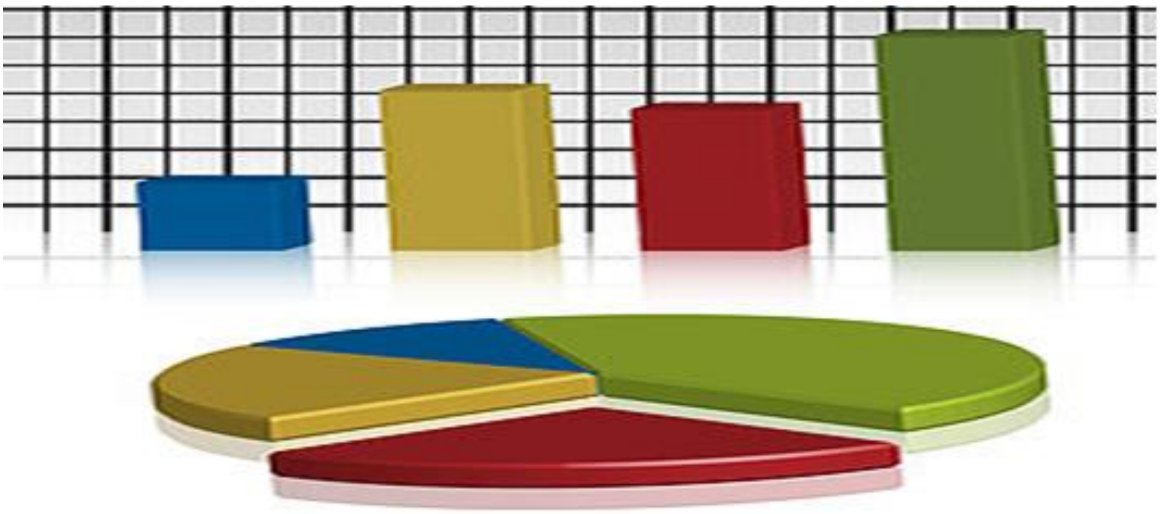
PROGRAMME PROJECT REPORT

Master of Science in Statistics Programme
&
Master of Arts in Statistics Programme

(2 Year Programme in accordance with NEP-2020)



School of Sciences

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1. Master's Degree Programme

The National Education Policy (NEP) 2020 envisions a new vision that enable an individual to study one or more specialized areas of interest at a deep level, and also develop capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. The NEP 2020 focuses on the formulation of expected learning outcomes for all higher education programmes. It states that "National Higher Education Qualifications Framework (NHEQF)" shall be align with the National Skills Qualifications Framework (NSQF) to ease the integration of vocational education into higher education. It also points out that higher education qualifications leading to a degree/diploma/certificate shall be described by the NHEQF in terms of Outcome Based Education (OBE).

The design of Master of Science in Statistics (MScSTAT) and Master of Arts in Statistics (MASTAT)programme in line with NHEQF offers opportunities and avenues to learn core subjects but also to explore additional avenues of learning beyond the core subjects for holistic development of a learner.

The uniform grading system will also enable potential employers in assessing the performance of the learner. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on learner's performance in examinations, guidelines framed by the UGC are followed. Hence, adoption of NHEQF helps to overcome the gap between university degree and employability by introducing skills and competencies in the graduates.

2. M. Sc. (Statistics) and M. A. (Statistics)

The structure and duration of postgraduate programme of M. Sc. (Statistics) and M. A. (Statistics) in accordance with NEP 2020 includes multiple exit options within this period, with appropriate certifications:

- Level 8: a **Bachelor' Degree (Research)** for 4 year programme after completing 4th year of 4-year B.Sc./B.A.programme **or PG Diploma in Statistics** after completing 1st year (2 semesters) of study of M.Sc./M.A. programme.
- Level 9: a M. Sc. (Statistics) and M. A. (Statistics) after 2 years (4 semesters) of study;

2.1 Programme Mission & Objectives

In line with the mission of the University to provide flexible learning opportunities to all, particularly to those who could not join regular colleges or universities owing to social, economic and other constraints, the 2-year Post-Graduate Programme in **Statistics** aims at providing holistic and value basedknowledge and guidance to promote scientific temper in everyday life. The program offers a platform to the learners to fulfill the eligible criteria in various scientific jobs in government and private sector.

The M. Sc. (Statistics) and M. A. (Statistics) Programme aims at the following objectives:

- Develop a broad academic and practical literacy in statistics and its tools and techniques, with relevance in research and statistical analysis used in statistical analysis, so that students are able to critically select and apply appropriate methods and techniques to extract relevant and important information from data.
- Provide strong core training so that graduates can adapt easily to changes and new demands from industry.
- Enable students to understand not only how to apply certain methods, but when and why they are appropriate.
- Statistics is used inother many more subjects' research and to create adept and well-rounded Statistician.
- Expose students to real-world problems in the classroom and through experiential learning.

These program objectives acknowledge the multidisciplinary as well as interdisciplinary of statistical knowledge and the importance of building a strong foundation with our students.

2.2 Relevance of the Programme with Mission and Goals

The 2-year Post-Graduate Programme M. Sc. (Statistics) and M. A. (Statistics) is designed with the objective of equipping learners to cope with the emerging trends and challenges in the scientific domain. In congruence with goals of the University, the Programme also focuses to provide statistically skilled manpower to the society to meet global demands. The Programme is designed in such a manner so that a successful learner can go for higher studies as well as join the research and industries, government organizations, monitoring projects and different (NGOs) organizations or can run their own start-ups.

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2.3 Nature of Prospective Target Group of Learners

The Program is targeted to all individuals looking to earn a postgraduation degree for employment, further higher education, promotion in career, professional development.

2.4 Appropriateness of Programme to be conducted in ODL mode to acquire specific skills & competence

Learning outcomes after Level 8		
Learning Outcomes	**Elements of the descriptor**	**Level 8** **Bachelor' Degree (Research)** OR **PG Diploma in Statistics**
LO 1	Knowledge and understanding	• advanced knowledge about a specialized field of enquiry, with depth in one or more fields of learning within a broad multidisciplinary/interdisciplinary context. • a coherent understanding of the established methods and techniques of research and enquiry applicable to the chosen fields of learning.
LO 2	Skills required to perform and accomplish tasks	• a range of cognitive and technical skills required for performing and accomplishing complex tasks relating to the chosen fields of learning, • cognitive and technical skills relating to the established research methods and techniques,
LO 3	Application of knowledge and skills	• apply the acquired advanced technical and/or theoretical knowledge and a range of cognitive and practical skills to analyze the quantitative and qualitative data gathered drawing on a wide range of sources for identifying problems and issues relating to the chosen fields of learning, • apply advanced knowledge relating to research methods to carryout research and investigations to formulate evidence-based solutions to complex and unpredictable problems.
LO 4	Generic learning outcomes	• listen carefully, read texts and research papers analytically and present complex information in a clear and concise manner to different groups/audiences, • communicate technical information and explanations, and the findings/results of the research studies relating to specialized fields of learning, • present in a concise manner one's views on the relevance and applications of the findings of research and evaluation studies in the context of emerging developments and issues. • pursue self-paced and self- directed learning to upgrade

		knowledge and skills that will help accomplish complex tasks and pursue higher level of education and research. • problematize, synthesize and articulate issues and design research proposals, • define problems, formulate appropriate and relevant research questions,
LO 5	Constitutional, humanistic, ethical and moral values	• embrace and practice constitutional, humanistic, ethical, and moral values in one's life. • adopt objective, unbiased, and truthful actions in all aspects of work related to the chosen field(s) of learning and professional practice.
LO 6	Employment ready skills, and entrepreneurship skills and mindset	• managing complex technical or professional activities or projects, requiring the exercise of full personal responsibility for output of own work as well as for the outputs of the group as a member of the group/team. • exercising supervision in the context of work having unpredictable changes.

Learning outcomes after Level 9		
Learning Outcomes	**Elements of the descriptor**	**Level 9** **M. Sc. (Statistics) / M. A. (Statistics)**
LO 1	Knowledge and understanding	• advanced knowledge about a specialized field of enquiry with a critical understanding of the emerging developments and issues relating to one or more fields of learning, • advanced knowledge and understanding of the research principles, methods, and techniques applicable to the chosen fields of learning or professional practice, • procedural knowledge required for performing and accomplishing complex and specialized professional tasks relating to teaching, and research and development.
LO 2	Skills required to perform and accomplish tasks	• advanced cognitive and technical skills required for performing and accomplishing complex tasks related to the chosen fields of learning, • advanced cognitive and technical skills required for evaluating research findings and designing and conducting relevant research that contributes to the generation of new knowledge, • specialized cognitive and technical skills relating to a body of knowledge and practice to analyse and synthesize complex information and problems.
LO 3	Application of knowledge and skills	• apply the acquired advanced theoretical and/or technical knowledge about a specialized field of enquiry or professional practice and a range of cognitive and practical skills to identify and analyse problems and issues, including real-life problems, associated with the chosen fields of learning.
LO 4	Generic learning outcomes	• listen carefully, read texts and research papers analytically and present complex information in a clear and concise manner to different groups/audiences, • communicate, in a well-structured manner, technical information and explanations, and the findings/ results of the research studies undertaken in the chosen field of study, • meet one's own learning needs relating to the chosen fields of learning, work/vocation, and an area of professional practice, • pursue self-paced and self- directed learning to upgrade knowledge

		and skills, including research-related skills, required to pursue higher level of education and research.
LO 5	Constitutional, humanistic, ethical and moral values	• embrace and practice constitutional, humanistic, ethical and moral values in one's life, • adopt objective and unbiased actions in all aspects of work related to the chosen fields/subfields of study and professional practice, • participate in actions to address environmental protection and sustainable development issues,
LO 6	Employment ready skills, and entrepreneurship skills and mindset	• adapting to the future of work and responding to the demands of the fast pace of technological developments and innovations that drive shift in employers' demands for skills, particularly with respect to transition towards more technology-assisted work involving the creation of new forms of work and rapidly changing work and production processes. • exercising full personal responsibility for output of own work as well as for group/ team outputs and for managing work that are complex and unpredictable requiring new strategic approaches.

2.5 Instructional Design

2.5.1 2-year M. Sc. (Statistics) and M. A. (Statistics) (programme Structure

The University follows the credit system in all its programmes. One credit is equal to 30 hours of learner's study time which is equivalent to 15 lectures in conventional system. To earn a Master's Degree, a learner has to earn 80 credits in minimum four semesters (two years) with 20 credits per semester. For earning 80 credits, a learner has to go through the following Programme Structure:

Programme Structure of M. Sc./MA-Statistics under NHEQF

Level	Year	Sem	Core Course 1	Core Course 2	Core Course 3	Research component	Practical Lab/ Dissertation with viva voce	Total credit
8	1	1st	4	4	4	4	4	**20**
		2nd	4	4	4	4	4	**20**
9	2	3rd	4	4	4	4	4	**20**
		4th	4	4	4	4	4	**20**
Total credit								**80**

Explanation of terms used for categorization of courses:

A. **Core course:** A course, which should compulsorily be studied by a learner as a core requirement is termed as a Core course.
B. **Research Component:** The components included in this category are Basics in Research (PGBR-01), Mini Project (PGMP-02), Basic Research Tools (PGRT-03).
C. **Practical Lab:** Lab based on theory courses for implementing the algorithms discussed in theory papers.
D. **Industrial Training/ Survey/ Research Project/ Field Work/Apprenticeship/ Dissertation/Internship:** A course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a learner studies such a course on his own with an advisory support by a counsellor/faculty member.

2.5.2 Course curriculum: The details of syllabus is given in Appendix-I

2.5.3 Language of Instruction: English. However, learner can write assignment and give Term End Examination (TEE) in English.

2.5.4 Duration of the Programme

Minimum duration in years: 02 Maximum duration in years: 04

2.5.5 Faculty & Support Staff

Director (1), Professor (1), Associate Professor (1), Assistant Professor/Academic Consultant (04) and supporting staff (3)

2.6 Instructional Delivery Mechanisms

The Open University system is more learner-oriented, and the student is an active participant in the teaching-learning process. Most of the instructions are imparted through distance rather than face-to-face communication.

The University follows a multi-media approach for instruction. It comprises of:

- Self-instructional printed material (Self Learning Material)
- Audio and video lectures
- Face-to-face counselling
- Assignments
- Laboratory work
- Project work in some courses
- Teleconference/Web conference
- Web Enabled Academic Support Portal
- e-GYANSANGAM (Open Educational Repository): *http://gyansangam.uprtou.ac.in*
- e-GYANARJAN:Its a Learning Management System based on Moodle *(http://gyanarjan.uprtou.ac.in)* to aid the learner through web conferencing, sharing of learning resources, counselling classes etc.

2.6.1 Self-Learning Material

The Self Learning Material (SLMs) is prepared with the UGC guidelines on preparation of SLMs. The prepared study materials are self-instructional in nature.

The course material is divided into blocks. Each block contains few units. Lessons, which are called Units, are structured to facilitate self-study. The units of a block have similar nature of contents. The first page of each block indicates the numbers and titles of the units comprising the block. In the first block of each course, itstarts with course introduction. This is followed by a brief introduction to the block. After the block introduction, emphasis is given on contribution of ancient Indian knowledge into that specific course. Next, each unit begins with an introduction to talk about the contents of the unit. The lists of objectives are outlined to expect the learning based outcome after working through the unit. This is followed by the main body of the unit, which is divided into various sections and sub-sections. Each unit is summarized with the main highlights of the contents.

Each unit has several "Check Your Progress/ Self Assessment" Questions and Terminal Questions /Exercises. These questions help the learner to assess his/her understanding of the subject contents. At the end of units, additional references/books/suggested online weblink for MOOCs/Open Educational Resources for additional reading are suggested.

2.6.2 Audio and Video lectures

Apart from SLM, audio and video lectures have been prepared for some courses. The audio-video material is supplementary to print material. The video lectures are available at YouTube channel of university
(*https://www.youtube.com/channel/UCj2XTEB6iCZwwIqmKw_jzYg*).

2.6.3 Counselling Classes

The face to face (F2F) counselling classes are conducted at head quarter and study centers. The purpose of such a contact class is to answer some of questions and clarify the doubts of learner which may not be possible through any other means of communication. The study centers conducted thecounselingwith the help of well experienced counsellors and provide the guidance to learner in the courses that (s) he/she has chosen for study. The counselling sessions for each of the courses will be held at suitable intervals throughout the whole academic session. The time table for counselling classes are displayed at head quarter as well as by the coordinator of study center, however, attending counselling sessions is not compulsory. It is noted that to attend the counselling sessions, learner has to go through the course materials and note down the points to be discussed as it is not a regular class or lectures.

2.6.4 Assignments

The purpose of assignments is to test the comprehension of the learning material that learner receives and also help to get through the courses by providing self-feedback to the learner. The course content given in the SLM will be sufficient for answering the assignments.

Assignments constitute the continuous evaluation component of a course. The assignments are available at the SLM section of the home page of university website. In any case, learner has to submit assignment before appearing in the examination for any course. The assignments of a course carry 30% weightage while 70% weightage is given to the term-end examination (TEE). The marks obtained by learner in the assignments will be counted in the final result. Therefore, It is advised to take assignments seriously. However, there will be no written assignments for Lab/ practical courses.

2.6.5 Laboratory/ Practical Work

Laboratory / practical courses are an integral component of the M. Sc. (Statistics) (MScSTAT) [Master of Science in Statistics] and M. A. (Statistics) (MASTAT) [Master of Arts in Statistics] programme. While designing the curricula for laboratory/ practical courses, particular care has been taken to weed out experiments not significant to the present-day state of the discipline. Importance has been given to the utility of an experiment with respect to real life experience, development of experimental skills, and industrial applications. It is planned to phase the laboratory/ practical courses during suitable periods (such as summer or autumn vacations) so that in-service persons can take them without difficulty. Laboratory/ practical courses worth 2 credits will require full-time presence of the student at the Study Centre for one week continuously. During this time a student has to work for around 60 hours. Around 40 hours would be spent on experimental work and the remaining time will be used for doing calculations, preparations of records, viewing or listening to the video/audio programmes.

2.6.6 Teleconference/Web conference

Teleconference/web conference, using done through ZOOM/webex in form of online special counselling sessions is another medium to impart instruction to and facilitate learning for a distance learner. The students concerned would be informed about the teleconferencing schedule and the place where it is to be conducted by sending bulk SMS.

2.6.7 Web Enabled Academic Support Portal

The University also provide Web Enabled Academic Support Portal to access the course materials, assignments, and other learning resources.

2.6.8 e-GYANSANGAM

The e-GYAMSANGAM (UPRTOU-OER REPOSITORY) is an open access platform for educational resources that rely on the concept of 5Rs namely; Reuse Revise, Remix Retain and Redistribute. Uttar Pradesh Rajarshi Tandon Open University in support with Commonwealth Educational Media Centre for Asia initiated the implementation of philosophy behind the NEP-2020 to provide equitable use of technology to support learners (SDG4). This not only ensure inclusive and equitable quality education opportunities but also provide faculty to repurpose high quality open educational resources (OER) such that innovative, interactive and collaborative learning environment is built. UPRTOU believes the philosophy of Antyoday (reaching to last person of the society) and facilitate the learner by providing Self Learning Materials, Lecture Notes, Audio/video Lectures, Assignments, Course materials etc. through face-to-face mode as well as distance mode. This e-GYANSANGAM depository will fulfill the educational facilities through equitable use of technology to the learners.

Objectives

- To provide low-cost access model for learners. To foster the policy of reaching to unreached.
- To break down barriers of affordability and accessibility of educational resources.
- To give faculty the ability to customize course materials for learners.
- To provide equal access to affordable technical, vocational and higher education resources (SDG 4.3).
- To provide ubiquitous access to anyone. This will facilitate the quick availability of educational resources and reduces time.
- To supplement Self Learning Material (SLM).
- To reduce the mentor-mentee gap as depository provide access to number of local access as well as global access to educational resources.

2.6.9 e-GYANARJAN: It's a Learning Management System based on Moodle (*http://gyanarjan.uprtou.ac.in*) to aid the learner through web conferencing, sharing of learning resources, counselling classes etc.

2.6.10 Learner Support Service Systems

(a) Study Centre

A Study Centre has following major functions:

(i) **Counselling:** Counselling is an important aspect of Open University System. Face to face contact-cum-counselling classes for the courses will be provided at the Study Centre. The detailed programme of the contact-cum-counselling sessions will be sent to the learner by the Coordinator of the Study Centre. In these sessions learner will get an opportunity to discuss with the Counsellors his/her problems pertaining to the courses of study.

(ii) **Evaluation of Assignments:**The evaluation of Tutor Marked Assignments (TMA) will be done by the Counsellors at the Study Centre. The evaluated assignments will be returned to the learner by the Coordinator of Study Centre with tutor comments and marks obtained in TMAs. These comments will help the learner in his/her studies.

(iii) **Library:** Every Study Centre will have a library having relevant course materials, reference books suggested for supplementary reading prepared for the course(s).

(iv) **Information and Advice:** The learner will be given relevant information about the courses offered by the University. Facilities are also provided to give him/her guidance in choosing courses.

(v) **Interaction with fellow-students:** In the Study Centre learner will have an opportunity to interact with fellow students. This may lead to the formation of self-help groups.

(b) Learner Support Services (LSS)

The University has formed an LSS cell at the head quarter. The LSS cell coordinate with the Study Centre to get rid of any problem faced by the learner.

2.7 Procedure for admissions, curriculum transaction and evaluation

2.7.1 Admission Procedure

(a) The detailed information regarding admission will be given on the UPRTOU website and on the admission portal. Learners seeking admission shall apply online.

(b) Direct admission to 2-year M. Sc. (Statistics) and M. A. (Statistics) program is offered to the interested candidates.

(c) **Eligibility:** The eligibility condition for admission in M. Sc. (Statistics) and M. A. (Statistics) Program is Bachelor degree with Mathematics/ Statistics/ Engineering/ Biostatistics/Computer Science as one of the subject/paper OR Bachelor’s Degree (Research).

2.7.2 Programme Fee:

(i) M. Sc. (Statistics): Rs. 8200 / year and

(ii) M. A. (Statistics): Rs. 7200 / year.

The fee is deposited through online admission portal only.

2.7.3 Evaluation

The evaluation consists of two components: (1) continuous evaluation through assignments, and (2) term-end examination. Learner must pass both in continuous evaluation as well as in the term-end examination of a course to earn the credits assigned to that course. For each course there shall be one written Terminal Examination. The evaluation of every course shall be in two parts that is 30% internal weightage through assignments and 70% external weightage through terminal exams.

(a) Theory course	**Max. Marks**
Terminal Examination	70
Assignment	30
Total	**100**
(b) Practical course:	**Max. Marks**
Terminal Practical Examination	100

Marks of Terminal Practical Examination shall be awarded as per following scheme:

i.	Write up /theory work	30
ii.	Viva-voce	30
iii.	Execution/Performance/Demonstration	20
iv.	Lab Record/practical	20

The following 10-Point Grading System for evaluating learners' achievement is used for CBCS programmes:

10-Point Grading System in the light of UGC-CBCS Guidelines

Letter Grade	Grade Point	% Range
O (Outstanding)	10	91-100
A+ (Excellent)	9	81-90
A (Very Good)	8	71-80
B+ (Good)	7	61-70
B (Above Average)	6	51-60
C (Average)	5	41-50
P (Pass)	4	36-40
NC (Not Completed)	0	0-35
Ab (Absent)	0	
Q	Qualified	Applicable only for Non-Credit courses
NQ	Not Qualified	

Learner is required to score at least a 'P' grade (36% marks) in both the continuous evaluation (assignments) as well as the term-end examination. In the overall computation also, learner must get at least a 'P' grade in each course to be eligible for the M. Sc. degree.

Computation of CGPA and SGPA

(a) Following formula shall be used for calculation of CGPA and SGPA

For j^{th} semester SGPA (Sj) = Σ (Ci *Gi)/ Σ Ci	where, Ci = number of credits of the i^{th} course in j^{th} semester Gi= grade point scored by the learner in the i^{th} course in j^{th} semester.
CGPA = Σ (Cj *Sj)/ Σ Cj	where, Sj = SGPA of the j^{th} semester Cj = total number of credits in the j^{th} semester

The CGPA and CGPA shall be rounded off up to the two decimal points. (For e.g., if a learner obtained 7.2345, then it will be written as 7.23 or if s(he) obtained 7.23675 then it be will written as 7.24)

CGPA will be converted into percentage according to the following formula:

Equivalent Percentage = CGPA * 9.5

(b) Award of Division

The learner will be awarded division according to the following table:

Division	Classification
1st Division	6.31 or more and less than 10 CGPA
2nd Division	4.73 or more and less than 6.31 CGPA
3rd Division	3.78 or more and less than 4.73 CGPA

2.7.4 Multiple Entry and Multiple Exit options

The 2-year M. Sc. (Statistics) and M. A. (Statistics) programme is an Outcome-Based Education (OBE) for qualifications of different types. The qualification types and examples of title/nomenclature for qualifications within each type are indicated in Table 1.

Table 1

Level	Qualification title	Programme duration	Entry Option	Exit option
8	B.Sc./B.A. (Research) OR PG Diploma in Statistics	Programme duration: First year (first two semesters) of the M.Sc./M.A. programme	Bachelor degree with Mathematics/ Statistics/ Engineering/ Biostatistics/Computer Science as one of the subject/paper OR Bachelor's Degree (Research).	**Exit** Awarded with Bachelor' Degree (Research) for 4 year programme OR Exit awarded with PG Diploma in Statistics
9	M.Sc./MA (Statistics)	Programme duration: First two years (first four semesters) of the of	B.Sc./B.A. (Research) OR PG Diploma in Statistics obtained after completing the first year	**Exit** awarded with Master's in (Statistics)

		the M.Sc. programme	(two semesters) of the M.Sc. Statistics programme.	

2.8 Requirement of the laboratory support and Library Resources

The practical sessions are held in the mathematical/computational science laboratories (Computer lab with statistical softwares i.e. SPSS, STATA, R, Matlab, Octave etc) of the Study Centre. In these labs, the learner will have the facility to use the equipment and consumables relevant to the syllabus. The SLM, supplementary text audio and video material of the various courses of the program is available through the online study portal of the University. The University also have a subscription of National Digital Library to provide the learners with the ability to enhance access to information and knowledge of various courses of the programme.

2.9 Cost estimate of the programme and the provisions

2-year M. Sc. (Statistics) and M. A. (Statistics) programme consists of 15 theory courses, 4laboratory/Practical courses and (basics in research, mini and major project, and Dissertation) research activities. One course is of 4 credits.The writing work of some courses has been completed and the total approximated expenditure on the development of rest courses is:

S. No.	Item	Cost per Unit (writing & editing)	Total cost (Rs.)
1	Total no. of units in 147	5000	735000
2	BOS Meetings etc.	10000	10000
		Total	**745000**

2.10 Quality assurance mechanism and expected programme outcomes

(a) **Quality assurance mechanism:** The program structure is developed under the guidance of the Board of studies comprising external expert members of the concerned subjects followed by the School board. The program structure and syllabus is approved by the Academic Council of the University. The course structure and syllabus is reviewed time to time according to the feedback received from the stakeholders and societal needs.

The Centre for Internal Quality Assurance will monitor, improve and enhance effectiveness of the program through the following:

- ✓ Annual academic audit
- ✓ Feedback analysis for quality improvement
- ✓ Regular faculty development programs
- ✓ Standardization of learning resources
- ✓ Periodic revision of program depending upon the changing trends by communicating to the concerned school

(b) **Expected programme outcomes (POs)**

Knowledge and understanding	**PO1**	Gain sound knowledge in theoretical and practical aspects of Statistics. Describe complex statistical ideas to non-statisticians. Handle and analyze large databases with computer skills and use their results and interpretations to make practical suggestions for improvement. Get wide range of job opportunities in industry as well as in government sector

Skills related to specialization	**PO 2**	To develop the problem-solving skills and apply them independently in pure and applied fields of research and many more scientific computing techniques to solve complex scientific and real-life problems.
Application of knowledge and skills	**PO 3**	To provide learners with strong statistical knowledge and capability in formulating & analysis of real-life problem using modern tools of statistics, which helps them to analyze any data and interpret those outcomes. With the help of projection tools and techniques learner will be capable for projection.
	PO 4	To provide knowledge and insight in statistics so that learners can work as excellent statistician and research professional.
Generic learning outcomes	**PO 5**	To prepare the learners to as per the need of different industry through knowledge of statistics and scientific statistical and computational techniques.
	PO 6	To prepare and motivate the learners to pursue their higher studies and conduct fundamental and applied research for the welfare of society and mankind.

Programme:	**Master of Science [M.Sc.-Statistics]**
Year	First Introduction year: 2008-09
Revision of Programme in accordance with NEP-2020	
Initiation year of revision	2022
Completion year of revision	2023

APPENDIX-I

Academic Year 2023-24
Detailed Programme Structure & Syllabus

M. Sc. (Statistics) [Master of Science in Statistics]
&
M. A. (Statistics) [Master of Arts in Statistics]

Year	Semester	Course Code	Title of Papers	Credit	Max. Marks	Min. Marks
1st Year		MScSTAT-101N / MASTAT -101N	Measure and Probability Theory	4	100	36
		MScSTAT-102N / MASTAT -102N	Statistical Inference	4	100	36
		MScSTAT-103N / MASTAT -103N	Survey Sampling	4	100	36
		PGBR-01	Basics in Research	4	100	36
		MScSTAT-105P /MASTAT -105P	Practical and Viva voce (Based on MScSTAT/MASTAT-101N, 102N and 103N	4	100	36
	Total of 1st Semester			**20**	**500**	**180**
		MScSTAT-201N /MASTAT-201N	Linear Model and Design of Experiment	4	100	36
		MScSTAT-202N/ MASTAT-202N	Non Parametrics	4	100	36
		MScSTAT-203 N /MASTAT-203N	Stochastic Process	4	100	36
		PGMP-02	Mini Project	4	100	36
		MScSTAT-205P /MASTAT -205P	Practical and Viva voce (Based on MScSTAT/MASTAT-201N,202N and 203N)	4	100	36
	Total of 2nd Semester			**20**	**500**	**180**
2nd Year		MScSTAT-301N /MASTAT-301N	Decision Theory and Bayesian Analysis	4	100	36
		MScSTAT-302N /MASTAT-302N	Multivariate Analysis	4	100	36
		MScSTAT-303N/ MASTAT-303N	Econometrics	4	100	36
		PGRT-03	Basic Research Tools	4	100	36
		MScSTAT-305P /MASTAT-305 P	Practical and Viva voce (Based on MScSTAT/MASTAT-301N,302N and 303N /MASTAT-301N,302N)	4	100	36
	Total of 3rd Semester			**20**	**500**	**180**
		Compulsory Papers MScSTAT-401N / MASTAT -401N	Demography	4	100	36
		Compulsory Papers MScSTAT-402N (DW) / MASTAT -402N (DW)	Dissertation Work & Viva-Voce	4	100	36

		Select any one group					
		Group-A	MScSTAT- 403NA /MASTAT -403NA	Survival Analysis and Reliability Theory	4	100	36
			MScSTAT- 404NA / MASTAT -404NA	Actuarial Statistics	4	100	36
			MScSTAT-405PA / MASTAT -405PA	Practical and Viva voce (Based on MScSTAT/MASTAT-401N, 403NA and 404 NA)	4	100	36
		OR					
		Group-B	MScSTAT- 403NB / MASTAT -403NB	Operation Research	4	100	36
			MScSTAT- 404NB/ MASTAT -404NB	Mathematical and Real Analysis	4	100	36
			MScSTAT-405PB / MASTAT -405PB	Practical and Viva voce (Based on MScSTAT/MASTAT-401N, 403NB and 404NB)	4	100	36
		Total of 4th Semester			**20**	**500**	**180**
	Total Credit/Max. Marks				**80**	**2000**	**720**

Syllabus

of

M. Sc. (Statistics) (MScSTAT) [Master of Science in Statistics]

&

M. A. (Statistics) (MASTAT) [Master of Arts in Statistics]

<table>
<tr><td colspan="3">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td>Programme: M.Sc./M.A.</td><td>Year: 1</td><td>Semester: I</td></tr>
<tr><td colspan="3">Subject: Statistics</td></tr>
<tr><td>Course Code: MScSTAT-101N/MASTAT -101N</td><td colspan="2">Course Title: Measure and Probability Theory</td></tr>
<tr><td colspan="3">Course Objectives:
Thecoursecoversthreeimportantareaswiththeobjectivestoacquaintstudentswithnew techniques.Understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions. Learn the concepts of weak and strong laws of large numbers and central limit theorem. Understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions</td></tr>
<tr><td colspan="3">Course Outcomes:
CO1:The learner will able to understand about the probability measures and distribution functions.
CO2:Learner should able to understand about the probability inequality and limit theorem.
CO3:Understand the concept of convergence, zero one law and characteristics functions.
CO4: Learner should able to understand the concept of measure, outer measure, signed measure
CO5: Learner should able to understand the concept of real analysis and fubini’s theorem.</td></tr>
<tr><td>Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td>Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
</table>

<table>
<tr><td>Block – 1</td><td>Measure Theory</td></tr>
<tr><td>Unit I</td><td>Measure:
Field, -Field, Borel field. Measure, Meassure on R^n, Properties of measure, Outer Measure, Extension of measures, Extension Theorem, Outer Extension. Simple functions, Integration, Non-negative integrable functions, Integrable measurable functions.</td></tr>
<tr><td>Unit II</td><td>Convergence:
Measure Space, Measurable Functions, Combinations of measurable function, point wise Convergence, Convergence in measure.</td></tr>
<tr><td>Unit III</td><td>Lebesgue Measure:
Lebesgue-Stielitjes measure, Lebesgue-Stieltjes integral, Riemann-Stieltjes integration, Lebesgue Dominated Convergence Theorem,Monotone convergence theorem, Fatou lemma, Fubini’s theorem.</td></tr>
<tr><td>Unit IV</td><td>Signed Measures:
Signed measures, Hahn and Jordan decomposition, Absolute Continuity, The Radon-Nikodym theorem, Derives of Signed Measures. Product Space, Cartesian products of two measurable spaces, Section, Product measures,</td></tr>
<tr><td>Block 2</td><td>Probability Measure, Distribution Function and Inequalities</td></tr>
<tr><td>Unit V</td><td>Probability Measure:
Probability space of a random experiment .probability measures, random variables as a measurable function. Field induced by a sequence of random variables,</td></tr>
</table>

<table>
<tr><td>Unit VI</td><td>Distribution Functions:
Decomposition of distribution functions in purely discrete, absolutely continuous and singular components</td></tr>
<tr><td>Unit VII</td><td>Probability Inequalities:
CR-inequality, Chebyshev’s inequality, Cauchy-Schwartz inequality, Holder inequality, Minkowski inequality, Jensen inequality, Lyapunov inequality, Kolmogorov inequality, Hajck-Renyki inequality.</td></tr>
<tr><td>Block 3</td><td>Convergence, Characteristics Function and Limit Theorems</td></tr>
<tr><td>Unit VIII</td><td>Convergence:
Sequences of distribution functions, weak and complete convergence of sequence ofdistribution function, Different types of convergence of sequence of random variables distribution function of random vectors,</td></tr>
<tr><td>Unit IX</td><td>Law of Large Numbers:
Weak law of large numbers (WLLN), Strong law of large numbers (SLLN), Khinchin’s theorem,Borel zero-one law,Borel-Cantelli lemmas,</td></tr>
<tr><td>Unit X</td><td>Characteristic Function:
Helly– Bray lemma and theorem, Weak compactness theorem, Kolmogorav theorems, Characteristic function, Inversion theorem, Continuity theorem, uniqueness theorem,.</td></tr>
<tr><td>Unit XI</td><td>Central Limit Theorems:
One dimensional central limit problem: lindeberg-levy, Lyapunov, Lindeberg-Feller theorems.</td></tr>
<tr><td colspan="2">Suggested Text Book Readings:
• Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997):Statistics: A Beginner’s Text, Vol. II, New Age International (P) Ltd.
• Edward P.J., Ford J.S.and Lin (1974): Probability for Statistical Decision-Making, Prentice Hall.
• Goon A.M., Gupta M.K., Das Gupta.B. (1999): Fundamentals of Statistics, Vol.II, WorldPress, Calcutta.
• Mood A.M, Graybill F.A and Boes D.C. (1974): Introduction to the Theory of Statistics,McGraw Hill.
• Cooke, Cramer and Clarke (): Basic Statistical Computing, Chapman and Hall.
• David S (1996): Elementary Probability, Oxford Press.
• Hoel P.G (1971): Introduction to Mathematical Statistics, Asia Publishing House.
• Meyer P.L (1970): Introductory Probability and Statistical applications. Addision Wesley
• Apostol, T. M. (1985). Mathematical Analysis, Narosa, Indian Ed.
• Courant, R. and John, F. (1965). Introduction to Calculus and Analysis, Wiley.
• Miller, K. S. (1957). Advanced Real Calculus, Harper, New York.
• Rudin, Walter (1976). Principles of Mathematical Analysis, McGraw Hill.</td></tr>
<tr><td colspan="2">This course can be opted as an elective by the students of following subjects:
P.G. inMathematics, Data Science, Computer Science and B.Techstudents</td></tr>
<tr><td colspan="2">Suggested equivalent online courses (MOOCs) for credit transfer: NA</td></tr>
<tr><td colspan="2">Learner can join this for their own knowledge: https://onlinecourses.nptel.ac.in/noc, Measure Theory, Prof. Inder Kumar Rana</td></tr>
</table>

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.

Programme: M.Sc./M.A.	**Year:** 1	**Semester:** I

Subject: Statistics

Course Code: ***MScSTAT-102N / MASTAT-102N***	**Course Title:** ***Statistical Inference***

Course Objectives: The aim of the course is to pay a special attention to applications of measure theory in the probability theory, understanding of Weak Law of Large numbers, Strong Law of Large Numbers and the Central Limit Theorem with their applications. to provide a thorough theoretical grounding in different type of distributions, non-central distributions, censoring, delta method, robustprocedures etc.

Course Outcomes:

CO1: To make students aware of estimation (point, as well as, interval) and testing (simple, as well as, composite hypotheses) procedures.

CO2: Apply various estimation and testing procedures to deal with real life problems.Understand Fisher Information, Lower bounds to variance of estimators, MVUE.Understand Neyman-Pearson fundamental lemma, UMP test, Interval estimation andConfidence interval.

CO3: To make aware the students of parametric, non-parametric and sequential estimation (point, as well as, interval) and testing (simple, as well as, composite hypotheses) procedures.

CO4: Learner will able to understand about the estimation theory, and hypothesis testing.

Credits: 4	**Type of Course:** Core
Max. Marks: 100	**Min. Passing Marks:** 36

Block 1	**Estimation Theory**
Unit I	**Point and Interval Estimation:** Basic Concept of Point Estimation and Interval estimation, confidence level, unbiasedness, Criterion for Good Estimators, best linear unbiased estimator, relation between interval estimation and hypotheses testing.
Unit II	**Sufficiency:** Sufficiency, factorization theorem, Fisher- Neyman – Halmos – Savage factorization criterion, minimal sufficiency and Ancillary statistics, invariance properties of sufficiency.
Unit III	**Completeness:** Completeness, Bounded completeness, Rao-Blackwell theorem, Lehman Schaffer theorem, Cramer-Rao inequality.
Unit IV	**Exponential Family:** Basu's theorem on independence of Statistics, Exponential families and Pitman families,
Block 2	**Estimation, Hypothesis Testing and Confidence Estimation**
Unit V	**Methods of Estimation:** Maximum likelihood estimation, method of moments, MVUE, necessary and sufficient conditions for MVUE, etc., Zehna theorem for invariance, Cramer theorem for weak consistency. Cramer-Huzurbazar theorem.
Unit VI	**Criterion for Good Estimators:** Criterion for Good Estimators, Bhattacharya bound, Chapman Robbins and Kiefer (CRK) bound, asymptotic normality, BAN and CAN estimators, asymptotic efficiency, equivariant consistency.
Unit VII	**Confidence Estimation:** Confidence interval and confidence coefficient, shortest length confidence interval, relation between confidence estimation and hypotheses testing.
Unit VIII	**Hypothesis Testing:** Generalized Neyman Pearson lemma, MP and UMP tests for distributions with MLR, LR tests and their properties, UMPU tests, similar regions, Neyman structure, Invariant tests.

Suggested Text Book Readings:

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

This course can be opted as an elective by the students of following subjects:
P.G. inMathematics, Data Science, Computer Science, Medical Sciences, Agricultural Sciences and B.Tech students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Learner can join this for their own knowledge: *https://onlinecourses.nptel.ac.in/noc*, Introduction to Probability Theory and Statistics, Prof. S Dharmaraja

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.			
Programme: M.Sc./M.A.		**Year:** 1	**Semester:** I
Subject: Statistics			
Course Code: ***MScSTAT-103N / MASTAT-103N***		**Course Title:** ***Survey Sampling***	
Course Objectives: The main aim of the course is provide the basic knowledge of techniques in survey sampling with practical applications in daily life this would be beneficial for the learners to their further research. The objective of this is to provide advanced techniques in survey sampling with practical applications in daily life and to provide accessible statistical tool for applying sampling strategies and methodologies.			
Course Outcomes: **CO1:**Understand the distinctive features of sampling schemes and its related estimation problems, Learn about the applications of sampling methods; systematic, stratified and cluster sampling. Understand the cluster and two stage sampling with varying sizes of clusters/first stage units.. **CO2:** Learn about various approaches (design based and model-based) to estimate admissible parameters; with and without replacement sampling scheme, sampling with varying probability of selection. Understand the super population approach to estimation and also Learn about the randomized response techniques **CO3:** Learn about the methods of post‐stratification (stratified sampling) and controlled sampling and also double sampling procedure with unequal probability of selection. Learner will understand the non ‐existence of uniform estimators and repetitive surveys. Apply the re-sampling techniques for variance estimation ‐ independent and dependent random groups. Understand the design based estimation procedures and double sampling technique for stratification **CO4:** Learner will able to understand the response and non- response techniques; Randomized Response Technique and a technique to predict non observed residue under design and model based model and also understand the model assisted sampling strategies; super population model.			
Credits: 4		**Type of Course:** Core	
Max. Marks: 100		**Min. Passing Marks:** 36	
Block 1	**Random Sampling Procedures - I**		
Unit I	**Basics of Sampling Theory:** Sampling Theory, sampling surveys vrs complete enumeration, types of sampling, sampling and non sampling errors.		
Unit II	**Simple random sampling:** Sampling methods, SRSWOR and SRSWR, sampling for attributes.		
Unit III	**Systematic sampling:** Systematic sampling, Mean and variance of systematic sampling.		
Block 2	**Random Sampling Procedures - II**		
Unit IV	**Stratified Sampling and Use of Auxiliary Information:** Sampling Theory, stratified sampling, advantage of stratification, Post-stratification and deep stratification, Methods of allocation		
Unit V	**Ratio and Regression Sampling:** Ratio and Regression estimators, product method of estimation, double sampling in ratio estimation and double sampling in regression estimation, sub sampling.		
Unit VI	**Cluster and Multi-Stage Sampling:** Cluster sampling with equal clusters, Cluster sampling with varying size of clusters, two stage sampling and multi-stage sampling.		
Unit VII	**Response and Non Response Sampling:**		

	Non sampling errors, Randomized Response Techniques (Warner's Model: related and unrelated questionnaire methods), ranked set sampling, controlled sampling, Non Response techniques, Non sampling errors with Non Response techniques.
Block 3	**Varying Probability Sampling**
Unit VIII	**Methods of Selection and Ordered Estimators:** Varying probability sampling with and without replacement, cumulative total and Lahiri's methods of selection, Estimation of population mean.
Unit IX	**Ordered Estimators:** Concept of Ordered estimators, Desraj ordered estimates.
Unit X	**Unordered Estimators**: Unordered estimator, Horvitz- Thompson estimator, Yates – Grundy modifications, Midzuno and Narain system of sampling.

Suggested Text Book Readings:

1. Rosen, K. H. Discrete Mathematics and Its Applications. 7thedition, Tata McGraw Hill, 2011.
2. Trembley, J. P. and Manohar, R. A First Course in Discrete Structure with applications to Computer Science. Tata McGraw Hill, 1999.
3. Khanna, V. K. Lattices and Boolean Algebras. PHI Publication, 2004.
4. Liu, C. L. Elements of Discrete Mathematics. Tata McGraw Hill, 2000.
5. Ram, B. Discrete Mathematics, Pearson Education, 2012.
6. Lipschutz, S., Lipson, M. L. and Patil, V. H. Discrete Mathematics. Schaum's Outline Series, Tata McGraw-Hill Education, 2006.

This course can be opted as an elective by the students of following subjects:
P.G. inMedical Sciences, Agricultural Sciences, Management Sciences and Social Sciences students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.			
Programme: M.Sc./M.A.		**Year:** I	**Semester:** I
Subject: Statistics			
Course Code: ***PGBR-01***		**Course Title:** ***Basics in Research***	
Course Objectives: The main objective of this course is to develop a research orientation among the scholars and toacquaint them with fundamentals of research methods, survey, Plagrism and copyright issue.			
Course Outcomes: **CO1:**To write a good qualitative research statement and design the research questions. **CO2:**To know about the hypothesis, conduct the survey and a qualitative case study. **CO3:** Able to know the Plagrism and copyright issue for writing research paper and project.			
Credits: 4		**Type of Course:** Core	
Max. Marks: 100		**Min. Passing Marks:** 36	
Unit I	**Introduction to Research** Meaning of Research, Purpose, Characteristics and Types of Research,ProcessofResearch,Formulationofobjectives.		
Unit II	**Literature Survey** Introductions: Sources of information, need for reviewing literature, primary-secondary and tertiary sources, journals, journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text books, current contents, patents. Introduction to abstracts and beilstein, subject index, substance index, author index, formula index and other indices with examples. Digital Web resources, E-journals, journal access, TOC alerts. Hot articles: Citation index, UGC infonet, E-books, Impact Factors, Search engines- Google scholar, Wiki-databases, Science Direct, SciFinder, Scopus, etc.		
Unit III	**Survey** Scientific research and literature survey, History of mathematics, findingand solving research problems, role of a supervisor, a survey of a research topic.		
Unit IV	**Plagrism and Copy Right Issue** Publishing a paper, reviewing a paper, research grant proposal writing, copyright issues, ethics and plagiarism.		
Unit V	**Ethics and IPR** Regulatory bodies, practices and compliances, Research Ethics & Misconduct, Patents, Copyrights, GI and Trademarks, Product and process patent, Patent Treaties and Convention, process of filing patent, database of patent, search and retrieval, etc.		
Suggested Text Book Readings: 1. C.R. Kothari, Gaurav Garg. Research Methodology: Methods and Techniques, New Age International Publishers, 2019. 2. Kumar. R: Research Methodology: A Step-by-Step Guide for Beginners, (3rd Edition), SAGE, Inc., 2011. 3. https://onlinecourses.swayam2.ac.in/cec22_ge28/preview			
Note:- In this paper, learner itself study the objectives and prepare a report. The report will be submitted along with assignment to respective study center for evaluation. The maximum marks for evaluation are 100.			

<table>
<tr><td colspan="3">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td>Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: I</td></tr>
<tr><td colspan="3">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT-105P /MASTAT -105P</td><td>Course Title: Practical and Viva voce</td></tr>
<tr><td colspan="3">Course Objectives: The main objective of this course is to develop askill to: understand the practical methods and tests related to estimation of real-life data.</td></tr>
<tr><td colspan="3">Course Outcomes:
CO1: Learner should able to solve the numerical problems related with probability theory.
CO2: Learner should able to solve the numerical problems related with statistical inference.
CO3: Learner should able to solve the numerical problems related with sampling techniques.
CO4:Learner should able to solve the numerical problems related with measure theory.</td></tr>
<tr><td>Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td>Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td colspan="3">Practical based on MScSTAT-101N,102N and 103N/MASTAT-101N,102N and 103N</td></tr>
</table>

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: II</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT-201N / MASTAT-201N</td><td colspan="2">Course Title: Linear Models and Design of Experiments</td></tr>
<tr><td colspan="4">Course Objectives:This course provides the learner the ability to understand the design and conduct experiments, as well as to analyze and interpret data. To provide learners the ability to learn and use linear and non-linear models for normal data, and generalized linear models for normal and non-normal responses. And also to equip learners to apply experimental design techniques in real world problems and in research.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1: Apply ANOVA for two -way classification, fixed effect models with equal, unequal andproportional number of observations per cell, Random and Mixed effect models with m(>1) observations per cell.
CO2: Design and analyse incomplete block designs, understand the concepts of orthogonality,connectedness and balance. Use linear and Non-linear models, apply data transformations, and appreciate the needand uses of generalized linear models. Use the concepts of Generalized Linear Models in real life problems.Understand the concepts of finite fields and finite geometries and apply them, balanced incomplete block designs, confounded factorialexperiments.
CO3: Identify the effects of different factors and their interactions and analyse factorialexperiments.Construct complete and partially confounded factorial designs and perform their analysis.Apply Split-plot designs and their analysis in practical situations.Understand the effects of independence or dependence of different factor under study.
CO4: Understand the design and analysis of Partially Balanced Incomplete Block Designs andapply them in situations where balanced designs are not available.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Block 1</td><td colspan="3">Linear Estimation and Analysis of Variance</td></tr>
<tr><td>Unit I</td><td colspan="3">Linear Model and BLUE:
Linear Estimation- estimable functions, estimations and error space, Best linear unbiased estimate (BLUE), Markov theorem distribution of quadratic form, Estimable linear hypotheses generalized F and T tests.</td></tr>
<tr><td>Unit II</td><td colspan="3">Analysis of Variance- I:
Analysis of Variance: one-way and two-way classification with equal number of observation per cell and analysis with missing observations.</td></tr>
<tr><td>Unit III</td><td colspan="3">Analysis of Variance- II:
Analysis of Variance: one-way and two-way classification with unequal number of observation per cell, analysis with missing observations, Tukey’s test general two-way classification, Analyses of covariance.</td></tr>
<tr><td>Block 2</td><td colspan="3">Design of Experiment</td></tr>
<tr><td>Unit IV</td><td colspan="3">Basic Designs:
Terminology and basic Principles of Design, CRD, RBD and LSD, analysis with missing observations.</td></tr>
<tr><td>Unit V</td><td colspan="3">Factorial Experiments:
2^3 , 2^n , 3^2 and 3^3 factorial experiments with its analysis.</td></tr>
<tr><td>Unit VI</td><td colspan="3">Confounding:
Orthogonality, Complete and Partial confounding, construction of confounded factorial experiments.</td></tr>
</table>

Block 3	**Advance Theory of Design of Experiment**
Unit VII	**BIBD and PBIBD:** Balanced Incomplete Block Design (BIBD), Partially Balanced Incomplete Block Design (PBIBD), construction of BIBD and PBIBD, association schemes and construction, resolvable and affine resolvable design.
Unit VIII	**Split and Strip Plot Design:** Intra block and inter block analysis, Split Plot Design, Strip Plot Design.
Unit IX	**Other Advance Design:** Dual and linked block design, Lattice Designs, Cross-over designs, optimal designs-optimal criteria, robust parameter design, response surface design – orthogonality, rotatability and blocking, weighing designs, mixture experiments.

Suggested Text Book Readings:

- Aloke Dey (1986): Theory of Block Designs, Wiley Eastern.
- Angela Dean and Daniel Voss (1999): Design and Analysis of Experiments, Springer.
- Das, M.N. and Giri, N.(1979): Design and Analysis of Experiments, Wiley Eastern
- Giri,N.(1986): Analysis of Variance, South Asian Publishers
- John, P.W.M.(1971): Statistical Design and Analysis of Experiments, Macmillan
- Joshi,D.D.(1987): Linear Estimation and Design of Experiments, Wiley Eastern
- Montgomery,C.D.(1976): Design and Analysis of Experiments, Wiley, New York
- Myers, R.H..(1971): Response Surface Methodology, Allyn & Bacon
- Pearce,S.C.(1984): Design of Experiments, Wiley, New York
- Rao,C.R..andKleffe, J.(1988): Estimation of Variance Components and applications,
- North Holland.
- Searle, S. R., Casella, G. and McCulloch, C. E.. (1992): Variance Components, Wiley.

This course can be opted as an elective by the students of following subjects:
P.G. inMedical Sciences, Agricultural Sciences, Management Sciences and Social Sciences students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.		
Programme: M.Sc./M.A.	**Year:** I	**Semester:** II
Subject: Statistics		
Course Code: ***MScSTAT-202N / MASTAT-202N***	**Course Title:** ***Nonparametrics***	
Course Objectives: The main aim of this course will provide the ability to learn the fundamentals of the most relevant nonparametric techniques for statistical inference. The objective of this course is to make the learners aware of the properties and applications of order statistics.		
Course Outcomes: **CO1:** Learn about the basic concepts of record values, nonparametrics and generalized order statistics. **CO2:** Solve hypothesis testing problems where the conditions for the traditional parametric inferential tools to be applied are not fulfilled. Build nonparamteric density estimates. **CO3:** Find joint, marginal and conditional probability distributions of order statistics in the continuous and discrete cases. Find the distribution of sample range and other systematic statistics in case of sampling from an arbitrary continuous population and, in particular, from some specific continuousdistributions such as uniform and exponential. **CO4:**Learn how to obtain distribution-free confidence intervals for population quantile and distribution-free tolerance intervals for population distributions based on order statistics. Understand the distribution-free bounds for moments of order statistics and of the range. Find the approximations to moments of order statistics in terms of quantile function and its derivatives.		
Credits: 4	**Type of Course:** Core	
Max. Marks: 100	**Min. Passing Marks:** 36	

Block 1	**Order Statistics**
Unit I	**Basic Distribution Theory:** Order statistics, Distribution of maximum, minimum and r-th order statistic, Joint distribution of r-th and s-th order statistic.
Unit II	**Asymptotic Distribution Theory:** Moments of order statistics, asymptotic distributions of an order statistic, asymptotic relative efficiency, non parametric estimation of distribution function, Glivenko-Cantelli fundamental theorem.
Unit III	**Distribution Free Intervals:** Distribution of range function of order statistics, distribution free confidence intervals for quintiles, distribution free tolerance interval, distribution free bounds for moments, Fooleries limits.
Unit IV	**Rank order Statistics:** Rank order statistics, Dwass' technique, Ballot theorem its generalization, extension and application to fluctuations of sums of random variables.
Block 2	**Sequential Analysis**
Unit V	**Sequential Tests:** SPRT and its properties, Wald's Fundamental identity, OC and ASN functions, Wald's equation, Wolfowitz generalization of FRC bound, Stein's two stage procedure.
Unit VI	**Sequential Estimation:** Asymptotic theory of sequential estimation, sequential estimation of normal mean.
Block 3	**Nonparametric Tests and Inference**
Unit VII	**One- sample Location Tests** One and two sample location tests, Sign test. Wilcoxon test, Median test.

<table>
<tr><td>Unit VIII</td><td>Other non- parametric tests
Mann- Whitney U- Test, Application of U-statistic to rank tests. One sample and two sample Kolmagorov-Smirnov tests. Run tests.</td></tr>
<tr><td>Unit IX</td><td>Nonparametric Inference
The Kruskal-Wallis one way ANOVA Test, Friedman’s two-way analysis of variance by ranks, efficiency criteria and theoretical basis for calculating ARE, Pitman ARE.</td></tr>
<tr><td colspan="2">Suggested Text Book Readings:
• Davison, A.C. and Hinkley, D.V. (1997) : Bootstrap methods and their application,Cambridge University Press.
• Gibbons, J.D. (1985) : Nonparametric statistical inference, 2nd ed., Marcel Dekker, Inc.
• Randles, R.H. and Wolfe, D.A. (1979) : Introduction to the theory of nonparametric statistics, John Wiley & Sons, Inc.
• Fraser, D.A.S. (1957) : Nonparametric methods in statistics, John wiley& sons, Inc.
• Hajek, J. and Sidak, Z. (1967) : Theory of rank tests, Academic Press.
• Puri, M.L. and Sen, P.K. (1971) : Nonparametric methods in multivariate analysis, John Wiley & Sons, Inc.
• Cox, D.R. and Oakes, D. (1983) : Survival analysis, Chapman and Hall.</td></tr>
<tr><td colspan="2">This course can be opted as an elective by the students of following subjects:
P.G. inMedical Sciences, Agricultural Sciences, Management Sciences and Social Sciences students etc.</td></tr>
<tr><td colspan="2">Suggested equivalent online courses (MOOCs) for credit transfer: NA</td></tr>
<tr><td colspan="2">Learner can join this for their own knowledge:https://onlinecourses.nptel.ac.in/noc22_ma60/preview;Non-parametric Statistical Inference, Prof. Niladri Chatterjee</td></tr>
</table>

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: II</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code:MScSTAT—203N / MASTAT- 203N</td><td colspan="2">Course Title: Stochastic Process</td></tr>
<tr><td colspan="4">Course Objectives:The aim of this course is to extend the students'awareness for the use of stochastic models for representing random phenomena evolving in time such as inventory or queuing situations or stock prices behavior. Survival analysis and Reliability Theory is one area of Statistics that concerns itself with the application of statistical methods to medical, biological, epidemiological and health related problems.</td></tr>
<tr><td colspan="4">CO1:This course is to develop awareness for the use of stochastic models for representing random phenomena evolving in time such as inventory or queueing situations or stock prices behavior.
CO2:Use notions of long-time behavior including transience, recurrence, and equilibrium in applied situations such as branching processes and random walk. Construct transition matrices for Markov dependent behavior and summarize process information. Use selected statistical distributions for modeling various phenomena. Understand the principles and objectives of model building based on Markov chains, Poisson processes and Brownian motion.
CO3: This paper is to provide understanding of mathematical challenges from a purely applied perspective for a majority of random processes in terms of sequence of event-time pairs.
CO4: Make assumptions about the way in which scenarios based on random processes develop. Create realistic model for real time situation and to seek solutions to systems orientedproblems. Construct approximate theoretical solutions and simulation analysis. Theoretical derivations and results based on theorems are exhaustively dealt with.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Block 1</td><td colspan="3">Types of Processes</td></tr>
<tr><td>Unit I</td><td colspan="3">Poisson Processes
Poisson (point) process, Brownian motion process, thermal noise, Markov short noise, two valued process, Model for system reliability, mean value function and covariance kernel of Poisson process, Increment process of a Poisson process, Stationary and evolutionary process.</td></tr>
<tr><td>Unit II</td><td colspan="3">Branching Processes
Simple branching process, probability generating function, average size, variance and moments of number of individuals in the n-th generation, total progeny in branching process.</td></tr>
<tr><td>Unit III</td><td colspan="3">Wiener Process:
Wiener process, mean value function and covariance kernel of wiener process, Arc-sine law, Martingales, Stopping times, Optional sampling theorem.</td></tr>
<tr><td>Unit IV</td><td colspan="3">Renewal Process:
Renewal process, distribution and asymptotic distribution of renewal process, elementary renewal theorem, delayed and equilibrium renewal process.</td></tr>
<tr><td>Block 2</td><td colspan="3">Markov Chains and Markov Process</td></tr>
<tr><td>Unit V</td><td colspan="3">Markov Dependent Trials:
Two state Markov sequences, Markov chains, Markov classification of states and chain recurrent events, delayed recurrent events, application to the theory of success runs, more general patterns for recurrent events.</td></tr>
<tr><td>Unit VI</td><td colspan="3">Transition Probabilities:</td></tr>
</table>

	Determination of n-step transition probabilities, Chapman-Kolmogorov equations, first return and first passage probabilities, fundamental theorem of probability of extinction, higher transition probabilities in Markov classification of states and chain.
Unit VII	**Classification of States:** Classification of states, communication states, periodicity, stationary probability distributions, limit theorems, Ergodic chains and Irreducible Ergodic chains.
Unit VIII	**Continuous Time Markov Processes:** Markov processes in Continuous time. Interval arrival time, stopping time, optional stopping theorem, wald's equation, forward and backward equations for homogeneous case, random variable technique.
Block 3	**Random Walk and Queuing Process:**
Unit IX	**Random Walk and Gambler's Ruin Problem:** Random walk, Brownian motion as a random walk, one-dimensional, two-dimensional and three-dimensional random walks, duality in random walk and gambler's ruin problem.
Unit X	**Queuing Process:** Birth and death processes, renewal process, Queuing models- Specification & Effectiveness, Measures, the $E_k/M/1$, $M/E_k/1$; M/M/1; M/M/k & M/G/1 queuing process.
Unit XI	**Distributions:** Compound distribution, Machine Interference Problem, Waiting Time Distribution for M/M/1 and M/M/k models,
Unit XII	**Martingales:**Martingales, Boob – Decomposition, Martingale convergence theorems.
Block 4	**Applied Stochastic Process**
Unit XIII	**Homogeneous Process:** Forward and backward equations for homogeneous case, random variable technique, homogeneous birth and death process, divergent birth process, the general birth and death process, multiplicative process, effect of immigration for homogeneous process.
Unit XIV	**Non-Homogeneous Process:** Simple non homogeneous process, Polya process, effect of immigration for non homogeneous process, Diffusion, Backward Kolmogorov diffusion equation, Fokker-Planck equation
Unit XV	**Non Markovian Process:** Some multi dimensional prey and predator, Non Markovian Process, Embedded Markov Process, Application to population growth, epidemic and counter models.

Suggested Text Book Readings:

- Tijms, H.C. (1986) Stochastic Modeling and Analysis, Wiley.
- Medhi, J. (1982) Stochastic Processes, Wiley Eastern.
- Ross, S.M. (1983) Stochastic Processes, Wiley.
- Bhat, B.R. (2000) Stochastic Models : Analysis and Applications, New Age InternationalPublications.
- Feller, W. (1971) An introduction to Probability theory and its applications, Vol II.
- Ross, S.M. (1970) Applied Probability models with optimization applications. Holden-Day, San Franscisco.
- Wolff, R.W. (1989) Stochastic Modeling and the Theory of Queues, Prentice Hall.
- Cox, D. R. and Miller, H. D. (1965): The theory of Stochastic Processes, Mathuen& Co, London.
- Cramer, H. and Leadbetter, M. R. (1967): Stationary and Related Stochastic Processes, Wiley.
- Daley, D. J. and Vere- Jones (1988): An Introduction to the Theory of Point Processes, Springer Verlag.
- Karlin, S. and Taylor, H. M. (1981): A Second Course in Stochastic Processes Academic Press.
- Ross, S. M. (1983): Stochastic Processes, Wiley.

Learner can join this for their own knowledge:https://onlinecourses.nptel.ac.in/noc, Introduction to Probability & Theory and Stochastic, Prof. S Dharmaraja

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: II</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: PGMP-02</td><td colspan="2">Course Title: Mini Project</td></tr>
<tr><td colspan="4">Course Objectives: In the second semester of Masters the main objectives of the exposure of students towards the project is to elevate their understanding into the applications areas of Statistics. This course will develop their analytical ability, will provide them an apt exposure to work in any research group, and will motivate them to execute research in the area of their interest.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1:Students will be able to plan and strategize a scientific problem, and implement it within a reasonable time frame.
CO2: It is expected that after completing this project dissertation, students will learn to work independently and how to keep accurate/readable record of assigned project.
CO3: In addition, students will be able to know the library search and handle the data in a meaningful way. Also, the students will be able to interpret the spectral data independently.
CO4: Subsequently, the students should be able to critically examine research articles, and improve their scientific writing/communication skills and power point presentation.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Unit I</td><td colspan="3">Students prepare their reports on selected topic of their own choices by them self (without any Supervisor) and submit it to the University Examination Department/ School of Science of the University for evaluation.</td></tr>
<tr><td colspan="4">Suggested Text Book Readings:
1. Use different searching engine to get relevant information (Google scholar, Wiki-databases, Science Direct, SciFinder, Scopus, and YouTube.
2. Access to different online research library and research portal (Web resources, E-journals, journal access, TOC alerts)</td></tr>
<tr><td colspan="4">Note: Students shall make mini project on selected topic of their own choice studied so far (with or without any, Supervisor) and prepare the report. The report will be submitted along with assignment to respective study center for evaluation. The maximum marks for evaluation are 100.</td></tr>
</table>

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: I</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT-205P /MASTAT -205P</td><td colspan="2">Course Title: Practical and Viva voce</td></tr>
<tr><td colspan="4">Course Objectives: The main objective of this course is to develop askill to: understand the practical methods and tests related to estimation of real-life data.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1: Learner should able to solve the numerical problems related with design of experiment.
CO2: Learner should able to solve the numerical problems related with non parametrics.
CO3: Learner should able to solve the numerical problems related with stochastic process.
CO4:Learner should able to solve the numerical problems related with linear models.</td></tr>
<tr><td>Credits: 4</td><td colspan="3">Type of Course: Core</td></tr>
<tr><td>Max. Marks: 100</td><td colspan="3">Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Practical based on MScSTAT-201N,202N and 203N/MASTAT-201N,202N and 203N</td></tr>
</table>

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: II</td><td>Semester: III</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT—301N / MASTAT- 301N</td><td colspan="2">Course Title: Decision Theory and Bayesian Analysis</td></tr>
<tr><td colspan="4">Course Objectives:The main objective of this course is to provide the understanding of the fundamentals of decision theory and Bayesian inference including concept of subjectivity and priors by examining some simple Bayesian models and linear regression in a Bayesian framework.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1:Learner should able to understand about the concept of basic decision elements, bays and minimax rules.
CO2:Treat “evidence” as value of observations and prescribe methods to deal rationally with it and Equip students with skills to carry out and interpret posterior and pre posterior data based modeling and analyses.
CO3:Compute probability that the theory in question could produce the observed data. Examine some simple Bayesian models and linear regression in a Bayesian framework.
CO4: Learner should able to understand about the optimality of decision rules and multiple decision problem and also Bayesian rules.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Block 1</td><td colspan="3">Basic Elements and Bayes Rules</td></tr>
<tr><td>Unit I</td><td colspan="3">Basic Elements
Decision theoretic problem as a game, basic elements, optimal decision rules, unbiasedness, invariance, ordering</td></tr>
<tr><td>Unit II</td><td colspan="3">Bayes and Minimax Rules
Bayes and minimax principles, generalized. Bayes rules, extended Bayes rules, Limit of Bayes rule.</td></tr>
<tr><td>Unit III</td><td colspan="3">Bayesian interval estimation:
Baysian interval estimation, credible intervals, HPD intervals, comparison with classic confidence intervals</td></tr>
<tr><td>Block 2</td><td colspan="3">Optimality of Decision Rules</td></tr>
<tr><td>Unit IV</td><td colspan="3">Admissibility and Completeness:
Admissibility, completeness, minimal complete class, separating and supporting hyper plane theorems.</td></tr>
<tr><td>Unit V</td><td colspan="3">Minimaxity and Multiple Decision Problems:
Minimax theorem, complete class theorem, equalizer rules and examples, multiple decision problems, continuous form of Bays theorem, its sequential nature and need in decision making</td></tr>
<tr><td>Unit VI</td><td colspan="3">Bayesian Decision Theory:
Basic elements of Bayesian decision theory, theorem on optimal Bays decision function, relationship of bays and minimax decision rules, least favorable distributions.</td></tr>
<tr><td>Unit VII</td><td colspan="3">Bayesian inference:
Bayesian sufficiency, improper prior densities, Natural Conjugate Bayesian density (NCBD), posterior odd ratio, HPD regions, Bayesian inference for normal populations, empirical bayes procedures, bayesian testing of hypothesis</td></tr>
<tr><td>Block 3</td><td colspan="3">Bayesian Analysis</td></tr>
<tr><td>Unit VIII</td><td colspan="3">Prior and Posterior Distributions:
Subjective probability, its existence and interpretation, Prior Distribution, subjective determination of prior and posterior distribution, improper priors, non informative priors,</td></tr>
</table>

	invariant priors, conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension.
Unit IX	**Bayesian Inference Procedures:** Parametric empirical Bayes, Bayesian Inference, point estimation, credible sets, testing of hypothesis, Admissibility and minimaxity of Bays and Generalized bays procedures.
Unit X	**Bayesian Robustness:** Ideas of Bayesian robustness, asymptotic expansion for posterior density, Baysian calculation, Monto carlo Integration and Markov chain Monto Carlo techniques.

Suggested Text Book Readings:

- Berger, J. O. (1985). Statistical Decision Theory and Bayesian Analysis. 2nd Ed. Springer.
- Ferguson, T. S. (1967). Mathematical Statistics - A Decision Theoretic Approach, Academic Press.
- Berger, J. O. Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
- Robert C. P. and Casella, G. Monte Carlo Statistical Methods, Springer Verlag.
- Leonard T. and Hsu, J. S. J. Bayesian Methods. Cambridge University Press.
- DeGroot M. H. Optimal Statistical Decisions. McGraw Hill.
- Bernando J. M. and Smith, A. F. M. Bayesian Theory, John Wiley and Sons.
- Robert, C. P. The Bayesian Choice : A decision Theoretic Motivation, Springer.

This course can be opted as an elective by the students of following subjects:
P.G. inMedical Sciences, Bio Statistics students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: II</td><td>Semester: III</td></tr>
<tr><td colspan="4">Subject: Mathematics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT—302N / MASTAT- 302N</td><td colspan="2">Course Title: Multivariate Analysis</td></tr>
<tr><td colspan="4">Course Objectives:
The main objective of this course is to introduce learners the knowledgeof real field and complex field with their properties and relativity between complex plane and real line. These properties and relations provide grounds for Probability Theory and help in theoretical research in Statistics.And alsoTo introduce learners to the analysis of observations on several correlated random variables for a number of individuals. Such analysis becomes necessary in Anthropology, Psychology, Biology, Medicine, Education, Agriculture and Economics when one deals with several variables simultaneously. To learn statistical techniques useful for research work. To understand the quantitative methods used in Social, educational, business and management studies.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1:Account for important theorems and concepts in multivariate analysis and Summarize and interpret multivariate data.
CO2:Appreciate the range of multivariate techniques available and Understand the link between multivariate techniques and corresponding univariate techniques.
CO3:Conduct statistical inference about multivariate means including hypothesis testing, confidence region calculation, etc and also Use multivariate techniques appropriately, and draw appropriate conclusions.
CO4: Learner should able to understand about the MND and their applications.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Block 1</td><td colspan="3">Multivariate Normal Distribution and Estimation of Parameters</td></tr>
<tr><td>Unit I</td><td colspan="3">Multivariate Normal Distribution
Multivariate normal distribution, Moment generating function, Characteristic function, marginal and conditional distributions, multiple and partial correlation coefficient</td></tr>
<tr><td>Unit II</td><td colspan="3">MLE of Parameters and different coefficients
Maximum likelihood estimators of the mean vector and covariance matrix, sample Multiple and partial correlation coefficients, regression coefficient.</td></tr>
<tr><td>Unit III</td><td colspan="3">Sampling Distributions
Distributions of sample mean vector, Null sampling distributions of Multiple and Partial Correlations, distribution of sample regression coefficient. Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, Rao’s U-statistic, its distribution and applications.</td></tr>
<tr><td>Block 2</td><td colspan="3">Distributions Related to MND and their Applications</td></tr>
<tr><td>Unit IV</td><td colspan="3">Wishart Distribution
Wishart distribution. Its characteristic function, additive property of Wishart distribution, Cochran theoremdistribution of characteristic roots and vectors of wishartmatrices..</td></tr>
<tr><td>Unit V</td><td colspan="3">Hoteling’s T^2 Statistic
Hoteling’s T^2 Statistic, Null distribution and non null distribution of Hoteling’s T^2 Statistic, Applications in tests for the mean vector of one and more multivariate normal population</td></tr>
<tr><td>Unit VI</td><td colspan="3">Mahalnobis D^2
Equality of the component of a mean vector in a multivariate normal population, Mahalanobis D^2 and its various applications</td></tr>
<tr><td>Unit VII</td><td colspan="3">Discriminant Analysis
Discriminant analysis, classification and discriminatiuon procedures for discrimination betweentwo multivariate normal populations, sample discriminant function,</td></tr>
</table>

	tests associated with discriminant functions, probabilities of miss classification and their estimation, classification into more than two multivariate normal populations, Fuisher-Behren Problem
Block 3	**Advance Multivariate Analysis**
Unit VIII	**Advance Analysis** Inadmissibility of maximum likelihood estimator of mean vector of multivariate normal distribution when dimension is greater than three, James-Stein estimator of the mean vector and improved estimation of dispersion matrix of a MND
Unit IX	**Principle Component Analysis** Principle components, Principle component analysis, their maximum likelihood estimators and sample variances, canonical correlation and variable, Interference on canonical correlations
Unit X	**Factor Analysis** Factor analysis, linear factor models, estimation of factor loadings, factor rotation, estimation of factor scores.
Unit XI	**Tests of Hypothesis** Tests of hypothesis of equality of covariance matrices, sphericity tests for covariance matrix, mean vector and covariance matrix are equal to given vector and matrix.
Unit XII	**Linear Regression Model** Multivariate linear regression model, estimation of parameters and their properties. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambdacriterion.

Suggested Text Book Readings:

- Anderson T.W. (1984) An introduction to multivariate statistical analysis, 2nd Ed., J.Wiley.
- Eaton M.L. (1983) Multivariate statistics-a vector space approach, J. Wiley.
- Giri N.C. (1977) Multivariate statistical inference, Academic Press.
- Kshirsagar A.M. (1972) Multivariate analysis, Marcel Dekker.
- Morrison D.F. (1976). Multivariate statistical methods, McGraw Hill.
- Muirhead, R. J. (1982) Aspects of multivariate statistical theory, J. Wiley.
- Rao C.R. (1973) Linear statistical inference and its applications, J. Wiley.
- Roy S.N. (1957) Some aspects of multivariate analysis, J. Wiley.
- Srivastava M.S. and Khatri C.G. (1979)An introduction to multivariate statistics, NorthHolland.

This course can be opted as an elective by the students of following subjects:
P.G. inlife sciences,Medical Sciences, Bio Statistics students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.			
Programme: M.Sc./M.A.		**Year:** II	**Semester:** III
Subject: Statistics			
Course Code: ***MScSTAT-303N / MASTAT-303N***		**Course Title:** ***Econometrics***	
Course Objectives: To introduce learners to the analysis of observations on several correlated random variables for a number of individuals. Such analysis becomes necessary in Anthropology, Psychology, Biology, Medicine, Education, Agriculture and Economics when one deals with several variables simultaneously. To understand the quantitative methods used in Social, educational, business and management studies.			
Course Outcomes: **CO1:**Learn about the basic concepts of econometrics. **CO2:**Acquire knowledge of various advanced econometric models, estimation methods and related econometric theories. Conduct econometric analysis of data. **CO3:**Apply statistical techniques to model relationships between variables and make predictions. **CO4:** Understand Auto-covariance, auto-correlation function and Vector Autoregression. Understand Correlogram and Periodogram analysis and different Smoothing methods.			
Credits: 4		**Type of Course:** Core	
Max. Marks: 100		**Min. Passing Marks:** 36	

Block 1	**Linear Model and its generalizations**
Unit I	**Linear regression models:** Linear regression model. Assumptions, estimation of parameters by least squares and maximum likelihood methods. LOGIT, PROBIT, TOBIT and multinomial choice models, passion regression models.
Unit II	**Multicollinearity** Multicollieearity, problem of multicollinearity, consequences and solutions, regression and LASSO estimators.
Unit III	**Estimation of parameters and prediction** Testing of hypotheses and confidence estimation for regression coefficients, R^2 and adjusted R^2, point and interval predictors.
Unit IV	**Model with qualitative independent variables:** Models with dummy independent variables, discreet and limited dependent variables. Use of dummy variables, model with non-spherical disturbances, estimation of parametric by generalized equation.
Unit V	**Non-spherical disturbances** Seemingly unrelated regression equations (SURE) model and its estimation, Panel data models, estimation in random effect and fixed effect models.
Block 2	**Simultaneous Equations Models and Forecasting**
Unit VI	**Structural and reduced form of the model and identification problem** Simultaneous equations model, concept of structural and reduced forms, problem of identification, rank and order conditions of identifiability.
Unit VII	**Estimators in simultaneous equation models** Limited and full information estimators, indirect least squares estimators, two stage least squares estimators, three stage least squares estimators and k class estimator.
Unit VIII	**Estimation in simultaneous equation models** Limited information maximum likelihood estimation, full information maximum likelihood estimation, prediction and simultaneous confidence interval.
Unit IX	**Forecasting** Forecasting, exponential and adaptive smoothing methods, pereiodogram and correlogram analysis.
Unit X	**Instrumental Variable Estimation**

	Review of GLM, analysis of GLM and generalized leased square estimation, Instrumental variables, estimation, consistency properties, asymptotic variance of instrumental variable estimators.
Block 3	**Advance Econometrics**
Unit XI	**Autoregressive Process:** Moving average (MA), Auto regressive (AR), ARMA and ARMA models, Box-Jenkins models, estimation of ARIMA model parameters, auto covariance and auto correlation function
Unit XII	**Vector Autoregressive Process:** Multivariate time series process and their properties, vector autoregressive (VAR), Vector moving average (VMA) and vector autoregressive moving average (VARMA) process
Unit XIII	**Granger Causality:** Granger causality, instantaneous Granger causality and feedback, characterization of casual relations in bivariate models, Granger causality tests, Haugh-Pierce test, Hsiao test.
Unit XIV	**Cointegration:** Cointegration, Granger representation theorem, Bivariate cointegration and cointegration tests in static model.

Suggested Text Book Readings:

- Apte PG (1990); Text book of Econometrics. Tata McGraw Hill.
- Cramer, J.S. (1971) : Empirical Econometrics, North Holland.
- Gujarathi, D (1979) : Basic Econometrics, McGraw Hill.
- Intrulligator, MD (1980) : Econometric models - Techniques and applications, Prentice Hall of India.
- Johnston, J. (1984) : Econometric methods, Third edition, McGraw Hill.
- Klein, L.R. (1962) : An introduction to Econometrics, Prentice Hall of India.
- Koutsoyiannis, A (1979) : Theory of Econometrics, Macmillan Press.
- Malinvaud, E (1966) : Statistical methods of Econometrics, North Holland.
- Srivastava, V.K. and Giles D.A.E (1987) : Seemingly unrelated regression equations models,
- Maicel Dekker, Theil, H. (1982) : Introduction to the theory and practice of Econometrics, John Wiley.
- Walters, A (1970) : An introduction to Econometrics, McMillan & Co.
- Wetherill, G.B. (1986) : Regression analysis with applications, Chapman Hall.

This course can be opted as an elective by the students of following subjects:
P.G. inmanagement, commerce and business students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Learner can join this for their own knowledge:

1. *https://onlinecourses.nptel.ac.in/noc*, Introduction to Applied Statistics and Econometrics, Prof. Shalabh

2. *https://onlinecourses.nptel.ac.in/noc*, Econometric Modelling, Prof. Sujata Kar

3. *https://onlinecourses.nptel.ac.in/noc*, Spatial Statistics and Spatial, Prof. Gaurav Arora

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.

Programme: M.Sc./M.A.	**Year:** II	**Semester:** III

Subject: Statistics

Course Code: ***PGRT-03***	**Course Title:** ***Basics Research Tools***

Course Objectives: The main objective of this course is to develop a research orientation among the scholars and toacquaint them with fundamentals of basic computer tools,research tools, indexing of research paper and scientific report writing.

Course Outcomes:
CO1: To know about the research tools and indexing of a research paper.
CO2: To know about the fundamentals of basic computer tools and how to use it in research.
CO3: Able to know the writing the research paper and scientific report writing.

Credits: 4	**Type of Course:** Core
Max. Marks: 100	**Min. Passing Marks:** 36

Block 1	**Introduction to Research Tools**
Unit I	**Research Tools** Introduction, Researchtools:Searchinggoogle(querymodifiers),MathSciNet,ZMATH.
Unit II	**Indexing of Research Paper** Scopus,ISI,WebofScience,Impactfactor,h-index,GoogleScholar,ORCID,Onlineandopenaccessjournals,Virtuallibrary of various countries.
Unit III	Reference management tools Uses and application of Mendeley-software, EndNote, RefWorks and Zotero, etc.
Block 2	**Computer tools and software**
Unit IV	**Basic computer tools** ComputerNetworking,Internet,WebBrowsers,SearchEngines,MSWord:Handlinggraphic stablesandcharts,FormattinginMS-Word,MSPowerPoint: Creating Slide Show, Screen Layout and Views, Applying DesignTemplate, MSExcel: Features,Formulas and Functions, Data Analysis and Data Visualizationin Excel.
Unit V	**Scientific Report Writing** Scientificwritingandpresentation,writingaresearchpaper,surveyarticle,thesis writing; LaTeX, PS Tricks etc., use and application of Mendeley-software,
Unit VI	Uses and application of Softwares such as plagiarism software, Origin, SPSS, R-software, Octave, MATLAB, STATA, software Mathematica/MATLAB/Scilab/GAP.etc.

Suggested Text Book Readings:

1. C.R. Kothari, Gaurav Garg. Research Methodology: Methods and Techniques, New Age International Publishers, 2019.
2. Kumar. R: Research Methodology: A Step-by-Step Guide for Beginners, (3^{rd} Edition), SAGE, Inc., 2011.
3. Creswell. W.: Research Design, Qualitative, Quantitative and Mixed Methods Approaches (3^{rd}Edition), SAGE,Inc., 2018.
4. Shortis,T.:TheLanguageofICT:InformationandCommunicationTechnology,Taylor&Francis,2016.
5. Lamport.L.,LaTeX,aDocumentPreparationSystem,2^{nd} Ed.,Addison-Wesley,1994.
6. Shortis,T.:TheLanguageofICT:InformationandCommunicationTechnology,Taylor&Francis,2016 .https://onlinecourses.swayam2.ac.in/cec22_ge28/preview

Note:- In this paper, learner itself study the objectives and prepare a report. The report will be submitted along with assignment to respective study center for evaluation. The maximum marks for evaluation are 100.

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.			
Programme: M.Sc./M.A.		**Year:** I	**Semester:** I
Subject: Statistics			
Course Code: ***MScSTAT-305P /MASTAT -305P***		**Course Title:** ***Practical and Viva voce***	
Course Objectives: The main objective of this course is to develop askill to: understand the practical methods and tests related to estimation of real-life data.			
Course Outcomes: **CO1:** Learner should able to solve the numerical problems related with decision theory **CO2:** Learner should able to solve the numerical problems related with Bayesian analysis. **CO3:** Learner should able to solve the numerical problems related with multivariate analysis.. **CO4:**Learner should able to solve the numerical problems related with econometrics.			
Credits: 4	**Type of Course:** Core		
Max. Marks: 100	**Min. Passing Marks:** 36		
Practical based on MScSTAT-301N, 302N and 303N/MASTAT-301N, 302N and 303N			

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: II</td><td>Semester: IV</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT-401N / MASTAT-401N</td><td colspan="2">Course Title: Demography</td></tr>
<tr><td colspan="4">Course Objectives: The main objective of the course is to describe current population trends, in terms of fertility, mortality and population growth and the concepts of stable and stationary population and also to provide understanding of mathematical challenges from a purely applied perspective for a majority of random processes in terms of sequence of event-time pairs.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1: Identify principle sources of demographic data and assess their strengths and weaknesses. Discuss the demographic significance of age structures and the implications of variations in age structure.
CO2: Specify and calculate the principal demographic measures, and standardize these measures for comparison and interpretation.
CO3: Construct and interpret single-decrement life tables. Do population projection by different methods.
CO4:Identify the components of population change, including the effects of changing birth,death and migration rates, and demonstrate their influences on age structure.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Core</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Block 1</td><td colspan="3">Migration</td></tr>
<tr><td>Unit I</td><td colspan="3">Introduction, Estimation of life time and inter-censal migration from place of birth statistics, estimation of internal migration from statistics on duration of residence, at a fixed poor date.</td></tr>
<tr><td>Unit II</td><td colspan="3">Indirect measure of net internal migration based on growth rate method, methods to Estimate intercensal migration-using vital statistics, life time survival ratio method and census survival methods, estimation of international migration.</td></tr>
<tr><td>Block 2</td><td colspan="3">Stable Population Theory</td></tr>
<tr><td>Unit III</td><td colspan="3">Introduction, basic concepts of stable, quasi-stable, stationary and non-stable populations, vital rates and characteristics of stationary stable population and quasi-stable population.</td></tr>
<tr><td>Unit IV</td><td colspan="3">Definition of intrinsic rates of natural increase, intrinsic birth rate and intrinsic death rate, their relationship, derivation of Lotka’s formulae of fundamental relationship instable population.</td></tr>
<tr><td>Unit V</td><td colspan="3">Computation of intrinsic rate of natural increase and construction of stable age distribution from the given fertility and mortality schedules, relationship between net reproduction rate(NRR), intrinsic rate of natural increase and mean length of generation, concept of mean interval between two generations.</td></tr>
<tr><td>Block 3</td><td colspan="3">Fertility & Fertility Models</td></tr>
<tr><td>Unit VI</td><td colspan="3">Introduction, crude birth rate (CBR), gross fertility rate (GFR,) age specific fertility rate) ASFR), total fertility rate (TFR), gross reproduction rate (GRR)</td></tr>
<tr><td>Unit VII</td><td colspan="3">Period and cohort measures, use of birth order statistics, child women ratio, own-children method, children ever born(CEB) data and with data on current fertility, Brass P/F ration for adjusting fertility rates.</td></tr>
<tr><td>Unit VIII</td><td colspan="3">Simple model on time of first birth/conception and number of births/conception n specified time, birth interval models, study of fertility through birth interval analysis.</td></tr>
<tr><td>Block 4</td><td colspan="3">Mortality</td></tr>
</table>

Unit IX	Introduction, crude death rate (CDR), specific death rates (SDR), standardized death rate (STDR).
Unit X	Life table, abridge life table, model life table of UNO (old and new),coale and demny model, brass model through logit transformation

Suggested Text Book Readings:

- Bartholomew, D. J. (1982). Stochastic Models for Social Processes, John Wiley.
- Benjamin, B. (1969). Demographic Analysis, George, Allen and Unwin.
- Chiang, C. L. (1968). Introduction to Stochastic Processes in Biostatistics; John Wiley.
- Cox, P. R. (1970). Demography, Cambridge University Press.
- Keyfitz, N. (1977). Applied Mathematical Demography; Springer Verlag.
- Spiegelman, M. (1969). Introduction to Demographic Analysis; Harvard University Press.
- Wolfenden, H. H. (1954). Population Statistics and Their Compilation; American Actuarial Society.
- Cox, P. R. (1970). Demography, Cambridge University Press.
- Keyfitz, N. (1977). Applied Mathematical Demography; Springer Verlag.

This course can be opted as an elective by the students of following subjects:
P.G. inpopulation studies, biostatistics, medical students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: II</td><td>Semester: IV</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="3">Course Code: MScSTAT—402N(DW) / MASTAT- 402N(DW)</td><td>Course Title: Dissertation with viva-voce</td></tr>
<tr><td colspan="4">Course Objectives: In the last semester of Masters the main objectives of the exposure of students towards project/dissertation is to elevate their understanding into the applications areas of Mathematics. This course will develop their analytical ability, will provide them an apt exposure to work in any research group, and will motivate them to execute research in the area of their interest.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1:Students will be able to plan and strategize a scientific problem, and implement it within a reasonable time frame.
CO2: It is expected that after completing this project dissertation, students will learn to work independently and how to keep accurate/readable record of assigned project.
CO3: In addition, students will be able to know the library search and handle the data in a meaningful way. Also, the students will be able to interpret the spectral data independently.
CO4: Subsequently, the students should be able to critically examine research articles, and improve their scientific writing/communication skills and power point presentation.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Type of Course: Core</td></tr>
<tr><td colspan="3">Max. Marks: 100</td><td>Min. Passing Marks: 36</td></tr>
<tr><td>Unit I</td><td colspan="3">For project work and dissertation, the area of the work to be decided by the advisor/mentor.
On completion of the project work, students have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty members of the School in the University Campus Prayagraj.</td></tr>
<tr><td colspan="4">Suggested Text Book Readings:
1. Use different searching engine to get relevant information (Google scholar, Wiki-databases, Science Direct, SciFinder, Scopus, and YouTube.
2. Access to different online research library and research portal (Web resources, E-journals, journal access, TOC alerts)</td></tr>
<tr><td colspan="4">This course can be opted as an elective by the students of following subjects: Open for all</td></tr>
<tr><td colspan="4">Suggested equivalent online courses (MOOCs) for credit transfer: NA</td></tr>
</table>

<table>
<tr><td colspan="3">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: II</td><td>Semester: IV</td></tr>
<tr><td colspan="4">Subject: Mathematics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT-403NA / MASTAT – 403NA</td><td colspan="2">Course Title: Survival Analysis and Reliability Theory</td></tr>
<tr><td colspan="4">Course Objectives:The mainaim of this course is to develop the fundamental knowledge and understanding of the survival and reliability theories.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1: Learner will able to understand about the life distributions and Understand the concept of life table
CO2: Discuss about the Kaplan-Meier Estimator, deshpande test and discuss about the concept of hazard rate and cox proportional hazard model, etc etc.
CO3: Discuss about the concept of reliability, reliability functions and measures and Discuses about the concept of Aging.
CO4: Learner should able to understand about the life distributions and reliability growth models and Discuss about the basics idea of accelerated life testing.</td></tr>
<tr><td colspan="2">Credits: 4</td><td colspan="2">Type of Course: Discipline Elective</td></tr>
<tr><td colspan="2">Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td>Block 1</td><td colspan="3">Survival Analysis</td></tr>
<tr><td>Unit I</td><td colspan="3">Basic Concepts:
Concepts of time, Order and random Censoring, likelihood in these cases. Types of Censoring and truncation, Life tables, failure rate, mean residual life and their elementary properties. Ageing classes - and their properties, Bathtub Failure rate. Estimation of survival function - Acturial Estimator, Kaplan -Meier Estimator, log rank tests,</td></tr>
<tr><td>Unit II</td><td colspan="3">Parametric Survival Models:
Assumptions and Characteristics, Life distributions-Exponential Gamma, Weibull, Lognormal, Pareto, Rayleigh, piece-wise exponential etc, Linear Failure rate. Parametric inference (Point estimation, Confidence Intervals, Scores, LR, MLE tests (Rao-Willks-Wald)) for these distributions. Estimation under the assumption of IFR/DFR.</td></tr>
<tr><td>Unit III</td><td colspan="3">Non-Parametric Survival Models:
Assumptions and Characteristics, of exponentiality against non-parametric classes-Total time on test, Deshpande test. Two sample problem-Gehan test, Log rank test. Mantel-Haenszel test, Tarone – Ware tests.</td></tr>
<tr><td>Unit IV</td><td colspan="3">Proportional Hazard Models:
Assumptions and Characteristics, Semi-parametric regression for failure rate - Cox’s proportional hazards model with one and several covariates. Rank test for the regression coefficients. Competing risks model, parametric and non-parametric inference for this model. Multiple decrement life table.</td></tr>
<tr><td>Unit V</td><td colspan="3">Recurrent Event Survival Analysis:
Introduction, Outline and Objective, competing risks survival Analysis, competing risk events and Frailty models</td></tr>
<tr><td>Block 2</td><td colspan="3">Reliability Analysis</td></tr>
<tr><td>Unit VI</td><td colspan="3">Basic Concepts:
Reliability concepts and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.</td></tr>
<tr><td>Unit VII</td><td colspan="3">Ageing:
Concept of Ageing, Ageing classes - and their properties, Notions of ageing; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals;</td></tr>
<tr><td>Unit</td><td colspan="3">Reliability Estimation:</td></tr>
</table>

VIII	Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation
Unit IX	**Repairable Systems:** Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process, preventive maintenance policy, preliminary concepts of coherent systems.
Unit X	**Growth Models and Accelerated Life Testing:** Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing.

Suggested Text Book Readings:

- Cox, D.R. and Oakes, D. (1984) : Analysis of Survival Data, Chapman and Hall, NewYork.
- Gross A.J. and Clark, V.A. (1975) : Survival Distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons.
- Elandt - Johnson, R.E. Johnson N.L. : Survival Models and Data Analysis, John Wiley and Sons.
- Miller, R.G. (1981) : Survival Analysis (John Wiley).
- Kalbfleisch J.D. and Prentice R.L. (1980), The Statistical Analysis of Failure Time Data, John Wiley.
- Barlow R.E. and Proschan F.(1985) Statistical Theory of Reliability and Life Testing; Holt,Rinehart and Winston.
- Lawless J.F. (1982) Statistical Models and Methods of Life Time Data; John Wiley.
- Bain L.J. and Engelhardt (1991) Statistical Analysis of Reliability and Life TestingModels; Marcel Dekker.
- Nelson, W (1982) Applied Life Data analysis; John Wiley.
- Zacks S. Reliability Theory, Springer.

This course can be opted as an elective by the students of following subjects:
P.G. in computer science,life sciences, biostatistics, medical and engineering students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Learner can join this for their own knowledge:*https://onlinecourses.nptel.ac.in/noc,*
Statistical learning for Reliability Analysis, Prof. Monalisa Sarma

Course prerequisites: To study this course, a learner must have full fill all given eligibility criteria by university.			
Programme: M.Sc./M.A.		**Year:** II	**Semester**: IV
Subject: Mathematics			
Course Code: ***MScSTAT-404NA / MASTAT – 404NA***		**Course Title**: ***Actuarial Statistics***	
Course Objectives: The main aim of this course is to develop the fundamental knowledge and understanding of the **advanced techniques in Actuarial Science,** survival and reliability theories **with practical applications in daily life.**			
Course Outcomes: **CO1:** Learner will able to understand about the life distributions and understand the concept of life table **CO2:** Learner will able to understand Tools for applying actuarial methods in phenomena for financial research and insurance. **CO3** Learner will able to understand computation of premiums and settlement of claims. **CO4:**Learner should able to understand about the life distributions and reliability growth models and Discuss about the basics idea of accelerated life testing.			
Credits: 4		**Type of Course: Core Elective/Optional**	
Max. Marks: 100		**Min. Passing Marks:** 36	
Block 1	**Probability Models and Life Tables**		
Unit I	**Basic Concepts:** Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables.		
Unit II	**Utility Theory:** Introduction, Utility functions, Expected utility Criterion of insurance, Types of Utility Functions.		
Unit III	**Survival Distributions and Life Table:** Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables, curtate future lifetime, force of mortality.		
Unit IV	**Multiple Life Functions:** Introduction, Joint Distribution of Future life time, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality law.		
Unit V	**Application of Multiple Decrement Theory:** Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.		
Block 2	**Insurance and Annuities**		
Unit VI	**Fundamentals of computation of Interest Rate:** Principles of compound interest. Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.		
Unit VII	**Life Insurance:**		

	Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, diferred insurance and varying benefit insurance, recursions, commutation functions.
Unit VIII	**Life Annuities:** Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.
Unit IX	**Net premiums:** Continuous and discrete premiums, true monthly payment premiums, apporionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits.
Unit X	**Net premium reserves:** Continuous and discrete net premium reserve, reserves on a semicontinuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.
Unit XI	**Some practical considerations:** Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.
Suggested Text Book Readings: • Dickson, C. M. D. (2005). Insurance Risk and Ruin (International Series no.1 Actuarial Science), Cambridge University Press. Bowers, N. L., Gerber, H. U., Hickman. • Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A.	
This course can be opted as an elective by the students of following subjects: P.G. in commerce, economics, business students etc.	
Suggested equivalent online courses (MOOCs) for credit transfer: NA	

<table>
<tr><td colspan="4">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td colspan="2">Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: I</td></tr>
<tr><td colspan="4">Subject: Statistics</td></tr>
<tr><td colspan="2">Course Code: MScSTAT-405PA /MASTAT -405PA</td><td colspan="2">Course Title: Practical and Viva voce</td></tr>
<tr><td colspan="4">Course Objectives:The main objective of this course is to develop askill to: understand the practical methods and tests related to estimation of real-life data.</td></tr>
<tr><td colspan="4">Course Outcomes:
CO1: Learner should able to solve the numerical problems related with Demography
CO2: Learner should able to solve the numerical problems related with survival analysis.
CO3: Learner should able to solve the numerical problems related with reliability theory..
CO4:Learner should able to solve the numerical problems related with actuarial statistics.</td></tr>
<tr><td>Credits: 4</td><td colspan="3">Type of Course: Discipline Elective</td></tr>
<tr><td>Max. Marks: 100</td><td colspan="3">Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Practical based on MScSTAT-401N,403NA and 404NA/MASTAT-401N,403NA and 404NA</td></tr>
</table>

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.		
Programme: M.Sc./M.A.	**Year:** II	**Semester**: IV
Subject: Mathematics		
Course Code: ***MScSTAT-403NB / MASTAT – 403NB***	**Course Title**: ***Operation Research***	
Course Objectives: The main aim of this course is to develop the fundamental knowledge and understanding of theories and techniques of solving operations research problems in linear programming, inventory, simulation, queuing and reliability theory..		
Course Outcomes: **CO1:** Learner will able to Identify and develop operational research models from the verbal description of the real system **CO2:**Understand the characteristics of different types of decision-making environments and decision making approaches. **CO3:**Understand the mathematical tools that are needed to solve optimization problems. Analyze the queueing and inventory situations. **CO4:**Understand discrete event simulation and decision analysis with inclusion of modeling based on random events involving uncertainties and Able to know the inventory, queuing and replacement models with their real life applications.		
Credits: 4	**Type of Course: Discipline Elective**	
Max. Marks: 100	**Min. Passing Marks:** 36	

Unit I	**Introduction to Operation Research** Introduction, Definitions, Approaches and Scientific Methods of Operations Research, Modeling andClassifications of Operations Research, Advantages and Limitations of Modeling in Operation Research, Solutions for the Operations Research Models, Methodologies of Operations Research, Applications of Operations Research, Future Prospects and Limitations of Operations Research
Block 1	**Linear & Non-Linear Programming**
Unit II	**Introduction to Linear Programming Problem** Review of LP Problems, Methods of Solution, Duality Theorem, Transportations & AssignmentProblems with Proof of Relevant Results
Unit III	**Further Advancement in Linear Programming Problem :** Methods Using Artificial Variables, Two Phase and Penalty, Degeneracy & Cycling, Sensitivity Analysis
Unit IV	**Non-Linear Programming Problem**: Non-Linear Programming, Kutin Tucker Theorem, Wolfe’s and Beale’s Algorithm for Solving Quadratic Programming, Bellman’s Principle of Optimality.
Block 2	***Theory of Games & Sequencing & Network Analysis***
Unit V	**Theory of Games:** Games in Normal and Extended forms, Fundamental Theorem of Matrix Games, Solution of 2x2. 2xm and Mxn Zero-sum games by Dominance Principles
Unit VI	**Introduction to Sequencing Problem:** Sequencing and Scheduling Models, 2 Machin, n-Job Problem (no passing), 3 machine, n-job problems, different routing- 2 jobs & m stations, travelling sales-man problem..
Unit VII	**CPM and PERT:** Introduction to networks, determination of flows and of critical paths, CPM & PERT;
Block 3	***Queuing Theory***

Unit VIII	**Markovian Queuing Models:** Queuing models- Specification & Effectiveness Measures, the $E_k/M/1$, $M/E_k/1$; M/M/1; M/M/c & M/G/1 Queses, and their Steady State Solutions
Unit IX	**Non-Markovian Queuing Models:** Machine Interference Problem, Waiting Time Distribution for M/M/1 and M/M/C models.
Block 4	***Replacement Problem***
Unit X	**Replacement of Items that Deteriorate with Time:** Replacement Problems, Replacement of items that Depreciate, Discounted Cash Flow in Investment Problems.
Unit XI	**Replacement of Items that Fail Suddenly:** Replacement of items Failing According to a Probability Law; block and age replacement policies, Staffing Problem, Dynamic Programming Approach for Maintenance Problems.

Suggested Text Book Readings:

- Taha H.A. (1982) Operational Research: An Introduction; Macmillan.
- Hillier F.S. and Leiberman G.J. (1962) Introduction to Operations Research; Holden Day.
- Kanti Swarup, Gupta,P.K. and Singh,M.M.. (1985) Operations Research; Sultan Chand & Sons.
- Philips D.T.,Ravindran A. and Solberg J.( ) Operations Research, Principles and Practice.
- Churchman C.W., Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research; John Wiley.
- Hadley G. (1964) Non-linear and Dynamic programming;
- Addison Wesley Murthy K.G. (1976) Linear and Combinatorial Programming;
- John Wiley Kleinrock L. (1975) Queueing Systems, vol. 1, Theory;
- John Wiley Saaty T.L. (1961) Elements of Queueing Theory with Applications; McGraw Hill
- Hadley G. and Whitin T.M. (1963) Analysis of Inventory Systems; Prentice Hall
- Starr M.K. and Miller D.W. (1962) Inventory Control-Theory and Practice; Prentice Hall
- Mckinsey J.C.C. (1952) Introduction to the Theory of Games; McGraw Hill
- Wagner H.M. (1973) Principles of O.R. with Applications to Managerial Decisions; Prentice Hall
- Gross, D. Harris,C.M. (1974) Fundamentals of Queueing Theory; John Wiley

This course can be opted as an elective by the students of following subjects:
P.G. in computer science,Data science, Mathematics, MBA and engineering students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

Learner can join this for their own knowledge:*https://onlinecourses.nptel.ac.in/noc,*
Operations Research, Prof. Kusumdeep

Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.		
Programme: M.Sc./M.A.	**Year:** II	**Semester**: IV
Subject: Mathematics		
Course Code: ***MScSTAT-404NB / MASTAT – 404NB***	**Course Title**: ***Mathematical and Real Analysis***	
Course Objectives: The main aim of this course is to develop the fundamental knowledge and understanding of the mathematical and real analysis theories.		
Course Outcomes: **CO1:**Understand convergence of sequence and series of real valued function and complexvalued functions, multiple integral into line integral, maxima-minima of functions of several variables, residue at singularity and infinity via definition and via Cauchy integral formula and also understand existence of integral and their evaluation **CO2:**Find residue at singularity and infinity via definition and via Cauchy integral formulaetc. **CO3:**Learner should able to understand the concept of Riemann Stieltjes Integrals, Fourier Series and Functions of Bounded Variation. **CO4:**Learner should able to understand the concept of Metric Spaces & Continuity.		
Credits: 4	**Type of Course: Discipline Elective**	
Max. Marks: 100	**Min. Passing Marks:** 36	

Block 1	**Riemann Stieltjes Integrals, Fourier Series and Functions of Bounded Variation**
Unit I	**Riemann Stieltjes Integrals:** Absolutely continuous functions. Riemann Stieltjes integrals. Basic theorems. Definitions, Linear properties, integration by parts, change of variable in . Riemann Stieltjes integrals, upper and lower integrals, necessary and sufficient conditions for existence of . Riemann Stieltjes integrals, integral as a function of parameters, differentiation under the integral sign.
Unit II	**Fourier Series:** Fourier Series, orthogonal system of functions, Fourier series of a function relative to an orthogonal system, properties of Fourier Coefficients, Reusz- Fischar theorem, convergence and representation problems for Fourier Metric Series, Sufficient conditions for convergence of Fourier Series at a particular point
Unit III	**Bounded Variation:** Functions of bounded variation, total variation, function of bounded variation expressed as the difference of increasing functions, continuous functions of bounded variation, Absolutely continuous functions.
Block 2	**Metric Spaces & Continuity**
Unit IV	**Metric Spaces:** Metric Spaces, open and closed sets, limit and cluster points, Cauchy Sequences and completeness, Convergence of sequences, Completeness of R”. Baire’s theorem. Cantor’s ernary set as example of a perfect set which is now here dense.
Unit V	**Continuity:** Continuity and uniform continuity of a function from a Metric space to a Metric space. Open and closed maps, Compact spaces and compact sets with their properties. Continuity and compactness under continuous maps
Unit VI	**Analytic Functions and Transformation:** Analytic function, Cauchy-Riemann equations, Cauchy equation formula, its applications, Fourier and Laplace transforms.
Block 3	**Real Analysis**
Unit VII	**Basic Concepts:** Recap of elements of set theory; Introduction to real numbers, Introduction to n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano - Weirstrass theorem, Heine – Borel theorem;
Unit VIII	**Sequences and Series:**

	Sequences and series; their convergence. Taylor’s Series, Real valued functions, continuous functions; uniform continuity, sequences of functions, uniform convergence; Power series and radius of convergence, Singularities, Laurent Series
Unit IX	**Integration:** Differentiation, maxima - minima of functions; functions of several variables, constrained maxima - minima of functions, Multiple integrals and their evaluation by repeated integration. change of variables in multiple integration. Uniform convergence in improper integrals, differentiation under the sign of integral - Leibnitz rule, Residue and contour integration.

Suggested Text Book Readings:

- Apostol, T. M. (1985). Mathematical Analysis, Narosa, Indian Ed. Courant,
- R. and John, F. (1965). Introduction to Calculus and Analysis, Wiley.
- Miller, K. S. (1957). Advanced Real Calculus, Harper, New York.
- Rudin, Walter (1976). Principles of Mathematical Analysis, McGraw Hill.

This course can be opted as an elective by the students of following subjects:
P.G. in computer science,life sciences, biostatistics, medical and engineering students etc.

Suggested equivalent online courses (MOOCs) for credit transfer: NA

<table>
<tr><td colspan="3">Course prerequisites: For the study of the said course, the learner must fulfill all the eligibility criteria prescribed by the university for the concerned course.</td></tr>
<tr><td>Programme: M.Sc./M.A.</td><td>Year: I</td><td>Semester: I</td></tr>
<tr><td colspan="3">Subject: Statistics</td></tr>
<tr><td>Course Code: MScSTAT-405PB /MASTAT -405PB</td><td colspan="2">Course Title: Practical and Viva voce</td></tr>
<tr><td colspan="3">Course Objectives:The main objective of this course is to develop askill to: understand the practical methods and tests related to estimation of real-life data.</td></tr>
<tr><td colspan="3">Course Outcomes:
CO1: Learner should able to solve the numerical problems related with Demography
CO2: Learner should able to solve the numerical problems related with Operation Research.
CO3: Learner should able to solve the numerical problems related with Mathematical Analysis.
CO4: Learner should able to solve the numerical problems related with Real Analysis.</td></tr>
<tr><td>Credits: 4</td><td colspan="2">Type of Course: Discipline Elective</td></tr>
<tr><td>Max. Marks: 100</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td colspan="3">Practical based on MScSTAT-401N,403NB and 404NB /MASTAT-401N403NB and 404NB</td></tr>
</table>