SantGadgeBabaAmravatiUniversity,Amravati

FACULTY :

Scheme of Teaching, Learning, Examination & Evaluation leading toTwoYears PG Degree Master of Statistics following Three Years UG Programme wef 2023-24

(TwoYears-Four Semesters Master's Degree Programme-NEPv23with Exit and Entry Option

M.S c . I ---(-Statistics------)First Year Semester-I

S. N.	Subject	Typeof Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination&EvaluationScheme							
				TeachingPeriod PerWeek				Credits				MaximumMarks					MinimumPassing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		MarksI nternal	Marks External	Grade
0	*Pre-Requisite Course(s) ifapplicable/MOOC/Internship/FieldWorkcumulatively IfstudentswishtooptMinorCourseofUG as Major for PG, **balance 12Credits** Course will have to becompleted **(Asandwhenapplicable)**	**Th-Prq**		**0**	**0**	**0**	**0**	**AdditionalCreditstobeearned = (1) minus(2) (1).CreditsfromMajorDSCCourses in UG (minus) (2).The Credits alreadyearned from the Courseas Minor at UG, now tobeoptedasMajoratPG**			**2**	**15**	**35**			**50**	**06**	**14**	**P**
1	ResearchMethodology andIPR	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
2	DSC-I.1Probability Theory	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
3	DSC-II.1Estimation Theory	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
	DSC-III.1 Sampling Theory	**Th-Major**		**3**			**3**	**3**		**3**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
4	DSE-I Industrial Statistics	**Elective**		**3**			**3**	**3**		**3**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
	DSE- II Time Series																		
	DSE III Demography DSE IV Real Analysis & Measure Theory																**MinimumPassing Marks**		**Grade**
5	DSC-I.1(Lab-I Based on DSCI.I & DSC II.I)	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**40**	**60**	**100**	**40**		**P**
		Pr-Major				**2**	**2**		**1**	**1**	**3**								**P**
6	DSC-II.1(Lab-II Based on DSC III.I & DSE)	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**40**	**60**	**100**	**40**		**P**
7	DSE-ILaboratory/MOOCLab	**Pr-MajorElective**				**2**	**2**		**1**	**1**	**3**								**P**
8	#OnJobTraining,Internship/Apprenticeship;Fieldprojects**Related to Major @ during vacationscumulatively**	**Relatedto DSC**		**120Hourscumulatively duringvacationsofSemesterIand Semester II**						**4***									**P***
9	**Co-curricularCourses:Healthandwellness, Yoga Education, Sportsand Fitness, Cultural Activities,NSS/NCC, Fine/Applied/Visual/PerformingArts DuringSemesterI,II,IIIandIV**	Generic **Optional**		**90HoursCumulatively FromSemItoSemIV**															
	TOTAL									**22**						**600+50***			

L:Lecture,T:Tutorial,P:Practical/Practicum

Pre-requisiteCoursemandatoryifapplicable:**Prq**,Theory:**Th**,Practical/Practicum:**Pr**,FacultySpecificCore:**FSC**,DisciplineSpecificCore:**DSC**,DisciplineSpecificElective:**DSE**,Laboratory:**Lab**,**OJT:**OnJobTraining:Internship/Apprenticeship;Fieldprojects:**FP**;**RM:**Research Methodology;ResearchProject:**RP,Co-curricularCourses:CC**

Note :#OnJobTraining, Internship/Apprenticeship;Fieldprojects**RelatedtoMajor (DuringvacationsofSemesterIandSemesterII)fordurationof120hoursmandatorytoallthe students, tobecompletedduringvacationsofSemesterIand/orII. This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in SemesterII credit grade report.**

Note: **Co-curricular Courses:** In addition to the above, CC also includebut not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Shortterm course,ScientificSurveys,SocietalSurveys,FieldVisits,Studytours,IndustrialVisits,online/offlineCoursesonYoga(YogaforIQdevelopment,YogaforEgodevelopment,YogaforAngerManagement,YogaforEyesightImprovement,YogaforPhysicalStamina, YogaforStress Management,etc.).Thesecanbecompletedcumulativelyduring**Semester I,II, III andIV. Its credits and grades will be reflected in semesterIV credit grade report.**

Sant Gadge Baba Amravati University,
Amravati FACULTY :
Scheme of Teaching, Learning,Examination&EvaluationleadingtoTwoYearsPGDegreeMasterof------(----------)followingThreeYearsUGProgrammewef2023-24
(TwoYears-FourSemestersMaster'sDegreeProgramme-NEPv23with**ExitandEntryOption**
M.Sc.(Statistics) First Year Semester-II[Level6.0]

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	DSC-I.2 Testing of Hypothesis	**Th-Major**		4			4	4		4	3	30	70			100	12	28	P
2	DSC-II.2 Distribution Theory	**Th-Major**		4			4	4		4	3	30	70			100	12	28	P
3	DSC-III.2 Design of Experiment	**Th-Major**		3			3	3		3	3	30	70			100	12	28	P
4	DSE-II/MOOC Survival Analysis	**Th-MajorElective**		3			3	3		3	3	30	70			100	12	28	P
	DSE II Data Mining																		
	DSEII Statistical Genetics																		
	DSE II Order Statistics																Minimum Passing Marks		
5	DSC-I.2Lab 1(based on DSC I.2 and DSCII.2)	**Pr-Major**				2	2		1	1	3			40	60	100	40		P
6		**Pr-Major**				2	2		1	1	3								P
7	DSC-III.2Lab 2 based on DSC III.2 and DSE)	**Pr-Major**				2	2		1	1	3			40	60	100	40		P
8	DSE-II Laboratory/MOOC Lab	**Pr-Major Elective**				2	2		1	1	3								P
9	#On Job Training, Internship/ Apprenticeship; Field projects **Related to Major@during vacations cumulatively**	**Related to Major**		**120Hourscumulativelyduringvacationsof Semester I And Semester II**						**4***									**P***
8	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities ,NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I,II,III and IV**	Generic **Optional**		**90HoursCumulativelyFrom SemItoSemIV**															
				Exit Option with a P G Diploma with 4 Credits On-the-job training/internship in the respective Major subject • **Student has to earn Total minimum 4 Credits cumulatively during Vacations of Semester I and Semester II from internship in order to exit after First Year with PG Diploma (42-44 Credits) after Three Year UG Degree**														
	TOTAL									**18+4***						**550**			

L:Lecture,T:Tutorial,P:Practical/

Pre-requisite Course mandatory if applicable:**Prq**,Theory:**Th**,Practical/Practicum:**Pr**,FacultySpecificCore:**FSC**,Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/Apprenticeship; Field projects :**FP**; **RM**

: Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note:#On JobTraining, Internship/Apprenticeship;Fieldprojects**RelatedtoMajor(DuringvacationsofSemesterIandSemesterII)fordurationof120hoursmandatorytoallthestudents, tobecompletedduringvacationsofSemesterIand/orII.**

This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School /

Shortterm course,ScientificSurveys,SocietalSurveys,FieldVisits,Studytours,IndustrialVisits,online/offline Courses on Yoga(Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina,

Yoga for Stress Management ,etc.).These can be completed cumulatively during **Semester I,II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University Amravati
FACULTY :
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(Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**
M.S c . (Statistics) Second Year Semester- III

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory+ MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	Contemporary Applied Technological Advancements in Research relevant/supportive to Major DSC-I.3 Statistical Inference	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
2	DSC-II.3 Mathematical Programming	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
2	DSC-III.3 Linear & Non linear Modelling	**Th-Major**		**3**			**3**	**3**		**3**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
3	DSE-III /MOOC Operations Research	**Th-Major Elective**		**3**			**3**	**3**		**3**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
	DSE III Bioassay																		
	DSE III Econometrics DSE III Acuarial Statistics																**Minimum Passing Marks**		
4	DSC-I.3 Lab/Pr	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
5	DSC-II.3 Lab	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
5	DSC-III.3 Lab	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
6	DSE-III Lab /MOOC Lab	**Pr-Major Elective**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
7	**Research Project Phase-I**	**Major**			**2**	**4**	**6**	**2**	**2**	**4**				**50**	**--**	**50**	**25**		**P**
8	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
	TOTAL									**22**						**500**			

L: Lecture, T: Tutorial, P: Practical/Practicum
Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University, Amravati
FACULTY :
Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of ------(--------) following Three Years UG Programme wef 2023-24
(Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**

M. --- (----------) Second Year Semester- IV [Level 6.5]

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory+ MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	DSC-I.4 Computational Statistics	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
2	DSC-II.4 Multivariate analysis	**Th-Major**		**4**			**4**	**4**		**4**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
3	DSC- III.4 Stachastic Processes	**Th-Major**		**3**			**3**	**3**		**3**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
4	DSE-IV /MOOC Bayesian Inference	**Th-Major Elective**		**3**			**3**	**3**		**3**	**3**	**30**	**70**			**100**	**12**	**28**	**P**
	DSE IV Statistical Ecology																		
	DSE IV Regression Analysis DSE IV Reliability Theory																**Minimum Passing Marks**		
5	DSC-I.4 Laboratory	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
6	DSC-II.4 Laboratory	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
7	DSC-III.4 Laboratory	**Pr-Major**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
8	DSE-IV Laboratory/MOOC Lab	**Pr-Major Elective**				**2**	**2**		**1**	**1**	**3**			**25**	**25**	**50**	**25**		**P**
9	**Research Project Phase-II**	**Major**			**2**	**8**	**10**	**2**	**4**	**6**	**3**			**75**	**75**	**150**	**75**		**P**
10	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
	TOTAL									**24**						**600**			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Table: Comprehensive Credits distribution amongst the type of Courses over Two Years (Four Semesters) PG Programme and Minimum Credits to be earned for PG Degree [Master in Faculty ----------Major-----]

Sr. No.	Type of Course		Total Credits Offered	Minimum Credits Required
1	**MAJOR**			
	i. DSC	**56**		**56**
	ii. DSE	**16**		**16**
		TOTAL	**72**	**72**
2	**Research Methodology and IPR (FSC/DSC: Major)**	**04**	**04**	**04**
2	On Job Training, Internship/ Apprenticeship; Field projects **Related to Major**	**04**	**04 for 120 Hours OJT/FP cum.**	**02 (Minimum 60 Hours OJT/FP is mandatory)**
3	**Research Project**	**10**	**10**	**10**
	OPTIONAL			
4	**Co-Curricular Courses (offline and/or online as applicable): Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts,** CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.).		**Limited to Maximum 03 only** **(For 90 Hours of CC cumulatively)**	**00**
	TOTAL			
	TOTAL		**93**	**88**

Table A: Comprehensive Credit Distribution for CC

S. N.	Activities (offline/online as applicable)	Credits at Levels						Letter Grade
		College	University	State	Zone if exist	National	International if exist	
1	Health and wellness, Yoga* Competitions *If a Course (online/offline) on Yoga is completed for 60 Hours, 2 credits will be awarded to the student (1 Credit = 30 Hours)	1	2	3	4	5	6	P (Pass)
2	Unnat Bharat Abhiyan [UBA]	1	2	3	4	5	6	P (Pass)
3	Sports and fitness activities (see separate **Table B**)	1	1 / 2	2 / 3	3 / 4	4 / 5	5 / 6	P (Pass)
4	Cultural activities, Fine/Applied/Visual/Performing Arts	1	2	3	4	5	6	P (Pass)
5	N.S.S. activities Camps	1	2	3	4	5	6	P (Pass)
6	Academic activities like Research Paper/Article/Poster presentations, Aavishkar, start-up, Hackathon, Quiz competitions, other curricular, co-curricular activities, students exchange programme etc. Research Paper/Article published	1 --	2 1	3 2	4 -	5 4	6 6	P (Pass) P (Pass)
7	Participation in Summer school/ Winter School / Short term course (not less than 30 hours 1 or 2 weeks duration) (not less than 60 hours 2 or 3 weeks duration) Scientific Surveys, Societal Surveys Field Visits, Study tours, Industrial Visits,	2 Credits 4 Credits 2 Credits 1 Credit						P (Pass) P (Pass) P (Pass) P (Pass)
8	NCC Activities	As given in **Table C**						

Table B: Credit Distribution for Sports and Fitness

Sr. No.	Particulars of Sports Status (Individual/ Team)	Credits	Letter Grade
1	College Level Participation	1	P (Pass)
2	University Level Participation	1	P (Pass)
3	University Level Rank 1, 2, 3	2	P (Pass)
4	State Level Participation	2	P (Pass)
5	State Level Rank 1, 2, 3	3	P (Pass)
6	Zonal Level Participation	3	P (Pass)
7	Zonal Level Rank 1, 2, 3	4	P (Pass)
8	National Level Participation	4	P (Pass)
9	National Level Rank 1, 2, 3	5	P (Pass)
10	International Level Participation	5	P (Pass)
11	International Level 1,2,3	6	P (Pass)

Table C: Credit Distribution for NCC activities

Sr. No.	Particulars of NCC Activities	Credits	Letter Grade
1	Participation in NCC activities	1	P (Pass)
2	'B' Certificate obtained	2	P (Pass)
3	'C' Certificate obtained	3	P (Pass)
4	State Level Participation	4	P (Pass)
5	National level Participation	5	P (Pass)
6	International Level Participation	6	P (Pass)

Sant Gadge Baba Amravati University, Amravati

Faculty of Science and Technology
Programme: **M.Sc. Statistics (I & II Semester) (NEPv23)**

Program Outcomes (POs)

At the end of the programme, students would be able to
PO1: **Critical Thinking**: Think critically for data driven solution with advanced Methodology. Students may be able to think critically everything around him/ her. They will be able to take better action in any critical situation in their life.

PO2: Nurture their curious minds toward translation and application & Statistical knowledge to find solutions to real world problems.

PO3: **Employability**: get knowledge and skills in depth necessary for employability of students in industry, Govt Sector and organizations as well as in academics.

PO4: **Empowerment**: be empowered to investigate, solve questions for which answer lies beyond the boundariesof conventional thinking.

PO5: **Effective decision making**: take proper decision in critical and complicated situations. Reduce risk factorand be able to maximize project.

PO6: **Effective citizenship**: get acquainted with the needs of the industry and society, and they become the assets for the society.

PO7: **Social interaction**: Develop sensitivity for social issues and become productive citizen of the nation.

Program Specific outcomes (PSOs)
Upon completion of the programme successfully, students would be able to

PSO1: understand basic theoretical and applied principles of Statistics needed to enter the job force. They will be able to communicate key statistical concepts to non-statisticians. They also gain proficiency in using statistical ideas/ principles for data analysis.

PSO2: groom as the next generation statisticians ready for scientific decision making, aided with advanced statistical software translating into sharp and extensive analytics pertinent to various domains.

PSO3: start consultancy for statistical analysis and can be helpful in interdisciplinary research.

PSO4: perform Statistical quality control, which is the most important sector of any industry where students canwork as statisticians to approve the quality.

Employability Potential of the programme

The programme offers many opportunities, where statistician can work.By completing this programme, students are able to:

- Analyze the things
- Understand patterns in them by asking different questions to it
- Compete with the current demand of field
- To solve a specific problem

This “skill” is a key requirement for many analysis type jobs like,

1. Statisticians
2. Business Analyst
3. Mathematician
4. Professor
5. Risk Analyst
6. Data Analyst
7. Content Analyst
8. Statistic Trainer

Besides all these students can work in various banking sector.Students can also work in government sector:

- Indian statistical services (ISS)
- Staff selection services(SSC)
- Reserve Bank of India (Junior statistical officer)
  By taking the programme, students are able to:

- Analyze numbers
- Understand patterns in them by asking different questions to it
- Go about it in a systematic fashion
- To solve a specific problem

This “skill” is a key requirement for many analysis type jobs.

Career Options:

Data Analytics #1: Students could get into any Analytics firm, and can assist customers in getting patterns outof data.

Data Analytics #2: For Data Analytics in banks, there can be algorithms developed for fraud deduction usingthe digital imprints. This requires analyzing large amounts of data. That could a career choice - Digital Forensics.

Market Research: For doing a survey for customer expectations and behaviors, students utilize the data from online and offline channels to draw meaningful, actionable conclusions. For this the students need to use the various statistical methods which they learnt. So, Market Research in a MR firm or a corporate entity can be a large area of focus.

Software Programmer: With analytical bent of mind, Students could take up a software programming job. It might not leverage learning but will leverage the “bent of mind” cultivated out of the education. Students could focus on areas like: Visual Representation of Data (Tableau, Quilk, PowerBI), Data Reporting(Crystal Reports) - that are aligned to the core skills.

Government Statistician: Our country requires a lot of econometric and statistical data for its running. Acreage, Yields, Health Statistics and the like. Bright young idealistic people are required to run our country too. Students could be a District Statistical Officer, who is in charge of collecting information from the district,analyzing it and sharing with the State Authorities.

Semester I	Paper	Name of the paper	Course code	Credit
	I	Probability Theory	MSTC1	4
	II	Estimation Theory	MSTC2	4
	III	Sampling Theory	MSTC3	4
	IV	Industrial Statistics	MSTEA	4
		Time Series	MSTEB	4
		Demography	MSTEC	4
		Real Analysis and Measure Theory	MSTED	4
	LAB I	Practical I	MSPPI	2
	LAB II	Practical II	MSPP2	2
			Total credits	24
Semester II	**Paper**	**Name of the paper**	**Course code**	
	I	Testing of Hypothesis	MSTC4	4
	II	Distribution Theory	MSTC5	4
	III	Design of Experiment	MSTC6	4
	IV	Survival analysis	MSTEA	4
		Data Mining	MSTEB	4
		Statistical Genetics	MSTEC	4
		Order Statistics	MSTED	4
	LABIII	Practical III	MSPP3	2
	LABIV	Practical IV	MSPP4	2
			Total credits	24

M.Sc. I Statistics (Semester I)

MSTC1: Probability Theory

Course Objectives

A majority of topics in Statistics depend upon a strong foundation of Probability theory.It also serves as base for applied probability theory. Another basic concept is that of a random variable, its distribution and associated properties. Sequences of random variables is also a part of this course so that asymptotic or long run behavior of the sequence can be studied.

Course Outcomes

At the end of the course, students become well versed with,

1. Students learn the concept of probability as a measure and its various properties. Besides this, they learn the concept of random variable, its types, probability distribution, cumulative distribution function, and its various properties.
2. Types of convergences for sequences of random variables and their inter- relationships. Weak and strong law of large numbers based on the above types of convergence
3. Concept and importance of Central Limit Theorem which helps in understanding the limiting behavior and the concept of characteristic function and its properties.
4. This course gives a strong base for advanced theoretical as well as advanced applied probability.

Unit I: Classes of sets, field, sigma field, minimal sigma field, Borel field, sequence of sets, limits of a sequence of sets, measure, probability measure, Integration with respect to measure, Probability measure, Properties of probability measure, Random experiment, outcomes, sample space, events, various definitions of probability, laws of total and compoundprobability, Axiomatic definition of probability, Boole's inequality, Conditional probability, independence of events. Bayes Theorem.

Unit II: Random variable, probability mass function, probability density function, cumulative distribution function. Expectationof a random variable, properties of expectation, conditional expectation and its properties. Bivariate distributions and the joint probability distribution. Independence of random variables. Marginal and conditional distributions, Distribution function and their properties.

Unit III: Moment generating function, probability generating function, cumulant generating function, characteristic function and their properties. Inversion, continuity and uniqueness theorems

Unit IV: Convergence in probability, almost sure convergence, convergence in distribution and their relationships. Chebyshev's inequality, weak law of large numbers (WLLN), strong law of large numbers (SLLN), central limit theorems- DeMoivre Laplace, Lindeberg Levy, Lindeberg Feller(Sufficiency only).

MSTC2: Estimation Theory

Course Objectives: Students should be able to

1. Derive suitable point estimators of the parameters of the distribution of a random variable andgive a measure of their precision.
2. Learn computational skills to implement various statistical inferential approaches.

Course Outcomes: Students are able to

1. Understand the notion of a parametric models, point estimation of the parameters of those models.
2. Obtain the sufficient statistic, minimal sufficient statistic, M L E., moment estimator of the parameter.
3. Understand the concept of MVUE, MVBUE, and UMVUE.
4. Describe the concept of Bayesian inference and their real life applications.

Unit I: Sufficiency principle, factorization theorem, minimal sufficiency, minimal sufficient partition ,construction of minimal sufficient statistics, minimal sufficient statistic for exponential family, power series family, curved exponential family, Pitman family. Completeness, bounded completeness, ancillary statistics, Basu's theorem and applications.

Unit II: Problem of point estimation, unbiased estimators, minimum variance unbiased estimator, Rao-Blackwell theorem and Lehmann-Scheffe theorem and their uses. Necessary and sufficient condition for MVUE and their applications. Fisher information and information matrix, Cramer- Rao inequality, Chapmann-Robinson bounds, Bhattacharya bounds, their applications.

Unit III: Method of maximum likelihood (MLE) and small sample properties of MLE, method of scoring and application to estimation in multinomial distribution. MLE in non-regular families. Other methods of estimation: method of moments, minimum Chi square. U-Statistics: one and two sample; U-Statistics theorem for one sample and two sample (statements only).

Unit IV: The concept of prior distributions, various types of priors, non-informative, Jeffrey's, least favorable prior, posterior distribution; Posterior distribution conjugate family and standard examples of such families. Bayes estimation under squared error and absolute error loss functions.

Books Recommended

1. V. K. Rohatgi, and A.K.MD. E. Saleh, Introduction to Probability Theory and Mathematical Statistics, John Wiley & sons, 3rd Edition. 2015.
2. E. L. Lehmann, Theory of Point Estimation, John Wiley and sons, 1983.
3. C. R. Rao, Linear Statistical Inference and its Applications, Wiley, 2nd Edition, 1973.
4. B. K. Kale, and K. Muralidharan, Parametric Inference: An Introduction, Alpha Science InternationalLtd., 2015.
5. P. Mukhopadhyay, Mathematical Statistics, Books and Allied (p) Ltd., 2015.
6. E. J. Dudewicz and S. N. Mishra, Modern Mathematical Statistics, John Wiley and Sons, 1988.
7. Casella and Berger, Statistical Inference, Duxbury advanced series, IInd edition, 2002.

MSTC3: Sampling Theory

Course Objectives

The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits,demerits and comparisons in appropriate practical situations.

Course Outcomes

Students are able to learn

1. Learn the basic concepts of population and sample or the basic concepts of survey.
2. Learn the principles of sample survey and the steps involved in selecting a sample.
3. Understand the distinctive features of different sampling techniques and their relatedestimation problems.
4. Learn the practical applications of the various sampling techniques in real life situations.

Unit I: Introduction to sampling, concept of population and sample, census and sample surveys, sampling and non-sampling errors. Types of sampling, non-probability sampling, probability sampling, basic principles of sample surveys. Simple random sampling, sampling from finite populations with and without replacement, unbiased estimation and confidence intervals for population mean and total, simple random sampling of attributes.

Unit II: Stratified sampling, reasons for stratification, choice of strata, choice of sampling unit, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata. Systematic Sampling: merits and demerits of systematic sampling, estimation of sample mean and its variance, comparison of systematic sampling with

simple random and stratified sampling.

Unit III: Ratio and regression method of estimation, Variance of the estimates, optimum property of ratio estimates, comparison among ratio, regression and simple random sampling estimates, ratio estimate in stratified sampling, comparison with the ratio and mean per unit. Cluster Sampling,estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intraclass correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance.

Unit IV: Sampling with varying probabilities with and without replacement, sampling with probability proportional to size, Lahiri's method of selection, Horvitz-Thompson estimator, its variance and unbiased estimate of this variance. Introduction of multistage sampling, two stage sampling with equal first stage units, estimation of its mean and variance,introduction of multiphase sampling, double sampling for ratio and regression methods of estimation.

Books Recommended

1. Singh, D. & Chaudhary, F.S. (2016). Theory and Analysis of Sample Survey Designs. New AgeInternational Publishers.
2. Arnab, R. (2017). Survey Sampling Theory and Applications. Academic Press.
3. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. & Ashok, C. (2014). Sampling Theory of Surveys withApplications. New Delhi: Piyush Publications.
4. Cocharn, W.G. (2007). Sampling Techniques, 3rd Edition. Wiley.

MSTEA: Industrial Statistics

Course Objectives:

Objective here is to introduce to the students a branch of statistics that helps in maintaining quality in the industry. Course contains various methods for quality maintenance.

Course Outcome

After completing this course successfully, students would be able to

1. Use Quality systems ISO 9000 and QS 9000, Total Quality Management, PDSA cycle
2. know how to use various statistical tools such Design of Experiment for quality improvement
3. perform Process Capability Analysis, various Capability indices
4. use Taguchi philosophy – system, parameter and tolerance design

Unit I: Basic concept of process monitoring and control, process capability and process optimization. Review of control charts for attributes and variable data. O.C. and ARL of control charts. Moving average charts. Cusum & V-masks charts. Exponentially weighted moving average control chart.

Unit II: Acceptance sampling plan for attributes inspection, single, double and sequential sampling plans and their properties. Plan for Inspection by variable (one & two sided specifications) Mil Std & I.S. plans. Continuous sampling plans of Dodge types, Wald-Wolfowitz type and their properties. Bayesian sampling plans.

Unit III: Use of experiments is SPC, factorial experiments, fractional factorial designs, construction of such designs and analysis data. Introduction of software R and SPSS.

Unit IV : Capability indices Cp, Cpk and Cpm, estimation, confidence intervals and tests of hypothesis relating to capability indices for normally distributed characteristics. Multivariate quality control. Quality Systems: ISO 9000 standards, QS 9000 standards, concept of six sigma, Precision and accuracy in measurement systems. Estimation of measurement uncertainty. Total Quality management.

References:

1. Montgomery D.C (1985): Introduction to Statistical Quality Control, Wiley.
2. Montgomery D.C. (1985): Design and Analysis of Experiments, Wiley.
3. Wetherill G. B. (1977): Sampling Inspection & Quality Control, Halsted Press.
4. Wetherill G. B. & Brown D.W. (…..): Statistical Process Control, Theory and Practices, Chapman & Hall.
5. Logothetis N. (1992): Managing Total Quality, Prentice Hall of India
6. Oakland J.S. (1989): Total Quality Management; Butterworth Heinemann.
7. Mittog HJ, and Rinne H. (1993): Statistical Methods of Quality Assurance.
8. Eric Goh Ming Hui (2018): Learn R for applied Statistics, with data visualization.
9. John Macinnes (2017) : An introduction to secondary data analysis with IBM SPSS Statistics.

MSTEB: Time Series

Course Objectives

A time series is a series of data points indexed in time order. When this data is plotted,one can observe trends and other variations. Time series analysis is used to study the patterns of variations in data with time. These methods are useful in finance, weather forecasting, agriculture, etc. where the primary goal is forecasting. Since the observations are in the form of sequence, the methods of modelling are different. Objective here is to introduce the concept of time series, different methods of analyzingand modelling the time series data and their use in forecasting.

Course Outcomes

At the end of the course, students become well versed with,

1. Different methods of data smoothing to remove random variations.
2. Stationary and Nonstationary processes.
3. Estimation of the parameters of the time series model and using the models forforecasting.
4. Multivariate time series models, estimation and forecasting.

Unit I: Exploratory time series analysis, tests for trend and seasonality. Exponential and moving average smoothing. Holt -Winters smoothing. Forecasting based on smoothing, adaptive smoothing. Time - series as a discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties.

Unit II: Stationary processes: General linear processes, moving average (MA), auto regressive (AR), and autoregressive moving average (ARMA). Auto regressive integrated moving average (ARIMA) models, Box –Jenkins models Stationarity and inevitability conditions. Non stationary and seasonal time series models: Seasonal ARIMA (SARIMA) models, Transferfunction models (Time series regression)

Unit III: Forecasting in time series models, Durbin-Levinson algorithm, innovation algorithm (without proof). Estimation of mean, auto covariance and autocorrelation functions, Yule-Walker estimation, Estimation of ARIMA model parameters, maximum likelihood method, large sample theory (without proofs). Choice of AR and MA periods, FPE, AIC, BIC, residualanalysis and diagnostic checking.

Unit IV: Multivariate Time series model, VAR models, Vector ARMA models. Conditional heteroscedastic models, ARCH and GARCH, properties, examples, estimation & forecasting, extensions of ARCH and GARCH.

MSTEC: Demography

Course Objectives

The objective of the course is to make the students conversant with various techniques used insummarization and analysis of data related to demographic and vital events.

Course Outcomes

After completing this course, student is expected to learn the following:

1. Understand the basic concepts of demography and vital statistics.
2. Understand the trends of mortality and compare and contrast among different age and sex group.
3. Identify the components of population change, including the effects of changing birth, death and migration rates, and demonstrate their influences on age structure.
4. Do population projection by different methods.

Unit I: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula tocheck completeness of registration data, adjustment of age data, Use of Whipple, Myer and UN indices, population composition, dependency ratio, population transition theory.

Unit II: Measures of Fertility: Stochastic models for reproduction, distribution of time to first birth, inter-live birth intervals andof number of births, Estimation of parameters, estimation of parity progression ratio from open birth interval data.

Unit III: Measures of Mortality: Construction of abridged life tables, distribution of life table functions and their estimation. Stable and quasi-stable populations, intrinsic growth rate models for Population Growth and their fitting to population data. Stochastic models for population growth.

Unit IV: Stochastic models for migration and for social and occupational mobility based on Markov chains, Estimation ofmeasures of mobility, Methods for population projection, Use of Leslie matrix, Nuptuality and its measurements.

Books Recommended

1. Kumar R. (2006): Technical Demography, New Age International (P) Ltd, New Delhi.
2. Samuel P., Patrick, H. and Michel, G. (2000): Demography: Measuring and Modeling PopulationProcesses, Wiley-Blackwell.
3. Rowland D.T. (2003): Demographic Methods and Concepts, Oxford university press, Inc., NewYork.
4. Pathak K. B. and Ram F. (2013): Techniques of Demographic Analysis, Himalaya Publishing House.
5. Keyfitz N. and Caswell H. (2005): Applied Mathematical Demography, Springer.

MSTED: Real Analysis and Measure Theory

Course Objectives

The main objective of this course is to introduce students the knowledge of real field with their properties and relativity real line. These properties and relations provide grounds for Probability Theory and help in theoretical research in Statistics. The aim of the course is to pay a special attention to applications of measure theory in the probability theory.

Course Outcomes

After successful completion of this course, student will be able to:
After completing this course successfully, students would be able to

1. Work comfortably with classes of sets.
2. Recognize the concept of Reimain Stieljes integral.
3. Enhance the knowledge regarding convergence its application.
4. Understand matrix algebra.
5. Acquire knowledge of complex integral.

Unit I: Real valued functions. Riemann and Riemann Stieltjes integral, Integrationby Parts, mean value theorem, Elements of complex integration, Analytic function, definition of line integral, Cauchy integration formula, Residue theorem.

Unit II: Matrix algebra: characteristic roots of real matrices, right and left characteristic vectors, Independence of characteristic vectors their multiplicities, Generalized inverse Definiteness of a real quadratic form Reduction to quadratic form.

Unit III: Sets : Classes of sets, Sequences of sets, lim sup and lim inf of sequencesof sets, field, s-field, s-field generated by a class, Borel s- field. Set functions, additive set functions and their properties, Measure, Measure spaces, Measurable function, simple function, Integral of measure function w.r.t. measure.

Unit IV: Sequences of measurable functions, convergence a.e. and in measure. Monotone convergence theorem, Fatous lemma, Dominated convergence theorem and their application, Construction of measures: definitionof Lebesgue measure in R^n and its determination by translational invariance, Lebesgue integral on the line and Riemann integral, calculation of Lebesgue integral in R^n including the use of the substitution theorem but not its proof.

References

1. T Apostol : Mathematical analysis
2. Churchill : Functions of a complex variable
3. M E Munroe : Introduction to measure and Integration
4. R Ash : Real analysis and Probability theory
5. K. Basu : Measure Theory and Probability

MSPP1: Practical Problems I

1. Problems on method of Maximum likelihood
2. Problems on Method of Moments
3. Problems on UMVUE
4. Problems on Confidence Intervals for mean and difference of means
5. Problems on Confidence Intervals for proportions and sample size
6. Confidence Intervals for variance and ratio of variances

MSPP2: Practical Problem II

1). Simple Random Sampling

2). Simple Random Sampling with varying Probability with Replacement

3). Ratio and Regression estimate of population mean and standard error in case of SRS

4). Des-Raj and Horvitz-Thompson estimator

5). Hartley Ross estimator

6). Cluster sampling with unequal cluster sizes

7). Problems on Two Stage sampling

8). Estimation of population mean and variances using Double sampling

M.Sc. I Statistics (Semester II)

MSTC4: Testing of Hypothesis

Course Objectives:

There are some standard statistical methods useful in testing various types of hypotheses. These methods are widely used in almost all disciplines. Sometimes we need to construct a test procedure if the situation is not as required in the standard methods. The course includes basic lemma useful in construction of the test. The test procedure also changes according to the nature of null hypothesis, alternative hypothesis, the distribution of a random variable under consideration etc. The course helps in constructing most powerful or uniformly most powerful tests for different types of hypotheses for any given distribution. Some situations require sequential test procedure.

Course Outcome:

After completing this course successfully, students would be able to

1. Apply Concept of hypothesis, be able to state appropriate null and alternative hypothesis.
2. Calculate p – value and interpret it.
3. Understand Neyman-Pearson fundamental lemma, generalized NP lemma, and MP and UMP test.
4. Understand MLR property, its applications, Karlin Rubin theorem
5. Use Likelihood Ratio test, Wald test, Rao's score test, Bartlett's test.
6. Understand SPRT, OC and ASN function for SPRT.

Unit I: Test of Hypothesis, concept of critical region, test function, two kinds of errors, size function, power function, level, p-value concept, MP and UMP test in the class of size level test, Neyman-Pearson lemma, MP test for simple hypothesis against simple alternative hypothesis.

Unit II: UMP test for simple null hypothesis against one sided alternative and for one sided null and one-sided alternative in one parameter exponential family. Non-existence of UMP test for simple null against two-sided alternative in one parameter exponential family.

Unit III: Likelihood ratio test. Asymptotic distribution of LR test statistic (Without proof) Wald's test, Rao's score test, Pearson's chi-square test for goodness of fit. Bartlett's test for homogeneity of variances (without proof)

Unit IV: Sequential Testing, sequential probability ratio test. Relation among parameters. Application of SPRT for Binomial, Poisson, Normal distribution. Generalized Neymann

Pearson Lemma (Statement only), UMPU test, and their existence in case of exponential family

References:

1) Ferguson T.S.: Mathematical Statistics.

2) Goon, A.M., Gupta, Dasgupta: An Outline of Statistical Inference

3) H.C. Saxena, Surendran: Statistical Inference: S. Chand.

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

5) Lehman E.L. (1986): Testing Statistical Hypothesis, Student Edition.

6) Rao C.R. (1973): Linear Statistical Inference.

7) Rohatgi V. (1998): An Introduction to Probability and Mathematical Statistics, Wiley EasternLtd. New York.

8) Zack. (1971): Theory of Statistical Inference, John Wiley.

MSTC5: Distribution Theory

Course Objectives

The main objective of the course is to provide the detailed knowledge of the characterization of all the useful discrete and continuous distributions.

Course Outcomes

After completing this course, student is expected to learn the following:

1: Formulate the mathematical and statistical models for real data sets arising in various fields in order to analyze in respect of various useful characteristics of the populations.

2: Understand how to use univariate distributions in real life problems.

3: Understand central and Non-central χ^2, t and F distributions.

4: Work with bivariate normal and multivariate normal distribution, which is a challenging problem in today's life.

Unit I : Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Multinomial, Hypergeometric and discrete uniform distributions; their means, variances, modes, moment generating functions, cumulant generating function, probability generating functions and characteristic functions, important properties with their proofs related to these distributions.

Unit II: Continuous uniform, Exponential, Gamma, Normal, Beta, Cauchy, Laplace, Weibull, Pareto and lognormal with their properties including proofs; their means, variances, momentgenerating functions, cumulant generating function and Characteristic functions.

Unit III: Compound, truncated and mixture distributions. Central and Non-central Chi-square (χ^2), *t* and *F* distributions with their properties including their means, variances, moment generating functions, cumulant generating function and characteristic functions, Multidimensional random variables, its pdf/pmf and cdf.

Unit IV: Bivariate normal distribution with its applications and important properties including their means, variances, moment generating functions, Multivariate normal distribution, its marginal and conditional distributions and related properties.

Books Recommended

1. Krishnamoorthy, K. (2015). Handbook of Statistical Distributions with Applications, 2nd Edition.CRC Press.
2. Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition.Wiley.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I. World Press.
4. Forbes, C., Evans, M., Hastings, N. & Peacock, B. (2010). Statistical Distributions, 4th Edition. Wiley

MSTC6: Design of Experiment

Course Objective

To provide orientation of statistics while designing statistical experiments, particularly in agricultural set-up and in pharmaceutical production processes. Exposure to various statisticaldesigns leading to the analysis of variance, eliminating heterogeneity of the data, construction of designs will be provided.

Course Outcome

After completing this course, student is expected to learn the following:

1) Understand the concepts of design of experiments and application of ANOVA, ANCOVA
2) Construct complete and partially confounded factorial designs and perform their analysis.
3) Design and analyses incomplete block designs, understand the concepts of efficiency of BIBD relative to RBD.
4) Understand the concepts of first order, orthogonal and treatment-control designs.

Unit I: Introduction to design of experiments. Three basic principles of design of experiments: randomization, replication and local control. Uniformity trials. Analysis of basic design, asymptoticrelative efficiency, missing plot techniques, analysis of Covariance for CRD and RBD.

Unit II: Factorial experiments: 2^k, 3^2 and 3^3 systems only. Complete and partial confounding, factorial replication in 2^k systems.Two-level fractional factorial designs: introduction, the one- quarter fraction of the 2^k design. Alias structure in fractional Factorials and other designs.

Unit III: Incomplete block design: balanced incomplete block design,simple lattice design, split-plot design, strip-plot design, comparison of two treatments, and efficiency of BIBD relative to RBD.

Unit IV: Response surface methodology, first order designs, and orthogonal designs, treatment-control designs, model variationand use of transformation.

References:

1. Montgomery, D.C. (2013). Design and Analysis of Experiments, 8th Edition. Wiley.
2. Toutenburg, H. & Shalabh (2010). Statistical Analysis of Designed Experiments, 3rd Edition. Springer.
3. Cobb, G.W. (2014). Introduction to Design and Analysis of Experiments. Wiley.
4. Lawson, J. (2014). Design and Analysis of Experiments with R. CRC Press.

MSTEA: Survival Analysis

Course Objective

The objective of this course is to provide the applications of statistics in handling survival data.This course introduces the concept of censoring and various life time distributions used to analyses such data.

Course Outcome

On completion of this course, students will be able to:

1) Understand basic concepts of survival data and lifetime models.
2) Learn how to handle censored data under different scenarios.
3) Learn non-parametric estimation of survival function.
4) Learn the Log-Rank test for testing differences between survival curves and Cox'
5) Regression model for estimating and testing effects of covariates.

Unit I: Concepts of survival function, failure rate or hazard function, mean residual life and their properties. Ageing classes- IFR, DFR, IFRA, DFRA, NBU, NBUE, BT and UBT, scaled TTT transform and characterization of ageing classes.

Unit II : Life testing plans or censoring methods, right and left censoring, concepts of Type-I (time) and Type-II (failure), random censoring schemes. Life distributions-exponential, Weibull, log-logistic, gamma,log-normal distributions. Parametric inference- estimation of parameters associated with various life time distributions and life testing plans.

Unit III: Nonparametric methods of estimation of survival function - actuarialestimator, Kaplan-Meier estimator. Tests of exponentiality against non-parametric classes-Total time on Test, Deshpande Test.

Unit IV : Two sample problem - Gehan test, log-rank test, Mantel-Haenzel test. Cox proportional hazards model, competing risks model.

Books Recommended

1. Deshpande, J.V. & Purohit, S.G. (2016). Life Time Data: Statistical Models and Methods, 2nd Edition.Word Scientific.
2. Lee, E.T. & Wang, J.W. (2015). Statistical Methods for Survival Data Analysis, 4th Edition. Wiley.
3. Miller, R.G. (2011). Survival Analysis, 2nd Edition. Wiley.
4. Moore, D.F. (2016). Applied Survival Analysis using R. Springer.

MSTEB: Data Mining

Course Objectives:

All over the globe, a huge amount of data is getting generated at a very high rate. This huge data needs to be analyzed everywhere around us. Data mining is an interdisciplinary subfield of computer science and statistics. The techniques are useful in discovering patterns in large data sets. Objective here is to introduce the students to this branch of statistics and impart knowledge in data processing, data management, analysis of large data, model and inference consideration and online updating.

Course Outcomes:

At the end of the course, students become well versed with,

1. Use of machine learning and statistical models to uncover the hidden patterns in large volume of data.
2. Clustering methods from statistical and data mining point of view. Unsupervised

and supervised learning of data in different cases.

3. Dimension reduction, feature selection. Artificial neural network, extension of regression models.
4. Online analytical data processing. Association rules, predictions and applications.

Unit-I: Review of classification methods from multivariate analysis, classification and decisiontrees, clustering methods from both statistical and data mining viewpoints, vector quantization.

Unit-II: Unsupervised learning from univariate and multivariate data, Dimension reduction andfeature selections**.** Supervised learning from moderate to high dimensional input spaces, artificial neural networks and extensions of regression models, regression trees.

Unit-III: Supervised learning from moderate to high dimensional input. Spaces, artificial neural networks and extensions of regression models, regression trees. Introduction to data bases, including simple relational databases, data ware houses and introduction to online analytical data processing.

Unit IV: Association rules and prediction, data attributes, applications to electronic commerce. Introduction to database including simple relational databases, data ware houses, introduction to online analytical data processing. Data attributes, applications to electronic commerce. Problem solving using software R and SPSS.

References:

1) A.Borson and S.J.Smith (1997): Data Ware Housing, Data Mining and OLAP, McGraw Hill.
2) Breiman, J.H.Friedman, R.A.Olsher and C.J.Stone (1984): Classification and Regression Trees, Wordsworth& Brooks/Cole.
3) J.Han and M.Kamber (2000): Data Mining Concepts and Techniques, Morgan Gaufmann.
4) T.M. Mitchell (1997): Machine Learning McGraw Hill.
5) P.Naughton (1996): The Java Handbook, Tata McGraw Hill.
6) W.J.Savich (2001): Problem Solving with C++: The Object of Programming (3" Edn.) Addison Wesley,Longman.
7) Eric Goh Ming Hui (2018): Learn R for applied Statistics, with data visualization.
8) John Macinnes (2017): An introduction to secondary data analysis with IBM SPSS Statistics.

MSTEC: Statistical Genetics

OBJECTIVES:

The course includes basic results in genetics from their probability distribution point of view, population equilibrium, dominating alleles and estimation of their probability. Objective is to make the students aware about the concept of natural selection, inbreeding, linkage, segregation etc. which are probability distribution based concepts in genetics. This probability distribution can be used to estimate the frequency of the gene in coming generations. This is very useful in some rare diseases

OUTCOMES:

At the end of the course, students become well versed with,

1. Concept of random mating, Hardy Weinberg equilibrium, calculating probabilities for various gene combination and study of X-linked genes.
2. Nonrandom mating, inbreeding, various coefficients of inbreeding.
3. Concept of Natural selection, its effect on equilibrium.
4. Analysis of family data, linkage detection, and estimation of linkage.

Unit I: Basic biological concepts in genetics. Mendel's law.Hardy Weinberge equilibrium. Matrixtheory of random mating. Mating tables. Estimation of allel frequency for dominant and co dominant cases. Approach to equilibrium for X-linked gene.

Unit-II: Non random mating, Inbreeding, Coefficients of inbreeding, Inbreeding in randomly mating populations of finite size. Phenotypic assortative mating.

Unit-III: Natural selection, mutation, genetic drift. Equilibrium when both natural selection and mutation are operative. Statistical problems in human genetics, Blood group analysis.

Unit-IV: Analysis of family data: (a) Relative pair data, I, T, O matrices, identity by descent. (b) Family data- estimation of segregation ratio under ascertainment bias. (c) Pedigree data – Elston- Stewart algorithm for calculation of likelihoods, linkage, Detection and estimation of linkage, estimation of recombination fraction, inheritance of quantitative trials models and estimation of parameters.

References:

1. C.C.LI. (1976): First Course on Population genetics, Boxwood Press, California.
2. W. J. Ewens (1979): Mathematical Population Genetics, Springer Verlag.
3. T. Nagylaki (1992): Introduction to Theoretical Population genetics, Springer Verlag.
4. R Durbin, S. R. Eddy, A. Krogh, G. Mitchinson (1998): Biological sequence Analysis Probabilistic Models of Proteins and Nucleic Acids.

MSTED: Order Statistics

Course Objective

The objective of the course is to learn general strategies for problems about order statistics and how to learn to find the median (or k^{th} largest) in linear average-case number of comparisons (and time).

Course Outcome

After completing this course, student is expected to learn the following:

1 Understand the basic concepts of order statistics, joint, marginal and conditional probability distributions of order statistics.
2 Learn about distribution-free confidence intervals for population quantile and distribution free tolerance intervals for population distributions.
3 Construct the recurrence relations and identities for moments of order statistics.
4 Enhanced with the concepts of distributions of order statistics for independently and nidentically distributed variates and also for dependent variates.

Unit I: Introduction to order statistics, joint, marginal and conditional distributions of order statistics (discrete and continuous cases).Distribution of the range and other systematic statistics, order statistics as a Markov chain. Examples based on discrete and continuous distributions.

Unit II: Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals. Distribution-free bounds for moments of order statistics and of the range. Approximations to moments in terms of the quantile function and its derivatives.
lemma, uniformly most powerful (UMP) tests.

Unit III: Moments of order statistics, recurrence relations and identities for moments of order statistics. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics.

Unit IV: Order statistics for independently and not identically distributed (i.ni.d.) variates, Concomitants of order statistics. Random division of an interval and its applications. Order statistics from a sample containing a single outlier. Concepts
of record values and generalized order statistics.

Books Recommended

1. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). Ordered Random Variables:Theory and Applications. Springer.
2. David, H.A. & Nagaraja, H.N. (2005). Order Statistics, 3rd Edition. Wiley.
3. Ahsanullah, M., Nevzorov, V.B. & Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studiesin Probability and Statistics, Vol. III. Atlantis Press.
4. Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (2008). A First Course in Order Statistics. SIAM Publishers

MSPP1: Practical Problems I

1). Fitting of truncated Binomial distribution

2). Fitting of truncated Poisson distribution

3). Drawing a random sample from a bivariate normal distribution

4). Estimation of μ and σ using random sample

5). Estimation using Minimum chi-square method

8). Problems on size and power of test

9). Problems on most powerful test

10). Construction of uniformly most powerful test

MSPP2: Practical Problems II

1. Analysis of missing data in RBD
   Analysis of missing data in LSD
2. Analysis of covariance for one way classification
3. Analysis of covariance for two way classification
4. Analysis of BIBD
5. Analysis of Youden square Design
6. Analysis of 2^3 and 2 factorial experiment without confounding
7. Analysis of completely confounded factorial experiment
8. Analysis of partially confounded factorial experiment
9. Analysis of Split Plot Design

Sant Gadge Baba Amravati University, Amravati

Faculty of Science and Technology
Programme: **M.Sc. II (SEM III & SEM IV) Statistics (NEPv23)**

Program Outcomes (POs)

At the end of the Programme, students would be able to
PO1: **Critical Thinking**: Think critically for data driven solution with advanced Methodology. Students may be able to think critically everything around him/her. They will be able to take better action in any critical situation in their life.

PO2: Nurture their curious minds toward translation and application & Statistical knowledge to find solutions to real world problems.

PO3: **Employability: Get** knowledge and skills in depth necessary for employability of students in industry, Govt Sector and organizations as well as in academics.

PO4: **Empowerment**: Be empowered to investigate, solve questions for which answer lies beyond the boundaries of conventional thinking.

PO5: **Effective decision making**: Take proper decision in critical and complicated situations. Reduce risk factor and be able to maximize project.

PO6: **Effective citizenship**: Get acquainted with the needs of the industry and society, and they become the assets for the society.

PO7: **Social interaction**: Develop sensitivity for social issues and become productive citizen of the nation.

Program Specific outcomes (PSOs)
Upon completion of the Programme successfully, students would be able to

PSO1: Understand basic theoretical and applied principles of Statistics needed to enter the job force. They will be able to communicate key statistical concepts to non-statisticians. They also gain proficiency in using statistical ideas/principles for data analysis.

PSO2: Groom as the next generation statisticians ready for scientific decision making, aided with advanced statistical software translating into sharp and extensive analytics pertinent to various domains.

PSO3: Start consultancy for statistical analysis and can be helpful in interdisciplinary research.

PSO4: Perform Statistical quality control, which is the most important sector of any industry where students can work as statisticians to approve the quality.

Employability Potential of the Programme

The Programme offers many opportunities, where statistician can work. By completing this programme, students are able to:

- Analyze the things
- Understand patterns in them by asking different questions to it
- Compete with the current demand of field.
- To solve a specific problem

This“skill”is a key requirement for many analysis type jobs like,

1. Statisticians
2. Business Analyst
3. Mathematician
4. Professor
5. Risk Analyst
6. Data Analyst
7. Content Analyst
8. Statistic Trainer

Besides all these students can work in various banking sector. Students can also work in government sector:

- Indian statistical services(ISS)
- Staff Selection Services(SSC)
- Reserve Bank of India (Junior statistical officer)

By taking the programme, students are able to:

- Analyze numbers
- Understand patterns in them by asking different questions to it
- Go about it in a systematic fashion.
- To solve a specific problem.

This “skill” is a key requirement for many analysis type jobs.

Career Options:

Data Analytics #1: Students could get into any Analytics firm, and can assist customers in getting patterns out of data.

Data Analytics #2: For Data Analytics in banks, there can be algorithms developed for fraud deduction using the digital imprints. This requires analyzing large amounts of data. That could a career choice – Digital Forensics.

Market Research: For doing a survey for customer expectations and behaviors, students utilize the data from online and offline channels to draw meaningful, actionable conclusions. For this the students need to use the various statistical methods which they learnt. So, Market Research in a MR firm or a corporate entity can be a large area of focus.

Software Programmer: With analytical bent of mind, Students could take up a software programming job. It might not leverage learning but will leverage the "bent of mind" cultivated out of the education. Students could focus on areas like: Visual Representation of Data (Tableau, Quilk, and PowerBI), Data Reporting (Crystal Reports)-that are aligned to the cores kills.

Government Statistician: Our country requires a lot of econometric and statistical data for its running. Acreage, Yields, Health Statistics and the like. Bright young idealistic people are required to run our country too. Students could be a District Statistical Officer, who is in charge of collecting information from the district, analyzing it and sharing with the State Authorities.

Semester	Paper	Name of the paper	Subject code	Total Credits
III	I	Statistical Inference	DSCVII (Sts-8)	4
	AEC on DSC VII	Performing inference including statistical modeling, data oriented strategies		2
	II	Mathematical Programming	DSC VIII (Sts-9)	4
	III	Linear and nonlinear modeling	DSC IX (Sts-10)	4
	IV	Operations Research	DSEIIIA (Sts-11)	4
		Bioassay	DSEIII B(Sts-12)	4
		Econometrics	DSE III C(Sts-13)	4
		Actuarial Statistics	DSE IIID(Sts-14)	4
	LAB I	Practical I	DSCP1	2
	LAB II	Practical II	DSCEP2	2
			Total Credits	26

Semester IV	Paper I	Name of the paper Computational Statistics	Subject code DSC X (Sts-15)	4
	AEC on DSCX	Application on Monte Carlo methods		2
	II	Multivariate Analysis	DSC XI (Sts-16)	4
	III	Stochastic Process	DSC XII (Sts-17)	4
	IV	Bayesian Inference	DSEIV A (Sts-18)	4
		Statistical Ecology	DSE IV B (Sts-19)	4
		Regression Analysis	DSE IV C(Sts-20)	4
		Reliability Theory	DSE IV D(Sts-21)	4
	LAB I	Practical I	DSCP1	2
	LAB II	Practical II	DSCEP2	2
			Total Credits	26

M.Sc. (Statistics) Semester III
DSC VII (STS -8): Statistical Inference

Course Objective

The objective of estimation theory is to arrive at an estimator that exhibits optimality. To provide easy stematic account of Neymann Pearson theory of testing and closely related theory of Point estimation and confidence sets, together with their applications.

Course Outcome

After completing this course, student is expected to learn the following:

1 Understand the various estimation and testing procedures to deal with real life problems.
2 Learn about the Fisher Information, lower bounds to variance of estimators, MVUE.
3 Understand the concept of Neymann- Pearson fundamental lemma, UMP test and interval estimation .
4 Understand the concept to critical regions, likelihood ratio test with its asymptotic Distribution.

Unit I: Criteria of a good estimator-Unbiasedness, consistency efficiency, sufficiency .Minimal sufficient statistic. Exponential and Pitman families of distributions. Cramer-Rao lower bound approach to obtain minimum variance unbiased estimator. Uniformly minimum variance unbiased estimator, Complete statistic, Rao-Blackwell theorem, Lehmann-Scheffe
theorem.

Unit II : Method of moments, minimum chi-square Estimation, maximum likelihood estimator and its properties, CAN& BAN estimators. Ancillary statistic and Basu's theorem. Simple and composite hypothesis, concept to critical regions, test functions, two types of error, power of the test, level of significance, Neymann-Pearson lemma, uniformly most powerful(UMP)tests.

Unit III :
Types A, A1 critical regions, likelihood ratio test (LRT) with its asymptotic distribution, UMP test for monotone likelihood ratio family of distributions. Similar tests with Neymann structure, Construction of similar and UMPU tests through Neyman structure.

Unit IV : Confidence interval, construction of confidence intervals using pivotal, shortest expected length confidence interval, uniformly most accurate one-sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypothesis.

Books Recommended

1. Rohatgi, V.K. & Saleh, A.K.Md.E. (2015).An Introduction to Probability and Statistics, 3rdEdition. Wiley.
2. Lehmann, E.L. & Casella. (2014). Theory of Point Estimation,2nd Edition. Springer.
3. Lehmann, E.L. & Romano, J.P. (2010). Testing Statistical Hypotheses,3rd Edition. Springer.
Casella. & Berger .L. (2013). Statistical Inference, 2ndEdition. CengageL earning.

AEC on DSC VII

Performing inference including statistical modeling, data oriented strategies

Syllabus

Understand the process of drawing conclusion about populations or scientific truths from data, Describe variability, distributions, limits and confidence intervals, Make informed data analysis decisions

DSC VIII (STS-9): Mathematical Programming

Course Objectives:

Optimization techniques have application in almost all disciplines. To get on optimum solution to the problem under given constraints is always challenging. To get the best solution to such problems, there are different methods depending on the problem and constraints. Various such problems and methods to solve them are part of this course.

Course Outcomes:

At the end of the course, students become well versed with,

1. To formulate and solve linear programming problem (LPP). They also learn various methods to solve LPP .Application of LPP in industry, management, transportation, assignment etc.
2. Sensitivity analysis of LPP by studying the effect of changes in coefficients of constraints on the solutions to the problem. They also learn the effect of any other changes in the constraints, addition of new constraint on the solution to the problem.
3. Pure and mixed integer linear programming problem and formulation of nonlinear programming problem and different methods to solve them.
4. The problem and different methods of solving two person zero sum game.

Unit I :L. P. : Simplex method, variants of simplex method, duality in L. P. duality theorem, complementary slackness theorem, dual simplex method ,transportation & assignment problems, method of solving transportation & assignment problems. Dynamic Programming :Dynamic programming approach for solving optimization problems, forward & backward recursion formula, minimum path problem ,single additive constraint & additively separable

return, single multiplicative constraint & additively separable return, single additive constraint & multiplicatively separable return, Goal Programming.

Unit II

: Sensitivity analysis of LP Changes in R.H.S .constraint bi, changes in cost coefficient cj, changes in coefficient of constraints aij, addition of new variables, addition of new constraints. I.L.P.P.: Pure & mixed I.L.P.P., methods for solving pure & mixed I.L.P.P. Gomory's cutting plane method, Branch & Bound

technique.

Unit III : N.L.P.P: General N.L.P.P. ,convex & concave functions, text for concavity & convexity, local optimum, global optimum, basic results for local optimum & global optimum, Lagrange's methods for optimality, KT conditions, Q.P.P. Wolfe's & Beale's method for solving Q.P.P.

Unit IV : Game Theory: Two person zero sum game, pure & mixed strategies, saddle point of a matrix game, matrix game without saddle point, methods for solving matrix game without saddle point, 2 x 2, m x n, m x 2, 2 x n matrix games, dominance principle, use of dominance principle in game theory, solving game problems by simplex method.

Books Recommended

1. S.M. Sinha: Mathematical Programming Theory and Methods Elsevier
2. Melvyn Jeter: Mathematical Programming An introduction to optimization Routledge Taylor and Francis group
3. N.S. Kambo: Mathematical Programming Technique East West Press Pvt Ltd.
4. R.K.Gupta: Linear Programming Krishna Prakashan

DSC IX (STS – 10): Linear and Nonlinear Modelling

Course Objectives:

Regression analysis is the most common statistical modelling approach used in data analysis and it is the basis for advanced statistical modelling.

The objective of this course is to impart knowledge about the use of different useful tools used in regression analysis. The relationship between variables can be of different types like linear, nonlinear etc. The relationship is represented in terms of a model. The adequacy of any model can be checked using residual plots and residual analysis. Appropriate statistical tools are required to check for the violations of model assumptions and for dealing with problems of Multicollinearity etc.

Course Outcomes:

At the end of the course, students become well versed with,

1. Linear and Multiple regression.
2. To interpret different types of plots such as residual plots, normal probability plots etc. To check for the violations of model assumptions using residual analysis and other statistical tests.
3. To differentiate between linear and nonlinear regression under given situation.
4. Generalized Linear Models including logistic.

Unit I : :Multiple Linear regression: Model assumptions and checking for the violations of model assumption., Residual analysis – definition of residuals, standardized residuals, residual plots, statistical tests on residuals, Press statistics. Transformation of variables, Box-Cox power transformation .Outliers: Detection and remedial measures, Influential observations: leverage, measures of influence, Cook's D, DFITS AND DFBETAS.

Unit II :Multi co-linearity : Concept and definition of M.C., sources of M.C. consequences of M.C. identification of M.C. using the correlation matrix, VIF remedial measures (collecting additional data, model respecification), concept to fridge regression. Autocorrelation: consequences, Durbin-Watson test, Estimation of parameters in the presence of autocorrelation.

Unit III : Variable selection: Problem of variable selection, criteria for evaluation subset regression models (choosing subsets), coefficient of multiple determination, residual mean square, Mallow's Cp Statistics. Computational Techniques for variable selection-Forward selection, Back ward elimination, stepwise regression.

Non-linear regression: Difference between Linear and Non-Linear Regression Models, transformation to a linear model, Intrinsically linear and non-linear models. Parameter estimation using the Newton-Gauss method, Hypothesis testing.

Unit IV: Generalized linear models: Exponential families, Definition of GLM, Link function, Estimation of parameters and inference in GLM. Logistic regression model: Link function, logit, probit, complementary log-log, estimation of parameters, odds ratio, hypothesis testing using model deviance.

Books recommended

1. Jean Gomes: Leading in nonlinear world: Building Wellbeing, strategic and innovation mindsets for the future
2. S. Nanda: Nonlinear Analysis
3. Steen Krenk: Nonlinear Modelling Cambridge
4. Giuseppe Lancia, Paolo Serafini: Compact Extended Linear Programming Models springer

DSEIII A (Sts-11): Operations Research

Course Objectives:

Operations research deals with the application of advanced analytical methods which helps in taking better decisions. The course includes advanced techniques that are useful in business, management, industry, project planning etc.

Course Outcomes:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis.
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit I : **Inventory problems** : Structure of inventory problem, EOQ formula, EOQ model with uniform rate of demand & having no shortages, EOQ model with different rate of demand in different cycles having no shortages, EOQ model with uniform rate of demand & finite rate of replenishment having no shortages, EOQ model with uniform rate of demand & finite rate of replenishment having shortages, EOQ model with uniform rate of demand, infinite rate of replenishment having shortages, EOQ model with single & double price breaks.

Unit II: Single period probabilistic inventory models with

i) Instantaneous demand & discrete units
ii) Instantaneous demand & continuous units
iii) Continuous demand & discrete units
iv) Continuous demand & continuous units

Unit III: Processing n jobs through two machines,
Processing n jobs through three machines,
Processing 2 jobs through m machines,
Processing n jobs through m machines,
Traveling salesman problem
Queuing Models: M/M/1 :FCFS/ / & its generalization
M/M/1:FCF/N/M/M/C/ ,
FCFS/M/Ek/1: FCFS/ / ,
/ ,

Unit IV: Networking: Basic steps in PERT & CPM, methods of solving PERT problem, crashing the network, updating (PERT & CPM) max. Flow min. cut theorem, problems based on max. flow min cut theorem.

Books Recommended

1. S. Kalavathy : Operations Research Vikas Publications
2. Frederick S. Hillier : An introduction to Operations Research McGraw Hill
3. Kanti Swaroop, P. K. Gupta, Man Mohan : Operations Research Sultan Chand & Sons
4. Sheikh Ahmed Hossain, SamarjitKar : Operations Research Recent Advances Narosa Publishing House

DSE III B (Sts-12): Bioassay

Course Objectives:

Bio assay is an analytical method to determine concentration of a substance by its effect on living cells tissues, insects, etc. There are various types of Bio assays like qualitative or quantitative, direct or indirect. These analytical methods are useful in environmental science, microbiology etc. The method of dose and response relationship in this analysis is used in pharmaceutical sciences. Objective of this course is to train students in analytical methods used in these fields.

Course Outcomes:

At the end of the course, students become well versed with,

1. Types of biological assays and methods for estimating dose response relationship.
2. Logit and probit approach for estimating dose-response relationship.
3. Methods of estimation of parameters and dose allocation schemes.
4. Sequential procedures, estimation of safe dose, ANOVA and Bayesian approach to Bio assays.

Unit I: Types of biological assays, direct assays, ratio estimators, asymptotic distributions, Fieller's theorem Regression approaches to estimating dose-response relationships, Logit and Probit approaches when dose-response curve for standard preparation is unknown.

Unit II : Methods of estimation of parameters, estimation of extreme quantiles., dose allocation schemes. Quantal Responses, Polychotomous quantal responses. estimation of points on the quantal response function

Unit III: Sequential procedures, estimation of safe doses.

Unit IV: ANOVA and Bayesian approach to Bio assay

Books Recommended

1. R.C. Dubey: Advanced Biotechnology S. Chand
2. S.J. Amdekar: Statistical Methods for Agricultural and Biological sciences
3. P.K. Bajpai: Biological instrumentation and Methodology S. Chand & Company
4. Thiemann: Introduction to Biotechnology Pearson

DSE III C (Sts-13): Econometrics

Course Objective

The purpose of this course is to give students a solid foundation in econometric techniques, various functions for economic analysis and future forecasting.

Course Outcomes

On completion of this course, students will be able to:

1: Understand the basic concepts of econometric models.

2: Learn knowledge of various econometric models, estimation methods and related econometric theories.

3: Understand the statistical techniques to model relationships between variables and make predictions.

4: Learn how to conduct econometric analysis of data.

Unit I :

Introduction to econometrics. A review of least squares and maximum likelihood estimation methods of parameters in classical linear regression model and their properties. Generalized least squares estimation and prediction, construction of confidence regions and tests of hypotheses. Regression analysis under linear restrictions, restricted least squares estimation method and its properties. Autocorrelation, sources and consequences, Autoregressive process tests for autocorrelation, Durbin Watson test.

Unit II:

Problem of Multi collinearity, its implications. Source of multi collinearity, tools for handling the problem of multi collinearity. Remedies for multi collinearity. Ridge regression. Heteroskedasticity, consequences and tests for it, estimation procedures under Heteroskedastic disturbances, Bartlett's test, Breusch Pagan test and Goldfelf Quandt test, Dummy Variable Models.

Unit III:

Specification Error Analysis, Tests for Structural Change and Stability, Asymptotictheoryandregressors.Stein-RuleEstimation.Instrumentalvariableestimation.Measurement Error Models.

Unit IV:

Simultaneous equations model, problem of identification, necessary and sufficient condition for the identifiability of parameters in a structuralequation,ordinaryleastsquares,indirectleastsquares,two-stageleast squares and limited information maximum Likelihood method.

Books Recommended

1. Gujrati, D.N. &Porter, D.C. (2017).BasicEconometrics,6th Edition. McGraw-Hill.
2. Maddala, G.S. & Lahiri, K. (2010).Introduction to Econometrics, 4thEdition.Wiley.
3. Greene, W.H. (2012).Econometric Analysis, 7th Edition .Pearson.
4. Studenmund, A.H. & Johnson, B.K. (2017).Using Econometrics: A Practical Guide,7thEdition.Pearson.

DSE III D (Sts-14): Actuarial Statistics

Course Objectives:

Actuarial science includes statistical methods to assess risk mainly in insurance and finance. The course includes these statistical methods based on probability theory and stochastic models. Objective here is to make the students aware about this important branch of statistics.

Course Outcomes:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis.
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit I:

Life table and its relation with survival function, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint and last survivor status, insurance and annuity benefits through multiple life functions. Multiple decrement models, deterministic and random survivor groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical valuations.

Unit II:

Principals of compound interest: Nominal and effective rates of interest and discount, fore of interest and discount,compoundinterest,accumulationfactor,continuouscompounding.Life insurance : Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursion, commutation functions.

Unit III: Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursion, and complete annuities-immediate and apportionable annuities-due. Net premiums: Continuous and discrete premiums, true monthly payments premiums, apportionable premiums, commutation functions, accumulation type benefits.

Unit IV:

Net premium reserves: Continuous and discrete net premium reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional duration, allocations of loss to policy years, recursive formulas and d differential equations for reserves, commutation functions. 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.

Books Recommended

1. Shailaja R. Deshmukh: Actuarial Statistics an introduction Universities Press (India)
2. Dale S. Borowiak, Arnold F Shapiro : Financial and Actuarial Statistics Chapman and Hall
3. P. S. Waldhe: Actuarial Statistics Nirali Prakashan
4. Swiss Re: Statistical foundations of Actuarial Learning and its applications Springer

LAB I: Practicals Based on DSC VII and DSC VIII

LAB II : Practicals Based on DSC IX and DSEIII

M.Sc. II (Statistics)(CBCS Pattern) Semester IV

DSCX(Sts-15): Computational Statistics

Course Objectives:

In many disciplines, results are established with the help of the data by fitting a suitable model . Analyzing the data plays an important role in such cases. Advanced statistical methods and different types of models can be applied to these data, even very big data .The course deals with different computational methods and algorithms necessary for analysis of the data. The course includes different methods that are particularly useful in simulating data from various distributions and analyzing them with the help of computers.

Course Outcomes:

At the end of the course, students become well versed with,

1. Visualization of data and exploratory data analysis.
2. Stochastic simulation techniques like MCMC.
3. Some important methods of handling missing data and incomplete data problems like EM algorithm etc.
4. Jackknife ,Bootstarp and nonparametric density estimation using kernels.

Unit I :

Exploratory data analysis: Components of EDA ,transforming data, Clustering: Similarity measures, similarity coefficients, Hierarchical clustering methods: single, complete and average linkage methods, dendrograms, Graphical Methods: Quintile plots, Box Plots, Histogram, Stem & leaf diagram, Q-Q plots, P-P plots

Unit II:

Stochastic simulation: generating random variables from discrete and continuous distributions, simulation bivariate/multivariate distributions, simulating stochastic processes such as simple queues. Variance reduction technique: Importance sampling for integration, control variates, antithetic variables. MCMC methods : Essence of MCMC methods, Time reversible MC, Law of large numbers for MC. Metropolis-Hastings algorithm, Gibbs sampling for bivariate/multivariate simulation. Simulated annealing for optimization, simulated annealing for M.C. Simulation based testing: simulating test statistics and power functions, permutation/randomization tests.

Unit III:

Resampling paradigms: Jackknife and Bootstrap: Delete one J-K,pseudovalues, Bias and S.E. Efron's bootstrap, Bootstrap C.I. Bootstrap-t C.I, Bootstrap C.I. (percentile method),Bootstrap in regression, Bootstrap C.I.for linear regression parameters.

Unit IV:

EM algorithm: Application to missing and incomplete data problems. Mixture models. Smoothing with Kernels: Density estimation, kernel density estimator for univariate data, Band width selection and cross validation, Max likelihood LCV, Least square CV.

Books Recommended

1. J. E. Gentle, W. K. Hardle, Y. Mori : Computational Statistics Concepts and Methods Springer
2. G.H. Givens, J.A. Hoeting: Computational Statistics Wiley
3. J.E. Gentle: Statistics and Computing Springer
4. R.L. Ruiz: Computational Statistics and Applications
5. MarepalliRao, C.R.Rao: Computational Statistics with R Elsevier

M.Sc. II (Statistics) (CBCS Pattern) SIV

AEC on DSCX

Applications of Monte Carlo Simulations

Syllabus

Simulation of sample paths of stochastic process: in particular Brownian motion and Poisson process

M.Sc. II (Statistics) (CBCS Pattern) SIV

DSC XI (Sts-16): Multivariate Analysis

Course Objective

The main objective of this course is to introduce students to the analysis of observations on several correlated random variables for a number of individuals. Multivariate analysis is applicable in almost all scientific studies, for example in Anthropology, Life sciences, Agriculture and Economics, when one deals with several variables simultaneously.

Course Outcome

After completing this course, student is expected to learn the following:

1Account for important theorems and concepts in multivariate analysis.

2Understand the concept of Wishart andHotelling's T^2distribution.

3Understand the link between multivariate techniques and corresponding univariate techniques.

4Conduct statistical inference about multivariate means including hypothesis testing, Confidence region calculation, etc.

Unit I:

Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Inference concerning the mean vector when the covariance matrix is known. Matrix normal distribution. Multivariate central limit theorem.

Unit II:

Wishart matrix, its distribution and properties. Distribution of sample generalized variance. Hotelling's T^2 statistic and its distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations. Mahalanobis' D^2.

Unit III:

Likelihood ratio test criteria for testing of independence of sets of variables, equality of covariance matrices, identity of several multivariate normal populations, equality of a covariance matrix to a given matrix, equality of a mean vector And a covariance matrix to a given vector and a given matrix

Unit IV:

Classification and discrimination procedures for discrimination between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, classification into more than two multivariate normal populations. Principal components, canonical variables and canonical correlations. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambda criterion.

Books Recommended

1. Johnson, R.A.and Wichern, D.W. (2015): Applied Multivariate Statistical Analysis, Sixth Edition, Pearson Education India.
2. Hardle, W.K.and Hlavka, Z. (2015): Multivariate Statistics, Springer.
3. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley.
4. Härdle, W.K.and Simar, L. (2015): Applied Multivariate Statistical Analysis, Springer.
5. Singh, B.M. (2004): Multivariate statistical analysis, South Asian Publishers.

M.Sc. II (Statistics) (CBCS Pattern) Semester IV

DSC XII (Sts-17): Stochastic Process

Course Objective

The objective of this course is to apprise the students with the basic concepts of the theory of stochastic processes in continuous time, also to make them able to use various analytical and computational techniques to study stochastic models that appears in applications.

Course Outcomes

After completing this course, student is expected to learn the following:

1 Study the fundamental concept of stochastic processes and its applications.

2 Understand Markov processes and Markov chains and their applications in real world.

3 Study the branching process and its properties.

4 Understand Poisson processes and its variations.

Unit I: Stochastic Processes: Introduction, classification according to state space and time domain. Countable state Markov chains, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities and their limits, Stationary distribution.

Unit II:

Branching Processes: Properties of generating function of branching processes, probability of ultimate extinction, distribution of the total number of progeny, generalization of the classical Galton-Watson branching process, general branching processes, random walk and gambler's ruin problem.

Unit III:

Continuous-time Markov Processes: Poisson process and related distributions, generalizations of Poisson process, simple birth-process, simple death-process, simple birth-death process, linear birth-death process. First passage time distribution.

Unit IV:

Renewal Theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, central limit theorem for renewals, study of residual and excess life time's process. Renewal reward Process, Markov renewal and semi- Markov processes, Markov renewal equations.

Books Recommended

1. Medhi, J. (2012).Stochastic Processes, 3rdEdition.New Age International.
2. Ross, S.M. (2016). StochasticProcesses, 2ndEdition.WileyIndia.
3. Karlin, S. &Taylor, H.M. (2012).A First Course in Stochastic Processes, 2nd Edition. Academic Press.
4. Prabhu, N.U. (2010).Stochastic Processes: Basic Theory and its Applications. World Scientific.

M.Sc. II (Statistics) (CBCS Pattern) SIV

DSEIVA (Sts-18): Bayesian Inference

Course Objective

The objective of this course is to provide the understanding of the decision theory and fundamentals of Bayesian inference including concept of subjectivity and priors by examining some simple Bayesian frame work.

Course Outcomes

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

1. To understand and utilize past experience along with present observation and improve the inferences.
2. Equip students with skills to carry out and interpret posterior data-based modeling and analyses.
3. Understand Decision theoretical concepts, game theory and their applications.

4. To understand the Bayesian estimation and testing procedures and compare them with classical inference.

Unit I:
Bayes Rule, extended Bayes rule, Minimax rule, methods for finding minimax rules, Generalized Bayes and limit of Bayes rule, Concept of admissibility and completeness Bayes rules, Admissibility of Bayes and minimax rules, Supporting and separating hyper plane theorems, complete class theorem ,Minimax estimators of Normal and Poisson means.

Unit II:
Subjective interpretation of probability in terms of fair odds, Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter, Bayes theorem and computation of the posterior distribution, Natural Conjugate family of priors for a model, Hyper parameters of a prior from conjugate family

Unit III:
Bayesian point estimation as a prediction problem from posterior distribution, Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 -1 loss, Bayesian interval estimation: credible intervals, highest posterior density regions

Unit IV: Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval, Bayesian Testing Hypothesis: Specification of the appropriate from of the prior distribution for a Bayesian testing of hypothesis problem, Prior odds, Posterior odds, Bayes factor.

Books Recommended

1. James O Berger (1985): Statistical Decision Theory and Bayesian analysis. Springer.
2. Ferguson T.S. (1967): Mathematical Statistics-A decisions theoretic Approach. Academic Press.
3. DeGroot. M.H.: Optimal Statistical Decisions. McGraw-Hill.
4. Leonard T and Hsu J.S.J.: Bayesian Methods. Cambridge University Press.
5. Bernardo, J. M. and Smith AFM: Bayesian Theory. John Willey.
6. Rao, C. R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
7. Robert, C. P.: The Bayesian Choice :A Decision Theoretic Motivation, Springe

M.Sc. II (Statistics) (CBCS Pattern) Semester IV

DSE IV B (Sts-19): Statistical Ecology

Course Objectives:

Ecology is study of interaction of organisms that include biotic and a biotic components and their environment. Ecologists can explain life processes, interactions, adoptions, movement of materials, distribution of organisms, biodiversity etc. by using various statistical methods. The course gives knowledge of these methods and models in this particular branch.

Course Outcomes:

At the end of the course, students become well versed with,

1. Concept of inventory problem, need of inventory and types of inventory models and types of probabilistic inventory models.
2. Sequencing problems and methods to solve sequencing problems in different situations
3. Concept of queues, different types of queues and their analysis.
4. Concept of Networking, CPM, PERT and methods of obtaining optimum solutions to the problems.

Unit I:

Population Dynamics One species exponential, logistic and Gompertz models, Two species competition, co-existence, predator prey oscillation, Lotka-Volterra Equations, isoclines, Lestie matrix model for age structured populations. Survivorship curves constant hazard rate, monotone hazard rate and bath tub shaped hazard rates

Unit II: Population density estimation: Capture recapture models, nearest neighbor models, Line transect sampling, Ecological Diversin, Simpson's index, Diversity as average rarity

Unit III: Optimal Harvesting of Natural Resources, Maximum Sustainable field, tragedy of the commons Game theory in ecology, concepts of evolutionarily stable strategy, its Properties, simple cases such as Hawk-Dovegeme.

Unit IV: Foraging Theory: Diet choice Problem, patch choice problem mean variance tradeoff.

Books Recommended

1. L.J. Young, J. H. Young: Statistical Ecology Springer
2. D.I. Warton : Data analysis in Ecology Springer
3. A. P. Robinson, S.T. Buckland, P. Reich M. McCarthy: Methods in statistical Ecology Springer
4. G. Guillot, A. Arab, J. B. Illian, S Dray: Advances in statistical Ecology

M.Sc. II (Statistics) (CBCS Pattern) SIV

DSE IV C (Sts-20): Regression Analysis

Course Objective

The objectives of this course are to develop theoretical foundation of regression models and understand fundamental concepts of regression analysis.

Course Outcome

On completion of this course, students will be able to:
1Understand simple and multiple linear regression models with their applications.
2 Learn the fitting of these models to simulated and real data sets.
3Learn model adequacy using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them.
4Understand the basic concepts of logistic, Poisson and generalized linear models.

Unit I:

Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Prediction of new observations. Coefficient of determination. Estimation by maximum likelihood. Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2.

Unit II:

Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test

based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation and Weighting to Correct Model Inadequacies: Variance stabilizing transformations. Transformations to linearize the model. Analytical
Methods for selecting a transformation on study variable.

Unit III:
Generalized and weighted least square estimation. Polynomial Regression Models: Polynomial models in one variable. Orthogonal Polynomials. Piece wise polynomial (Splines). Variable Selection and Model Building: Incorrect model specifications. Evaluation of subset
Regression model. Computational techniques for variable selection.

Unit IV:
Logistic and Poisson regression models: Introduction, Linear predictor and link functions, logit, probit, odds ratio, maximum likelihood estimation, test of hypothesis. Generalized linear models: Exponential family of distribution, linear predictors and link functions, Maximum likelihood estimation of GLM. Prediction and confidence interval with GLM.

Books Recommended

1. Montegomery, D.C., Peck, E.A. & Vining, G.G. (2015).Introduction to Linear Regression Analysis, 5th Edition. Wiley.
2. Rao, C.R. (2009).Linear Statistical Inference and its Applications, 2ndEdition.Wiley.
3. Draper, N.R. & Smith, H. (2011).AppliedRegressionAnalysis,3rd Edition. Wiley.
4. Chatterjee, S.andHadi, A.S. (2012).RegressionAnalysisbyExample,5thEdition.Wiley.
5. Fox, J.and Weisberg, S. (2019).An R Companion to Applied Regression,3rd Edition. Sage Publications

M.Sc. II (Statistics) (CBCS Pattern) Semester IV

DSE IV D (Sts-21): Reliability Theory

Course Objectives:

Manmade systems suffer from imperfections for several reasons. Often these imperfections lead to improper functioning resulting in failure of the system. It may be the result of defect in the system while producing it or may be because of natural component deterioration on some interacting factors. Probability of non-failure is termed as reliability. Reliability models can be developed for predicting the reliability of a component or of system prior to its implementation.

Course Outcomes:

At the end of the course, students become well versed with,

1. Failure time distribution, reliability function, hazard function etc.
2. Increasing failure rate as an effect of ageing, shock models.
3. Reliability estimation in various cases.
4. Reliability growth models.

Unit I:

Reliability concepts and measures ,components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular compositions, bounds on system reliability, structural and reliability importance of components. Life distributions, reliability functions, hazard rate, common life distributions, exponential, Gamma, Weibull, Log normal etc. Estimation of parameters, confidence intervals, L R and MLE tests for these distributions.

Unit II:

Notions of ageing: IFR, IFRA, NBU, DMRL and NBUE classes and their duals, loss of memory property of the exponential distribution, closures of these classes under formation of coherent systems, convolutions and mixtures. Univariate shock models and life distributions arising out of them, bivariate shock model, common bivariate exponential distributions and their properties.

Unit III:

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items, stress and strength reliability and its estimation. A maintenance and replacement policies, availability of repairable systems, modeling of repairable system by a non-homogeneous Poisson process

Unit IV:

Reliability growth models, probability plotting techniques, Hollander-Proschan and Deshpande tests for exponentially, tests for HPP vs. NHPP with repairable systems.

Books Recommended

1. M. Rausand, A. Barros, A Hoyland : System Reliability Theory Wiley
2. I. Bazovsky: Reliability Theory and Practice Dover Publications
3. J. Navarro: Introduction to system Reliability Theory Springer
4. B.V. Gnedenko: Mathematical methods of reliability theory Academic Press

M.Sc. II (Statistics) (CBCS Pattern) SIV

LAB I : Practical based on DSC-X & DSC-XI

LAB II : Practical based on DSC-XII & DSE-IV