core/E-Elective, x-Semester number, 'P' is for practical and last two numbers represent xx-paper no. SVC indicates. We'll follow this analogy for assigning CODE to the courses. OJT indicated for on job training respectively. A student can enroll for a practical course if the student has enrolled for the corresponding theory course (as indicated) in the same term.

I, as Chairman, Board of Studies in Statistics, Swami Ramanand Teerth Marathwada University, Nanded, happy to state here that we all members made a curriculum and finalized it. The Program Educational Objectives were finalized for postgraduate program in Statistics. I am thankful our Dean of Science and Technology Dr. L. M. Waghmare and Associate Dean Dr. M. K. Patil who has given this opportunity.

The Program Educational Objectives finalized for Postgraduate program in Statistics are listed below:

Program Educational Objectives (PEO):

M. A. / M. Sc. Statistics program has semester pattern and credit system with variable credits. The program consists of 88 credits. Credits of a course are specified against the title of the course. The learning objectives of this program are:

PEO1: Students should able to understand, implement and overcome problems through statistical techniques.

PEO2: To develop scientific view among students for better understanding and analytic ability the collected data for specific perspectives.

PEO3: Demonstrate graduate-level skills in communicating mathematics and statistics, orally and in writing.

PEO4: Students should able understand appropriate, relevant, fundamental and applied mathematical; and statistical methodologies and modern computational tools.

PEO5: The ability to bring together and flexibly apply knowledge to characterize, analyze and solve a wide range of problems an understanding of the balance between the complexity / accuracy of the mathematical / statistical models used and the timeliness of the delivery of the solution.

PEO6: Ability to contribute to professional work settings through effective participation in teams and organization of project tasks the ability to constructively engage with other team members and resolve conflict.

PEO7: The ability to communicate effectively in terms of technical and non-technical material in a range forms to different audiences.

4. Program Outcomes (PO):

On successful completion of the program students will able to:

PO1: Have specialised knowledge and understanding of statistical theory at an advanced level which take into account recent advances in the subject.

PO2: Acquire the **s**trong foundation of statistical concepts which will benefit them to become good academicians.

PO3: Use acquired statistical methodologies and modelling techniques to address real-life problems.

PO4: Gain the knowledge of software which has the wide range of opportunities in the Quality control, Planning and development, IT sector, R&D in industries, Business, Government and private sector etc.

PO5: Qualify various National / State level competitive exams like ISS, DSO, CSIR-UGC NET, SLET, GATE, MPSC, UPSC, Banking etc.

5. Program Specific Outcomes (PSO):

On successful completion of the program students will able to:

PSO1: Understand, implement and develop statistical models.

PSO2: Handle and analyze small as well as large databases with computer skills.

PSO3: Describe complex statistical ideas to non-statisticians and to present the results of their analyses in written, oral forms and can make practical suggestions for improvement.

PSO4: Get wide range of statistical skills in problem-solving.

PSO5: The project work and presentation may enable to take prominent roles in a wide spectrum of employment and research.

Course Outcomes (for all courses):

The course outcomes are the statement that describes the knowledge & abilities developed in the student by the end of course (subject) teaching. The focus is on development of abilities rather than mere content. There are 4 course outcomes of all courses defined here. These are to be written in the specific terms and not in general.

In addition to Program Educational Objectives, for each course of postgraduate program, objectives and expected outcomes from learner's point of view are also included in the curriculum to support the philosophy of outcome based education. I believe strongly that small step taken inright direction will definitely help in providing quality education to the stake holders.

Board of Studies of the Statistics

Swami Ramanand Teerth Marathwada University, Nanded

Details of the Board of Studies Members in the subject STATISTICS under the faculty of Science & Technology of S.R.T.M. University, Nanded

Sr No	Name of the Member	Designation	Address	Contact No.
1	Vacant	Chairman		
2	Dr. A. A. Muley	Member	School of Mathematical Sciences, SRTMUN	7276114558
3	Dr. S. V. Kawale	Member	Dr. B. A. M. Uni., Chhatrapati Sambhajinagar	9421303727
4	Dr. V.S. Jadhav	Member	Sanjeevanee College,Chapoli	9604421675
5	Dr. M. R. Fegade	Member	Digambarrao Bindu College, Bhokar	9922675834

Swami Ramanand Teerth Marathwada University, Nanded

Faculty of Science & Technology

Credit Framework for Two Year PG Program

Subject: Statistics

Year & Level 1	Sem. 2	Major Subject (DSC) 3	Major Subject (DSE) 4	RM 5	OJT / FP 6	Research Project 7	Practicals 8	Credits 9	Total Credits 10
1	1	SSTAC401 (4 Cr) SSTAC402 (4 Cr) SSTAC403 (4 Cr)	SSTAE401 (4 Cr) SSTAE402 (4 Cr) SSTAE403 (4 Cr) *(Select Any one Above / From Same School)*	SVECR 401 *Research Methodology* (3 Cr)	--	--	SSTAP401 (3Cr)	22	44
	2	SSTAC451 (4 Cr) SSTAC452 (4 Cr) SSTAC453 (4 Cr)	SSTAE451 (4 Cr) SSTAE452 (4 Cr) SSTAE453 (4 Cr) *(Select Any one Above / From Same School)*	---	SSTAO451 (3 Cr)	--	SSTAP451 (3Cr)	22	
Exit option: Exit Option with PG Diploma *(after 2024-25)*									
2	3	SSTAC501 (4 Cr) SSTAC502 (4 Cr) SSTAC503 (4 Cr)	SSTAE501 (4 Cr) SSTAE502 (4 Cr) SSTAE503 (4 Cr) SSTAE504 (4 Cr) SSTAE505 (4 Cr) *(Select Any one Above / From Same School)*	--		Research Project SSTAR551 (4Cr)	SSTAP501 (2 Cr)	22	44
	4	SSTAC551 (4 Cr) SSTAC552 (4 Cr)	SSTAE551 (4 Cr) SSTAE552 (4 Cr) SSTAE553 (4 Cr) SSTAE554 (4 Cr) *(Select Any one Above / From Same School)*	SVECP 551 Publication Ethics (2 Cr)		Research Project SSTAR552 (6 Cr)	SSTAP551 (2Cr)	22	
Total Credits		**44**	**16**	**05**	**03**	**10**	**10**	**88**	

M. Sc. First Year Semester I *(Level 6.0)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SSTAC401**	Real Analysis and Linear Algebra	04	--	**04**	04	--
	SSTAC402	Probability and Distribution Theory	04	--	**04**	04	--
	SSTAC403	Sampling Methods	04	--	**04**	04	--
Elective (DSE) (Any one from same Department/ School)	**SSTAE401**	Statistical Computing	04	--	**04**	04	--
	SSTAE402	Econometrics					
	SSTAE403	Computer Graphics					
	SSTAE404	NPTEL/SWAYAM MOOCs					
Research Methodology	**SVECR401**	Research Methodology	03	--	**03**	03	--
STA Practical	**SSTAP401**	Practical-I	--	03	**03**	--	06
Total Credits			**19**	**03**	**22**	**19**	**06**

M. Sc. First Year Semester I *(Level 6.0)*

Examination Scheme

[20% Continuous Assessment (***CA***) and 80% End Semester Assessment (***ESA***)]

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Avg of (T1+T2)/2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SSTAC401**	Real Analysis and Linear Algebra	20	20	20	80	--	--	100
	SSTAC402	Probability and Distribution Theory	20	20	20	80	--	--	100
	SSTAC403	Sampling Methods	20	20	20	80	--	--	100
Elective (DSE) (Any one from same Department/ School)	**SSTAE401**	Statistical Computing	20	20	20	80	--	--	100
	SSTAE402	Econometrics							
	SSTAE403	Computer Graphics							
	SSTAE404	NPTEL/SWAYAM MOOCs							
Research Methodology	**SVECR401**	Research Methodology	15	15	15	60	--	--	75
DSE Practical	**SSTAP401**	Practical-I	--	--	--	--	15	60	75

M. Sc. First Year Semester II *(Level 6.0)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SSTAC451**	Regression Analysis	04	--	**04**	04	--
	SSTAC452	Statistical Inference	04	--	**04**	04	--
	SSTAC453	Stochastic Processes	04	--	**04**	04	--
Elective (DSE) (Any one from same Department/ School)	**SSTAE451**	Statistical Methods in Finance	04	--	**04**	04	--
	SSTAE452	Categorical Data Analysis					
	SSTAE453	Calculus					
	SSTAE454	NPTEL/SWAYAM MOOCs					
On Job Training	**SSTAO451**	ON Job Training	03	--	**03**	03	--
STA Practical	**SSTAP451**	Practical-II	--	03	**03**	--	06
Total Credits			**19**	**03**	**22**	**19**	**06**

M. Sc. First Year Semester II *(Level 6.0)*

Examination Scheme

[20% Continuous Assessment (***CA***) and 80% End Semester Assessment (***ESA***)]

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Avg of (T1+T2)/2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SSTAC451**	Regression Analysis	20	20	20	80	--	--	100
	SSTAC452	Statistical Inference	20	20	20	80	--	--	100
	SSTAC453	Stochastic Processes	20	20	20	80	--	--	100
Elective (DSE) (Any one from same Department/ School)	**SSTAE451**	Statistical Methods in Finance	20	20	20	80	--	--	100
	SSTAE452	Categorical Data Analysis							
	SSTAE453	Calculus							
	SSTAE454	NPTEL/SWAYAM MOOCs							
On Job Training	**SSTAO451**	ON Job Training	15	15	15	60	--	--	75
DSE Practical	**SSTAP451**	Practical-II	--	--	--	--	15	60	75

M. Sc. Second Year Semester III *(Level 6.5)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SSTAC501**	Design and Analysis of Experiments	04	--	**04**	04	--
	SSTAC502	Applied Multivariate Analysis	04	--	**04**	04	--
	SSTAC503	Machine Learning	04	--	**04**	04	--
Elective (DSE) (Any one from same Department/ School)	**SSTAE501**	Time Series Analysis	04	--	**04**	04	--
	SSTAE502	Industrial Statistics					
	SSTAE503	Decision Theory					
	SSTAE504	Mathematical Biology					
	SSTAE505	Statistical Methods in Epidemiology and Ecology					
	SSTAE506	NPTEL/SWAYAM MOOCs					
Research Project	**SSTAR551**	Research Project	04	--	**04**	04	
STA Practical	**SSTAP501**	Practical III	--	02	**02**	--	04
Total Credits			**20**	**02**	**22**	**20**	**04**

M. Sc. Second Year Semester III *(Level 6.5)*

Examination Scheme

[20% Continuous Assessment (***CA***) and 80% End Semester Assessment (***ESA***)]

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Avg of (T1+T2)/2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SSTAC501**	Design and Analysis of Experiments	20	20	20	80	--	--	100
	SSTAC502	Applied Multivariate Analysis	20	20	20	80	--	--	100
	SSTAC503	Machine Learning	20	20	20	80	--	--	100
Elective (DSE) (Any one from same Department/ School)	**SSTAE501**	Time Series Analysis	20	20	20	80	--	--	100
	SSTAE502	Industrial Statistics							
	SSTAE503	Decision Theory							
	SSTAE504	Mathematical Biology							
	SSTAE505	Statistical Methods in Epidemiology and Ecology							
	SSTAE506	NPTEL/SWAYAM MOOCs							
Research Methodology	**SVECR501**	Research Project	--	--	--	--	--	--	100
STA Practical	**SSTAP501**	Practical - III Clinical Trials	--	--	--	--	10	40	50

M. Sc. Second Year Semester IV *(Level 6.5)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SSTAC551**	Asymptotic Inference	04	--	**04**	04	--
	SSTAC552	Reliability and Survival Analysis	04	--	**04**	04	--
Elective (DSE) (Any one from same Department/ School)	**SSTAE551**	Operational Research	04	--	**04**	04	--
	SSTAE552	Clinical Trials					
	SSTAE553	Statistical techniques in Microarray Data Analysis					
	SSTAE554	Directional Data Analysis					
Publication Ethics	**SVECP551**	Publication Ethics	02	--	**02**	02	--
Research Project	**SSTAR552**	Research Project	06	--	**06**	06	--
STA Practical	**SSTAP551**	Practical - IV	--	02	**02**	--	04
Total Credits			**20**	**02**	**22**	**20**	**04**

M. Sc. Second Year Semester IV *(Level 6.5)*

Examination Scheme

[20% Continuous Assessment (***CA***) and 80% End Semester Assessment (***ESA***)]

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Avg of (T1+T2)/2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SSTAC551**	Asymptotic Inference	20	20	20	80	--	--	100
	SSTAC552	Reliability and Survival Analysis	20	20	20	80	--	--	100
Elective (DSE) (Any one from same Department/ School)	**SSTAE551**	Operations Research	20	20	20	80	--	--	100
	SSTAE552	Clinical Trials							
	SSTAE553	Statistical techniques in Microarray Data Analysis							
	SSTAE554	Directional Data Analysis							
Publication Ethics	**SVECP551**	Publication Ethics	10	10	10	40	--	--	50
Research Project	**SSTAR552**	Research Project	--	--	--	--	--	--	150
STA Practical	**SSTAP551**	Practical -IV	--	--	--	--	10	40	50

Abbreviations: Yr.: Year; Sem.: Semester; OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; Research Project: RP; Cumulative Credits: Cum. Cr.

Vide G.R. No. NEP-2022 /CR No. 09/VISHI-3 /शिकाना dated April 20, 2023, the Directive, covering the Credit distribution structure for Four Year UG Honours/ Honours with Research Degree Programme with Multiple Entry and Exit options, was issued. In continuation of Section 8 of this GR- 'Design of PG / Master's Programmes', the illustrative Table depicting the Credit Distribution for Two Year PG Programme with one Exit Option/ One Year PG Programme is as given below:

(a) With effect from Academic Year 2023-24, Two years Master's Degree Program will be revamped as per the Illustrative Credit Distribution given in the above Table.
(b) Credits offered per Semester will be a Minimum of 20 and a Maximum of 22. While minimum credits are mandatory as per National Credit Framework, the Universities can evolve the mechanism for providing Semester/ Level wise credit attainment flexibility within the broad framework.
(c) Under the One-year PG Diploma program, and two-year master's Degree program, the students must complete on-the-job training/internship of 03 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.
(d) The 3 Credits Research Methodology Component is mandatory in the First Year.
(e) Since the Master's Programme is based on DSC Specialization, the PG curricular framework will not include Minor Subject. Electives selected in the PG program may be Relevant to OR Supportive of the Major Subject chosen.
(f) The students will have to undertake a research project of 4 credits in Semester III and a research project of 6 credits in Semester IV in the second year of the two-year master's degree program. This is also applicable to the students admitted to one year PG program after completion of four years UG Program.
(g) Colleges already having permission and recognition for the PG degree programme along with UG degree programme in the same Major shall be automatically allowed to continue PG degree programme in the same Major without undergoing any additional procedures. Similarly, the colleges with approved PG programme and Ph.D. Research Centre in the same Major shall be automatically allowed to continue PG and Ph. D. Degree programme without undergoing any additional procedures.
(h) The exit option at the end of one year of the Master's degree program will commence from AY 2024-25. Students who have joined a two-year Master's degree program may opt for exit at the end of the first year and earn a PG Diploma.
(i) The PG Diploma may be awarded to a student provided they have earned the requisite credits in one year including on-the-job training of 03 credits during summer break, after completion of the second semester of the first year in the respective Major Subject.
(j) The one-year Master's Degree Program will begin with effect from Academic Year 2027-28.
(k) Re-entry to complete the PG degree, after taking the exit option, will be permissible up to 05 years from the date of admission to the PG program.

Detailed Semester-wise syllabus:

M.Sc. Statistics Third semester

	Course Code	Course Name	Credits Assigned		
			Theory	Practical	Total
Major	**SSTAC501**	Design and Analysis of Experiments	04	--	**04**
	SSTAC502	Applied Multivariate Analysis	04	--	**04**
	SSTAC503	Machine Learning	04	--	**04**
Elective (DSE) (Any one from same Department/ School)	**SSTAE501**	Time Series Analysis	04	--	**04**
	SSTAE502	Industrial Statistics			
	SSTAE503	Decision Theory			
	SSTAE504	Mathematical Biology			
	SSTAE505	Statistical Methods in Epidemiology and Ecology			
	SSTAE506	NPTEL/SWAYAM MOOCs			
Research Project	**SSTAR551**	Research Project	04	--	**04**
STA Practical	**SSTAP501**	Practical III	--	02	**02**
Total Credits			**20**	**02**	**22**

SSTAC501 DESIGN AND ANALYSIS OF EXPERIMENTS

(Maximum no. of periods 60)

Course pre-requisite:

- This course requires basic designs–CRD, RBD, LSD and their analyses, missing plot techniques in RBD and LSD.

Course objectives:

- To learn the basic principles in the design of simple experiments.
- To learn different tests for comparing pairs of treatment means, ANCOVA, factorial experiments, fractional factorial experiments, confounding, BIBD, PBIBD with solving real life examples.
- To learn the applications of different designs in agriculture.

Course outcomes: After completion of the course students will able to:

- **CO1:** Compare the pairs of treatment means using different methods when null hypothesis in rejected in ANOVA.
- **CO2:** Analyze the data using split plot, strip plot and general factorial experiments.
- **CO3:** Construct fractional factorial experiments and apply confounding in real life problems.
- **CO4:** Understand the analysis of BIBD, PBIBD, Quasi-Latin square, Youden square and cross over design and their applications in agriculture, business and industries.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Tests for comparing pairs of treatment means: Tukey's test, Fishers LSD test	
	1.2	Duncan's Multiple Range Test (DMRT)	
	1.3	Newman- Keul's test, Dunnet test	
	1.4	ANCOVA: One way and Two way classification.	
2.0			**15**
	2.1	Definition and analysis of split plot design	
	2.2	split-split plot design and Strip plot design	
	2.3	General factorial experiments, factorial effects	
	2.4	Study of 2^2, 2^3, 2^4 and 2^k factorial experiments.	
3.0			**15**
	3.1	Study of 3^2, 3^3 designs: Contrasts for linear and quadratic effects, statistical analysis of 3^k design	
	3.2	Fractional factorial experiments	
	3.3	Resolution III, IV and V of a design aberration of a design	
	3.4	Confounding in factorial experiments, complete and partial confounding	
4.0			**15**
	4.1	Elementary parametric relations and analysis of BIBD. Definitions and parametric relations of PBIBD	
	4.2	Definition and analysis of Quasi-Latin square designs	
	4.3	Youden square design	
	4.4	Cross-over designs	
		Total	**60**

Text books:

1. Montgomery, D.C. (2005) Design & Analysis of Experiments, Wiley.
2. Das, M.N. and Giri, N. (1979) Design and Analysis of Experiments, Wiley.
3. Joshi, D. D. (1987) Linear Estimation and Design of Experiments, John Wiley.
4. Cochran W.G. & Cox D.R.(1957) Experimental Designs, 2nd Ed., JohnWiley.

Reference Books:

1. Courant Alok Dey (1986) Theory of Block Designs, Wiley Eastern.
2. Chakrabarti M. C.(1962) Mathematics of Design and Analysis of Experiments, Asia Pub. Hs.
3. Dean A. M. & Voss D. (1999) Design and Analysis of Experiments, Springer.
4. Dey A. & Mukerjee R. (1999) Fractional Factorial Plans, John Wiley.
5. Dey A. (1986) Theory of Block Designs, Wiley Eastern.
6. John J.A. & Quenouille M.H. (1977) Experiments: Design and Analysis, Charles & Griffin.
7. Kempthorne, O. (1976) Design and Analysis of Experiments, John Wiley.
8. Khuri A.I. & Cornell J.A. (1996) Response Surface Designs and Analysis. 2nd Ed.,Marcel Dekker.
9. Raghavarao D. (1971) Construction and Combinatorial Problems in Design of Experiments, John Wiley.

SSTAC502 APPLIED MULTIVARIATE ANALYSIS

(Maximum no of periods: 60)

- **Course pre-requisite:** Basic of data types, Linear algebra, univariate statistical inference, probability distribution, estimation procedures and statistical hypotheses testing.

Course objectives:

- To learn and develop scientific view to deal with multidimensional datasets and its uses in the analysis of research data.
- To understand the extensions of univariate techniques to multivariate frameworks and learn to apply dimension reduction techniques used in the data analysis.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand multivariate normal distribution and their real life applications.
- **CO2:** Understand Wishart distribution, Hotelling T^2 and Mahalanobis D^2 statistic.
- **CO3:** Implement dimension reduction techniques for large size data using software on real life problems.
- **CO4:** Demonstrate knowledge and understanding of the basic ideas behind Discriminant and clustering analysis techniques with applications.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0			**15**
	1.1	Multivariate normal distribution, Marginal and conditional distribution	
	1.2	Singular and non-singular normal distribution	
	1.3	Characteristic function Multivariate normal distribution	
	1.4	Maximum likelihood estimators of the mean vector and covariance matrix.	
2.0			**15**
	2.1	Wishart Distribution: Wishart matrix- its distribution and properties	
	2.2	Distribution of sample generalized variance.	
	2.3	Hotelling's T^2 statistics and its distribution.	

	2.4	Application T^2 Statistics and its relationship with Mahalanobis D^2 Statistics.	
3.0			**15**
	3.1	Dimension reduction techniques: Principal components analysis	
	3.2	Factor analysis.	
	3.3	Canonical variables and canonical correlation–definition, use, estimation and computation.	
	3.4	Multivariate Analysis of Variance (MANOVA) of one and two–way classified data.	
4.0			**15**
	4.1	Cluster analysis	
	4.2	Classification and discrimination procedures for discrimination between two multivariate normal populations	
	4.3	Sample Discriminant function	
	4.4	Probabilities of misclassification and their estimation	
		Total	**60**

Text books:

1. Anderson T.W. (1983) An Introduction to Multivariate Statistical Analysis, 2nd Ed. Wiley.
2. Giri N.C. (1977) Multivariate Statistical Inference, Academic press.
3. Johnson and Wichern (1992) Applied multivariate Statistical Analysis, Prentice Hall 3rd Ed.
4. Bhuyan K.C. (2005) Multivariate Analysis and its application, New Central book age, Ltd. Kolkatta.
5. Kshirsagar A.M. (1972) Multivariate Analysis, Marcel Dekker.

Reference Books:

1. Morrison D.F. (1976) Mathematical Statistics Methods, 2nd Ed Mc-Graw Hill.
2. Rao.C.R.(2002) Linear Statistical Inference and Its Application 2nd Ed. Wiley.
3. Seber G. A. F. (1984) Multivariate observations Wiley.
4. Sharma S. (1996) Applied multivariate techniques Wiley.
5. Srivastava S. and Khatri C.G. (1979) An introduction to Multivariate Statistics, North Holland.
6. Roy S.N. (1987) Some Aspects of Multivariate Analysis John Wiley.
7. Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, J. Wiley.

SSTAC503 MACHINE LEARNING

(Maximum no. of periods = 60)

- **Course pre-requisite:** Basic of data types, Linear algebra, univariate statistical inference, probability distribution, estimation procedures and statistical hypotheses testing.

Course objectives:

- To learn various machine learning algorithms.
- To learn and able to implement various Machine learning algorithms in different situations.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** To be able to formulate machine learning problems corresponding to different applications.
- **CO2:** To understand a range of machine learning algorithms along with their strengths and weaknesses.
- **CO3:** To understand the basic theory underlying machine learning.
- **CO4:** To be able to apply machine learning algorithms to solve problems of moderate complexity.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Introduction: Well-Posed Learning Problems, Designing a Learning System. The Inductive Learning Hypothesis and Concept Learning as Search (definitions).	
	1.2	Machine Learning Basics: Learning Algorithms, Capacity, Over fitting and Under fitting, Hyper parameters and Validation Sets	
	1.3	No Free Lunch theorem, Estimators, Bias and Variance, Bayesian statistics	
	1.4	Supervised Learning Algorithms, Unsupervised Learning Algorithms, Stochastic Gradient Descent, Building a Machine Learning Algorithm and Issues in Machine Learning.	
2.0			**15**
	2.1	Decision Tree learning: Introduction, Decision tree representation, Appropriate problems for decision tree learning,	
	2.2	The basic decision tree learning algorithm, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.	
	2.3	Implementation aspects of the Decision Tree and Classification Example.	
3.0			**15**
	3.1	Instance-Based Learning: Introduction, k-Nearest Neighbour Learning,	
	3.2	Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Remarks on Lazy and Eager Learning	
	3.3	Support Vector Machines: Optimal Separation: The Margin and Support Vectors, a Constrained Optimization Problem, Slack Variables for Non-Linearly Separable Problems.	
	3.4	KERNELS: Choosing Kernels. The Support Vector Machine Algorithm and Multi-Class Classification. Case Study.	
4.0			**15**
	4.1	Genetic Algorithms: Motivation, Genetic Algorithms, Elitism, Tournaments, and Niching, Using Genetic Algorithms and An illustrative Example.	
	4.2	Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning, Parallelizing Genetic Algorithms	
	4.3	Reinforcement Learning: Introduction, the Learning Task, Q Learning, Non-Deterministic, Rewards and Actions	
	4.4	Temporal Difference Learning, Generalizing from Examples, Relationship to Dynamic Programming, Case study.	
		Total	

Text books:

1. Mitchell, T. M. (1997). Machine learning, McGraw-Hill
2. Marsland, S. (2011). Machine learning: an algorithmic perspective. Chapman and Hall/CRC.
3. Haroon, D.& Clustering, I. (2017). Python machine learning case studies. Apress.
4. Langley, P. (1995). Elements of Machine Learning, Morgan Kaufmann Series in Machine Learning

Reference Books:

1. Harrington, P. (2012). Machine learning in action. Manning Publications Co.
2. Duda, R. O., & Hart, P. E. (2006). Pattern classification. John Wiley & Sons.
3. Flach, P. (2012). Machine learning: the art and science of algorithms that make sense of data. Cambridge university press.

4. Satpathy, R., Choudhury, T., Satpathy, S., Mohanty, S. N. and Zhang, X. (2021).Data Analytics in Bioinformatics: A Machine Learning Perspective, Wiley

SSTAE501 TIME SERIES ANALYSIS

(Maximum no of periods: 60)

- **Course pre-requisite:** Basic of data types, organization and tabulation of data, Series, Correlation Analysis, regression analysis, Standard normal distribution, Chi Square test, Hypothesis testing etc.

Course objectives:

- To learn and develop scientific view to understand the time series data and its analysis.
- To learn stationary and non-stationary, and seasonal and non-seasonal time series models.
- Learn to estimate model parameters and compare different models developed for the same dataset in terms of their estimation and prediction accuracy.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand the concept of time series with its components and able to compute ACVF and ACF.
- **CO2:** Remove trend and seasonality using different methods to convert the time series into stationary.
- **CO3:** Apply auto regressive, moving average, ARMA, ARIMA models, Box-Jenkins approach to forecast time-series data empirically.
- **CO4:** Check and validate models with its residual analysis and diagnostic checking.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Time-series as discrete parameter stochastic process.	
	1.2	Auto covariance and autocorrelation functions and their properties.	
	1.3	Exploratory Time Series Analysis: Tests for trend and seasonally, Exponential and Moving average smoothing.	
	1.4	Holt winters smoothing. Forecasting based on smoothing, adaptive smoothing.	
2.0			**15**
	2.1	Stationary processes: (i) moving average (MA), (ii) Auto Regressive (AR),	
	2.2	(iii) ARMA and (iv) AR integrated MA (ARIMA) models, Box-Jenkins models.	
	2.3	Discussion, (without proof) of estimation of mean, auto covariance and auto correlation functions under large sample theory.	
3.0			**15**
	3.1	Choice of AR and MA periods,	
	3.2	Estimation of ARIMA models parameters, Forecasting	
	3.3	Residual analysis and diagnostic checking	
4.0			**15**
	4.1	Spectral analysis of weakly stationary process,	
	4.2	Periodogram and Correlogram analysis.	
	4.3	Spectral Decomposition of weakly AR process and representations as one sided MA process- necessary and sufficient conditions	
	4.4	Representations of one sided MA process- necessary and	

		sufficient conditions	
		Total	**60**

Text books:

1. Anderson, T. W (1971) The Statistical Analysis of Time Series, Wiley, N.Y.
2. Box, G.E.P. and Jenkins, G.M. (1976) Time Series Analysis-Forecasting and Control, Hodlen-day, San Francisco.
3. Montgomery, D. C. and Johnson, L. A. (1977) Forecasting and Time Series Analysis, McGraw Hill.
4. Fuller W.A. (1976) Introduction to Statistical time series, John Wiley N.Y
5. Nelson C.R. (1973) Applied Time Series for managerial forecasting, Holden –day.
6. Findley D.F.(1981) Applied Time Series analysis, Academic Press.

Reference Books:

1. Priestley M.B. (1981) Spectral analysis and time Series Griffin London.
2. Kendall M.G. And Stuart A. (1996) The advanced theory of Statistics, Vol. 3, Charles Griffin London.
3. Bloomfield P (1976) Fourier analysis of Time series – an introduction, Wiley.
4. Granger C.W. J and Hatanks (1964) Spectral analysis of economic Time Series, Princeton University Press N.J.
5. Koopmens C.R. (1973) The Spectral analysis of time series, Academic presses.
6. Brockwell P.J. and Davis R.A. (1991) Time Series: Theory and Methods, 2nd Ed.,Springer-Verlag.
7. Kendall, Sir Maurice and Ord. J. K. (1990) Time Series, 3rd Ed., Edward Arnold.
8. Wethirll G.B. (1986) Regression analysis with applications, Chapman Hall.

SSTAE502 INDUSTRIAL STATISTICS

(Maximum no. of periods 60)

- **Course pre-requisite:** Basic of data types, organization and tabulation of data, graphical representation, data transformation, distribution theory and sampling methods.

Course objectives:

- To develop scientific view to analyze the industrial data about specific perspective.
- To learn the statistical quality control techniques used in industries such as control charts, acceptance sampling plans etc.
- To learn some advanced control charts, capability indices and the concept of six-sigma.

Course Outcomes: After completion of the practical students will able to:

CO1: Understand basic of production process monitoring and apply concept of control charts on it.
CO2: Apply the acceptance and continuous sampling plans in production process.
CO3: Compute capability indices and understand the concept of six sigma,Taguchi design.
CO4: Know and apply the concept of weighted control charts, ISO: 9000 series standards.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			
	1.1	Basic concepts of process monitoring and control.	**15**
	1.2	Review of control charts for attributes and variable data.	
	1.3	O. C. and ARL of control charts.	
	1.4	CUSUM & V-masks charts.	
2.0			**15**

	2.1	Concepts of AQL, LTPD, AOQL average amount of inspection and ASN functions.	
	2.2	Acceptance sampling plans for attributes inspection,	
	2.3	single, double and sequential sampling plans and their properties.	
	2.4	Continuous sampling plans of Dodge type and their properties.	
3.0			
	3.1	Capability indices Cp, Cpk and Cpm, estimation,	**15**
	3.2	confidence intervals and tests of hypothesis relating to capability indices for normally distributed characteristics	
	3.3	Concept of six sigma.	
	3.4	Total Quality management. Taguchi Design	
4.0			
	4.1	The weighted control charts: Exponential Weighted Moving Average chart	**15**
	4.2	Multivariate SPC: Multivariate quality control problem, description of Multivariate data	
	4.3	The Hotelling T^2 control chart, Multivariate EWMA control chart, regression adjustment, Latent structure methods.	
	4.4	Quality Systems: ISO 9000 standards,	
		Total	**60**

Text books:

1. Montgomery D.C. (1996) Introduction to Statistical Quality Control, Wiley.
2. Mahajan M. (2004) Statistical Quality Control. Dhanpat Rai & Co.
3. Oakland J.S. (1989) Total Quality Management; Butterworth- Heinemann.

Reference Books:

1. Wetherill G.B. (1977) Sampling Inspection & Quality Control, Halsted Press.
2. Logothetis N. (1992) Managing Total Quality, Prentice Hall of India.
3. Mittog H.J. and Rinne H. (1993) Statistical Methods of Quality Assurance.
4. Guenther W.C (1981) Sampling Inspection in Statistical Quality Control Charter Grifits.
5. Kotz S. (1993) Process capability indices, Chapman and Hall.
6. Abraham Bovas (1998) Quality Improvement through statistical methods, Birkhauser.

SSTAE503 DECISION THEORY

(Maximum no of periods: 60)

- **Course pre-requisite:** Basics of data types, distribution theory etc**.**

Course objectives:

- To learn various decision rules theories and its applications of decision making as individuals, in groups, and in organizations.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand decision problem, loss function, risk function and decision rules.
- **CO2:** Understand the concept of admissibility and completeness.
- **CO3:** Implement nonparametric statistical tests.
- **CO4:** Apply two sample problems on real life examples.

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Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Decision problem, loss function, risk function, randomized and non-randomized decision rule.	
	1.2	Decision principles (Conditional Bayes, Frequentist).	
	1.3	Testing and estimation problem as decision problems.	
	1.4	Optimal decision rule.	
2.0			**15**
	2.1	Concept of admissibility and completeness,	
	2.2	Bayes rules, minimax decision rule.	
	2.3	Admissibility of Bayes rules.	
	2.4	Existence of Bayes decision rule.	
3.0			**15**
	3.1	Definition of non-parametric test, advantages and disadvantages of nonparametric tests.	
	3.2	Single sample problems. (i) Test of randomness (ii) Tests of goodness of fit: Empirical distribution function. Kolmogorov-Smirnov test, comparison of Chi-square and KS test	
	3.3	(iii) Problem of location: Sign test, Wilcoxon's signed rank test,	
	3.4	Wilcoxon paired sample signed rank test.	
4.0			**15**
	4.1	Two Sample Problems: Different types of alternative, sign test,	
	4.2	Wilcoxon two sample rank sum test, Wald-Wolfiwitz run test, Mann-Whitney-Wilcoxon test, median test. K-S two sample test.	
	4.3	One sample U statistic, Kernel and symmetric Kernel, variance of U statistic,	
	4.4	Two sample U statistics, linear rank statistics and their distribution properties under null hypothesis	
		Total	**60**

Text books:

1. Ferguson T. S. (1967) Mathematical Statistics, Academic Press, New York.
2. Fraser, D.A.J. (1957) Non-parametric methods in Statistics, John Wiley.
3. Goon A.M., Gupta M.K., Dasgupta: An Outline of Statistical Inference. The World Press Pvt. Ltd.
4. Berger, J.O. (1980) Statistical Decision Theory: Foundations, Concepts and Methods, Springer-Verlag.

Reference Books:

1. Berger, J.O. (1985) Statistical Design Theory and Bayesian Analysis, 2nd ed., Springer-Verlag.
2. Gupta S. S. and Huang, D. (1981) Multiple Statistical Decision Theory, Springer- Verlag, New York.

SSTAE504 MATHEMATICAL BIOLOGY

(Maximum no of periods: 60)

Course pre-requisite: Basic of data types, stochastic processes etc.

Course objectives:

- To learn the theory of mathematical modeling and its applications in the analysis of biological systems including populations of molecules, cells and organisms.

- To develop skills in mathematical modeling.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand linearization of dynamical systems with various dimensions.
- **CO2:** Understand translation properties and various criterions.
- **CO3:** Describe single and multi-species population growth models.
- **CO4:** Apply the concept of deterministic and stochastic models on simple and general epidemics.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Linearization of dynamical systems (two, three, and higher dimensions),	
	1.2	Stability theory: (a) asymptotic stability (Hartman's theorem),	
	1.3	(b) Global stability (Liapunov's direct method).	
	1.4	Translation property,	
2.0			**15**
	2.1	limit sets, attractors, periodic orbits, limit cycles and separatrix,	
	2.2	Bendixon criterion, Dulac criterion,	
	2.3	Poincare-Bendixon theorem,	
	2.4	Bifurcation: saddle-node, transcritical, pitchfork, Hopf.	
3.0			**15**
	3.1	Single, and multispecies population growth models,	
		predator-prey models, competition models, models on mutualism, food chain models, time delay models,	
	3.2	Phytoplankton-zooplankton models. Fick's law, Turing pattern, diffusion driven instability,	
	3.3	Population dynamics models with self and cross diffusion.	
4.0			**15**
	4.1	Deterministic, and stochastic models on simple epidemics,	
	4.2	general epidemics, pure birth-death process, simple models on spatial spread of epidemics, recurrent epidemics models.	
	4.3	Models on malaria, HIV, AIDS, Dengue.	
	4.4	Basic concepts on eco-epidemiological systems.	
		Total	**60**

Text books:

1. D. N. Jordan and P. Smith (1998): Nonlinear ordinary equations-an introduction to dynamical systems (3rd ed)
2. H. I. Freedman (1990): Deterministic mathematical models in population ecology (pure and applied mathematics)
3. Mark Kot (2001): Elements of mathematical ecology.
4. Murray J.D.. Mathematical Biology. Springer-Verlag.
5. Eric Renshaw (1990): Modelling biological population in space and time.
6. Leah Edelestin-Keshet (2005): mathematical models in biology.
7. N. T. J. Bailey (1975): The mathematical theory of infectious diseases and its applications.
8. Alon, U. (2007). An introduction to systems biology: Design principles of biological circuits. Chapman & Hall.
9. Jones D.S. & Sleeman B.D. (2010). Differential Equations and Mathematical Biology. Chapman & Hall.
10. Strogatz, S.H,. Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering. Addison-Wesley.
11. Leah Edelstein-Keshet (2005). Mathematical Models in Biology. SIAM.
12. Nicholas Britton. Essential Mathematical Biology. Springer.

Reference Books:

1. Roy M Anderson and Robert M May (1991): Infectious diseases of humans: dynamics and control.
2. Horst Malchow, Sergei V Petrovoski, and Ezio Venturino (2008): Spatiotemporal patterns in ecology and epidemiology: theory, models and simulations.
3. L. Perko (1991): Differential equations and dynamical systems.
4. Glendinning, P. (1995). Stability, Instability and Chaos. Cambridge.
5. De Vries G., Hillen G., Lewis M., Müller J. and Schonfisch B. (2006). A Course in Mathematical Biology: Quantitative Modeling with Mathematical & Computational Methods. SIAM.

SSTAE505 STATISTICAL METHODS IN EPIDEMIOLOGY AND ECOLOGY

(Maximum no of periods: 60)

Course pre-requisite: Basics of data types, organization and tabulation of data etc. Much of this course deals with extensions of regression modelling to handle categorical response variables, so students should be comfortable with multiple regression modeling.

Course objectives:

- To learn different methods of carrying out and analysing, epidemiological studies.
- To study pertinent issues such as appropriate design, data quality, analysis, and interpretation and presentation of results in environmental studies.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand the basic epidemiology, parametric growth models and single species growth models.
- **CO2:** Understand effect of measurement errors on growth rate and related inference problems.
- **CO3:** Understand the concept of demographic and environmental stochasticity.
- **CO4:** Understand mathematical models of infectious diseases in stochastic environment.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Introduction to dynamical models in ecology and epidemiology,	
	1.2	Introduction to parametric growth models, Single species growth models -exponential, logistic, extended logistic, Gompertz etc.:	
	1.3	notion of density dependent and independent growth, asymmetry in growth dynamics,	
	1.4	The notion of growth rate metric and its extension, distribution of growth rate and its asymptotics..	
2.0			**15**
	2.1	Effect of measurement errors on growth rate and related inference problems,	
	2.2	Longitudinal data and growth curve analysis, goodness-of-fit test for growth curve models,	
	2.3	profile likelihood, nonlinear growth models and asymptotics,	
	2.4	Resampling techniques in growth curves. Stochastic extension of growth models.	
3.0			**15**
	3.1	Concept of demographic and environmental stochasticity,	
		notion of stochastic stability and related statistical diagnostics in population dynamics.	
	3.2	Concepts of equilibrium and quasi equilibrium distribution and its	

		moments,	
	3.3	Concept of Allee effects and association extinction dynamics, simple extension to interactive population dynamics.	
4.0			
	4.1	Mathematical models of infectious disease in stochastic environment,	**15**
	4.2	Concept of stochastic SI, SIR epidemic models	
	4.3	SIS epidemic models,	
	4.4	Estimation of basic reproduction number and time to extinction of disease, likelihood based inferences	
		Total	**60**

Text books:

1. Panik Michael, J. (2015) Growth Curve modeling: Theory and Applications by, Wiley.
2. M. Henry H. Stevens (2009) A primer in ecology with R by, Springer.
3. Ludwig and Reynolds (1988) Statistical Ecology: A primer in methods and computing by, John Wiley and Sons.

Reference Books:

1. Benjamin M. Bolker (2006) Ecological Models and Data in R by, Princeton University press.
2. F. Courchamp, L. Berec, and J. Gascoigne (2008) Allee effects in Ecology and Conservation.
3. Seber and Wild (2003) Nonlinear Regression, Wiley series in probability and statistics.
4. Jewell NP (2004). Statistics for epidemiology. London: Chapman & Hall/CRC Press.
5. Clayton D, Hills M (1993). Statistical models in epidemiology. Oxford: Oxford Science Publications.
6. Woodward M (1999). Epidemiology: Study design and data analysis. London: Chapman & Hall/CRC.

SSTAE506 NPTEL/SWAYAM MOOCs

SSTAR551 RESEARCH PROJECT

(60 Hours)

Course pre-requisite: Basics of data collection, tabulation and analysis of data.

Course objectives:

- It aims to provide necessary practical knowledge and hands-on experience in the application of Statistical tools to solve real-world problems.

Course Outcomes: After completion of the research project students will able to:

- **CO1:** Collect real world datasets.
- **CO2:** Apply various statistical tools to different societal problems.
- **CO3:** Interpret the results and its output to the end user.
- **CO4:** Explore himself / herself in competitive corporate environment.

In this course, there should be a supervisor from the organization/Institute from which the Research Project is being done.

The objectives of Research Project in Statistics are as follows:

1. A student is expected to spend not less than 60 working hours for Research Project and related activities.
2. Students are expected to gain the practical knowledge under the mentoring of personnel available therein.
3. Research Project will be carried out throughout the semester upto semester-end examination.
4. Students need to form a group of 2-4 members in each group.
5. Continuous evaluation of the students' performance in the Research Project will be carried out during the semester.

Evaluation: Students' performance will be evaluated for 100 marks (04 credits):

External/ End Semester Evaluation: 100 marks, out of which 50 marks will be for submitted report of research project and 50 marks for oral presentation/viva-voce examination.

M.Sc. Statistics Fourth semester

	Course Code	Course Name	Credits Assigned		
			Theory	Practical	Total
Major	**SSTAC551**	Asymptotic Inference	04	--	**04**
	SSTAC552	Reliability and Survival Analysis	04	--	**04**
Elective (DSE) (Any one from same Department/ School)	**SSTAE551**	Operational Research	04	--	**04**
	SSTAE552	Clinical Trials			
	SSTAE553	Statistical techniques in Microarray Data Analysis			
	SSTAE554	Directional Data Analysis			
Publication Ethics	**SVECP551**	Publication Ethics	02	--	**02**
Research Project	**SSTAR552**	Research Project	06	--	**06**
STA Practical	**SSTAP551**	Practical - IV	--	02	**02**
Total Credits			**20**	**02**	**22**

SSTAC551 ASYMPTOTIC INFERENCE

(Maximum no. of periods: 60)

Course pre-requisite: Basics of statistical inference, distribution theory, Series (Taylor Series Expansion), probability theory, testing of hypothesis. The knowledge about construction of point and interval estimators, and hypothesis testing; and the evaluation of these estimators and tests.

Course objectives:

- To develop generalization aspect of inferential theory.
- To get familiarise with the theories and methods of asymptotic inference.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand the concept of consistency and asymptotic normality.
- **CO2:** Understand method of moments and percentiles, maximum likelihood to find consistent estimator and Cramer Huzurbazar theorem.
- **CO3:** Apply likelihood ratio tests, Wald, Score and Bartlett's test in real life situations.
- **CO4:** Compare various tests through relative asymptotic efficiency.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Consistent estimator, joint and marginal consistency, invariance property of consistency.	
	1.2	Consistency and asymptotic normality (CAN) of real and vector parameters.	
	1.3	Invariance of consistency under continuous transformation.	
	1.4	Invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem.	
2.0			**15**
	2.1	Method of moments and percentiles,	
	2.2	Method of percentiles,	
	2.3	method of maximum likelihood,	
	2.4	Special cases such as exponential class of densities and multinomial distribution,	
3.0			**15**
	3.1	Cramer-Huzurbazar theorem, method of scoring. Likelihood ratio tests,	
	3.2	asymptotic distribution of log likelihood ratio,	
	3.3	Wald Test, Score Test,	
	3.4	Bartlett's test for homogeneity of variances.	
4.0			**15**
	4.1	Pearson's chi-square test and LR test.	
	4.2	Asymptotic comparison of tests.	
	4.3	Asymptotic Relative Efficiency (Pitman's),	
	4.4	asymptotic normality of posterior distributions.	
		Total	**60**

Text books:

1. Kale B.K. (2005) A First Course on Parametric Inference, Second Edition, Narosa.
2. Ferguson, T.S. (1996) A Course in Large Sample Theory, Chapman and Hall.
3. Casella G. & Beregar R.L.(2002) Statistical Inference, 2nd edition, Duxbury Advanced series.
4. M K Srivastava, A H Khan, N Srivastava (2014) Statistical Inference :Theory of Estimation 1st ed. Phi learning; 1st edition
5. Srivastava , Manoj Kumar (2009) Statistical Inference: Testing of Hypotheses, Prentice Hall India Learning Private Limited.
6. Rajagopalan (2012) Statistical Inference, Prentice Hall India Learning Private Limited.
7. Kartick Chandra Bhuyan (2010) Probability Distribution Theory and Statistical Inference, New Central Book Agency.

Reference Books:

1. Cramer, H.(1974) Mathematical Methods in Statistics, Princeton Univ. Press.
2. Rao,C.R.(1995) Linear Statistical Inference and its Applications,Wiley Eastern Ltd.
3. Silvey, S. D.(1975) Statistical Inference, Chapman- Hall.
4. Wilks, S.S.(1962) Mathematical Statistics, John Wiley.
5. Dudewicz E.J. & Mishra S.N.(1988): Modern Mathematical Statistics, Wiley Series
6. Rohatgi V.K.(2001): Introduction to Probability and Mathematical Statistics, Wiley.
7. Zacks S. (1971) Theory of Statistical Inference John Wiley and Sons, New York.

SSTAC552 RELIABILITY AND SURVIVAL ANALYSIS

(Maximum no of periods: 60)

Course pre-requisite: Basic of data types, organization of data, Distribution theory.

Course objectives:

- To learn the reliability theory and analysis of survival data.
- To distinguish censored and uncensored data.
- To visualize and communicate time-to-event data, to fit and interpret failure time model.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand the elements of reliability, hazard function and its applications.
- **CO2:** Understand the concept of censoring, life distributions and ageing classes.
- **CO3:** Estimate nonparametric survival function of the data.
- **CO4:** Explain test of exponentiality against nonparametric classes, two sample problems.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Elements of Reliability, definition and relationship between survival function,	
	1.2	hazard function, distribution with IFR and DFR,	
	1.3	series, parallel, k out of n: G, coherent systems	
	1.4	Life testing experiments, stress–strength reliability and its estimation.	

2.0			
	2.1	Basic concepts of Time, Order and Random Censoring.	**15**
	2.2	Life distributions - Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate.	
	2.3	Parametric inference Point estimation,	
	2.4	Confidence intervals, mean residual life and their elementary properties.	
3.0			
	3.1	Ageing classes - IFR, IFRA, NBU, NBUE, HNBUE and their duals,	**15**
	3.2	Bathtub Failure rate.	
	3.3	Estimation of survival function - Actuarial Estimator,	
	3.4	Kaplan-Meier Estimator, Estimation under the assumption of IFR/DFR.	
4.0			
	4.1	Tests of Exponentiality against non-parametric classes - Total time on test,	**15**
	4.2	Deshpande test. Two sample problem - Gehan Test, Log rank test. Mantel-Haenszel Test, Tarone-Ware tests	
	4.3	Semi-parametric regression for failure rate	
	4.4	Cox's proportional hazards model with one and several covariates.	
		Total	**60**

Text books:

1. Cox, D.R. and Oakes, D. (1984) Analysis of Survival Data, Chapman and Hall, New York.
2. Elandt - Johnson, R.E. Johnson N.L. (1980) Survival models and Data Analysis, John Wiley.
3. Miller, R.G. (1981) Survival Analysis, Wiley.
4. Zacks, S. Reliability.
5. Deshpande, J.V. and Purohit, S.G. (2005). Life Time Data: Statistical Models and Methods, Word Scientific.
6. Hanagal, D. D. (2011). Modeling Survival Data Using Frailty Models. CRC Press.

Reference Books:

1. Gross A.J. and Clark, V. A. (1975) Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
2. Collett, D. (2003). Modelling Survival data in Medical Research, Second Edition, Chapman & Hall/CRC
7. Hougaard, P. (2000). Analysis of Multivariate Survival Data. Springer: New York.
8. Kalbfleish, J. D. and Prentice, R. L. (2002). The Statistical Analysis of Failure Time Data. New York: Wiley.
9. Klein, J. P. and Moeschberger, M. L. (1997). Survival Analysis: Techniques for Censored and Truncated Data, Springer, New York
10. Liu Xan (2012). Survival Analysis: Models and Applications, Wiley.
11. Moore, D. F. (2016). Applied Survival Analysis Using R, Springer
12. Therneau, T. M. and Grambsch, P. M. (2000). Modeling Survival Data, Extending the Cox Model, Springer, New York.

SSTAE551 **OPERATIONAL RESEARCH**

(Maximum no. of periods = 60)

Course prerequisite: Basic knowledge of linear algebra, distribution theory and linear programming.

Course objectives:

- To learn advanced methods in operations research courses that are used in the systems approach to Engineering and Management, so as to provide them with the requisite tools for the mathematical representation of decision-making problems, in particular emphasizing the roles of uncertainty and risk.

Course Outcomes: After completion of the practical students will able to:

CO1: Understand and solve real life problems using linear programming, duality and sensitivity problems.
CO2: Understand Transportation and assignment problems, theory of games and PERT/CPM.
CO3: Understand and use Integer programming problems. Dynamic programming in multistage solution problems.
CO4: Understand and deal with inventory problems with and without shortages.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Introductions to Linear programming problems (LPP), General LPP and its Mathematical Formulation, Graphical method for solution, solution of linear programming problem, some important theorems.	
	1.2	Theory of Simplex methods: Introduction, slack and surplus variables, Fundamental theorems of linear programming, optimality of solutions.	
	1.3	Artificial variable technique. Duality, Dual simplex method.	
	1.4	Revised simplex method and sensitivity analysis.	
2.0			**15**
	2.1	Transportation problem, finding an initial basic feasible solution, test of optimality, degeneracy, MODI method, stepping stone method	
	2.2	Assignment problem, mathematical formulation, assignment method (Hungarian), special cases in assignment problem, traveling salesman problem	
	2.3	Competitive game, two person zero sum game, rectangular game, solution of game, saddle point, solution of a rectangular game with saddle point.	
	2.4	PERT-CPM, product planning control with PERT-CPM.	
3.0			**15**
	3.1	Integer Linear Programming Problem (ILPP): The concept of cutting plane, Gomory's method of cutting plane for all ILPP	
	3.2	Mixed ILPP, Branch and Bound method.	
	3.3	Dynamic programming: The Recursive equation approach,	
	3.4	Characteristics and algorithm	
4.0			**15**
	4.1	Inventory models: Inventory problems and their analytical structure.EOQ, deterministic models of inventory control.	
	4.2	Inventory (S,s) policy periodic review models with stochastic demand.	
	4.3	Probabilistic reorder point,	
	4.4	Lot size inventory system.	
		Total	**60**

Text books:

1. Kantiswaroop, P.K.Gupta and Manmohan, Operations Research, Sultan Chand & Sons, New Delhi.
2. G.Hadley, Linear Programming, Narosa publishing House, 1995.
3. G.Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
4. H.A.Taha, Operations Research - An Introduction, Macmillan Publishing Company, Inc, New York.
5. P. K. Gupta and D. S. Hira, Operations Research – A Introduction. S. Chand & company Ltd, New Delhi.

Reference Books:

1. R. K. Gupta "Linear Programming",Krishna Prakashan Mandir.
2. S.S.Rao, Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
3. F.S.Hillier and G.J.Liebermann,(1995) Introduction to Operations Research (6th Ed.) Mc Graw Hill.
4. N. S. Kambo, Mathematical Programming Techniques. Affiliated East-West Press Pvt. Ltd, New Delhi.

SSTAE552 CLINICAL TRIALS

(Maximum no of periods: 60)

Course pre-requisite: Basics of data types, data collection and design of experiment.

Course objectives:

- To learn and develop scientific view to study the statistical challenges of clinical comparison of two or more treatments in human subjects.
- To Aware of the use of the cross-over design and its limitations.

Course Outcomes: After completion of the practical students will able to:

CO1: Understand need and ethics of clinical trials.
CO2: Apply various designs of clinical trials to the data.
CO3: Describe optimal cross-over designs experiment with a continuous normally distributed outcome.
CO4: Understand designs based on clinical endpoints, drug interaction study.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Introduction to clinical trials: need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials,	
	1.2	overview of Phase I-IV trials, multicenter trials. Data management: data definitions, case report forms, database design,	
	1.3	data collection systems for good clinical practice. Bioavailability, pharmacokinetics and pharmaco-dynamics,	
	1.4	Two-compartment model.	
2.0			**15**
	2.1	Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, objectives and endpoints of clinical trials, design of Phase I trials,	
	2.2	design of single-stage and multi-stage Phase II trials.	
	2.3	Design and monitoring of Phase III trials with sequential	

		stopping, design of bio-equivalence trials.	
	2.4	Inference for 2x2 crossover design: Classical methods of interval.	
3.0			
	3.1	Power and sample size determination, multiplicative (or log-transformed) model, ML method of estimation, assessment of inter and intra subject variabilities, detection of outlying subjects.	**15**
	3.2	Optimal crossover designs: Balaam's design, Two sequence dual design. Optimal four period designs.	
	3.3	Assessment of bioequivalence for more than two drugs, Williams design.	
4.0			
	4.1	Designs based on clinical endpoints: Weighted least squares method, log-linear models, generalized estimating equations.	**15**
	4.2	Drug interaction study, dose proportionality study, steady state analysis.	
	4.3	Interim analysis and group sequential tests, alpha spending functions.	
	4.4	Analysis of categorical data.	
		Total	**60**

Text Books:

1. Chow S.C. and Liu J.P.(2009). Design and Analysis of Bioavailability and bioequivalence. 3rd Edn. CRC Press.
2. Chow S.C. and Liu J.P. (2004). Design and Analysis of Clinical Trials. 2nd Edn. Marcel Dekkar.
3. Fleiss J. L.(1989). The Design and Analysis of Clinical Experiments. Wiley.
4. Friedman L. M.Furburg C. Demets D. L.(1998). Fundamentals of Clinical Trials, Springer.

Reference Books:

1. Jennison .C. and Turnbull B. W. (1999). Group Sequential Methods with Applications to Clinical Trails, CRC Press.
2. Marubeni .E. and Valsecchi M. G. (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley.

SSTAE553 STATISTICAL TECHNIQUES IN MICROARRAY DATA ANALYSIS

(Maximum no of periods: 60)

Course pre-requisite: Basic of statistical inference, parametric-non parametric tests, multivariate analysis and a very basic knowledge of R statistical language.

Course objectives:

To learn and develop problem formulations that may be answered by microarray analysis.

Course Outcomes: After completion of the practical students will able to:

- **CO1:** Understand and setup for microarray experiments and quantification.
- **CO2:** Understand statistical inference procedures in comparative experiments for single channel microarray data.
- **CO3:** Formulate multiple hypotheses testing problems that can be addressed by microarray data analysis.
- **CO4:** Apply hierarchical cluster analysis in microarray data.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			
	1.1	Background of Microarrays and Normalization techniques	**15**
	1.2	Introduction to Biology relevant to microarray experiment.	

		Microarray experimental set up and quantification of information available from microarray experiments.	
	1.3	Data cleaning, transformation of data. Between array & within array normalization, in particular quantile and LOWESS normalization, stage wise normalization.	
	1.4	Concordance coefficient and its role.	
2.0			
	2.1	Statistical Inference procedures in comparative experiments for single channel microarray data.	
	2.2	Application of two sample t –test. Tests for validating assumptions of two sample t-test. Application of Welch test and Wilcoxon rank sum test. Inference procedures for two channel microarray data. Application of paired t –test. Tests for validating assumptions of paired t test.	**15**
	2.3	Application of Wilcoxon signed rank test. Inference procedures for comparing more than two types of mRNA samples in single channel or two channel microarray experiments.	
	2.4	Application of one way ANOVA F test, one way ANOVA Welch F test, Kruskal-Wallis test, pairwise t-test, pairwise Welch test and pairwise Wilcoxon rank sum test. Strip charts and its role to decide the profile of differentially expressed genes.	
3.0			
	3.1	Multiple hypotheses testing problem and Principal component analysis, Multiple hypotheses testing problem.	
	3.2	Adjustments for multiple hypotheses testing, adjusted p-values. False discovery rate.	**15**
	3.3	Principal component analysis for microarray data, scree plot, plot of scores to rectangular matrix and the concept of ballot. Its application to microarray data analysis.	
4.0			
	4.1	Hierarchical cluster analysis of microarray data to identify groups of genes and	
	4.2	Outlying genes K-means cluster analysis of microarray data to identify groups of genes.	**15**
	4.3	Application of logistic regression for microarray data..	
	4.4	Concept of AIC and BIC and its role to identify marker genes	
		Total	**60**

Text books:

1. Amartunga D. and Cabrera J. (2004). Exploration and Analysis of DNA Microarray and Protein Array Data. Wiley.
2. Deshmukh S.R. and Purohit S.G. (2007). Microarray Data: Statistical Analysis Using R, Narosa.
3. Draghici, S. (2003). Data Analysis Tools for DNA Microarrays, Chapman and Hall/CRC.

Reference Books:

1. Dov, S. (2003). Microarray Bioinformatics, Cambridge University Press.
2. McLachlan, G.J., Do, K.A. and Ambroise, C. (2004). Analyzing Microarray Gene Expression Data, Wiley.
3. Simon, R.M ,Korn, E.L., McShane, L.M. ,Radmacher, M.D. Wright, G.W. and Zhao, y. (2003). Design and Analysis of DNA Microarray Investigations. Springer.
4. Speed, T. (2003). Statistical Analysis of Gene Expression Microarray Data, Chapman and Hall/CRC.

SSTAE554 **DIRECTIONAL DATA ANALYSIS**

(Maximum no. of periods: 60)

- **Course pre-requisite:** Basic of data types, organization and tabulation of data, distribution theory and methods of estimation etc.

Course objectives:

To learn understanding of data analysis using statistics computational tools on problems of applied nature.

Course Outcomes: After completion of the practical students will able to

CO1: Visualize the large data-set effectively.
CO2: Understand circular models and concepts of some advanced distributions.
CO3: Understand the methods of estimation.
CO4: Apply nonparametric methods to real life problems.

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1	Graphical representation of data,	
	1.2	Frequency distribution, Measures of location, circular variance and concentration,	
	1.3	Correction for mean grouping,	
	1.4	Measures of skewness and kurtosis.	
2.0			**15**
	2.1	Circular models, distribution theory, independence, convolution, moments,	
	2.2	distributions of an arc, mixtures, lattice distributions, wrapped normal, Cauchy, Poisson distributions,	
	2.3	Von Mises, Fisher distribution characteristics functions, Polar distributions, isotropic random walk on the circle.	
3.0			**15**
	3.1	Point estimation,	
	3.2	Cramer Rao type bound, sufficiency, Methods of estimation.	
		Testing hypothesis from parametric models. Neyman-Pearson and likelihood ratio principles	
4.0			**15**
	4.1	Non-parametric methods: Tests for randomness, goodness of fit, Rayleigh's test.	
	4.2	Durand and Greenwood's test, Range test, Kuper's test, Watson's test, Uniform score tests,	
	4.3	Runs test, Rank sum test, Test for dispersion.	
		Total	**60**

Text Book:

1. Mardia K.V. (1972): Statistics of Directional data, Academic Press.
2. Batschelet E. (1981): Circular Statistics in Biology, Academic Press.

Reference Books:

1. Watson G. S. (1983): Statistics on Spheres, Wiley.

SVECP551 **PUBLICATION ETHICS**

(Maximum no. of periods: 30)

Course pre-requisite:

Course objectives:

Course Outcomes: After completion of the practical students will able to

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0			**15**
	1.1		
	1.2		
	1.3		
	1.4		
2.0			**15**
	2.1		
	2.2		
	2.3		
3.0			**15**
	3.1		
	3.2		
4.0			
	4.1		**15**
	4.2		
	4.3		
		Total	**60**

Text Book:

Reference Books:

SSTAR552 RESEARCH PROJECT

(90 Hours)

Course pre-requisite: Basics of data collection, tabulation and analysis of data.

Course objectives:

- It aims to provide necessary practical knowledge and hands-on experience in the application of Statistical tools to solve real-world problems.

Course Outcomes: After completion of the research project students will able to:

- **CO1:** Collect real world datasets.
- **CO2:** Apply various statistical tools to different societal problems.
- **CO3:** Interpret the results and its output to the end user.
- **CO4:** Explore himself / herself in competitive corporate environment.

In this course, there should be a supervisor from the organization/Institute from which the Research Project is being done.

The objectives of Research Project in Statistics are as follows:

1. A student is expected to spend not less than 90 working hours for Research Project and related activities.
2. Students are expected to gain the practical knowledge under the mentoring of personnel available therein.
3. Research Project will be carried out throughout the semester upto semester-end examination.
4. Students need to form a group of 2-4 members in each group.
5. Continuous evaluation of the students' performance in the Research Project will be carried out during the semester.

Evaluation: Students' performance will be evaluated for 150 marks (06 credits):

External/ End Semester Evaluation: 150 marks, out of which 100 marks will be for submitted report of research project and 50 marks for oral presentation/viva-voce examination.

Practical Courses

The practical based on the core courses will be taken accordingly.

Semester I: SSTAP401 (3 Credit)

Semester II: SSTAP451 (3 Credit)

Semester III: SSTAP501 (2 Credit)

Semester IV: SSTAP551 (2 Credit)

Guidelines for Course Assessment:

A. Continuous Assessment (CA) (20% of the Maximum Marks):

This will form 20% of the Maximum Marks and will be carried out throughout the semester. It may be done by conducting **Two Tests** (Test I on 40% curriculum) and **Test II** (remaining 40% syllabus). Average of the marks scored by a student in these two tests of the theory paper will make his **CA** score (col. 6).

B. End Semester Assessment (80% of the Maximum Marks):

1. **ESA Question paper will consists of 6 questions, each of 20 marks.**
2. **Students are required to solve a total of 4 Questions.**
3. **Question No.1 will be compulsory and shall be based on entire syllabus.**
4. Students need to solve **ANY THREE** of the remaining Five Questions (Q.2 to Q.6) and shall be based on entire syllabus.
5. Practical examination will be based on End semester examination.

N.B.: *As per above mentioned guidelines of course assessment **A** and **B** the respective split for 3 credit theory course too. Only there is small change in the question paper pattern in B (4) is: Students need to solve **ANY TWO** of the remaining Four Questions (Q.2 to Q.5) and shall be based on entire syllabus.*

Note: **Number of lectures required to cover syllabus of a course depends on the number of credits assigned to a particular course. One credit of theory corresponds to 15 Hours lecturing and for practical course one credit corresponds to 30 Hours. For example, for a course of two credits 30 lectures of one hour duration are assigned, while that for a three credit course 45lectures.**

%%%%%