Curriculum
for
the Graduate Program
Session: 2023-2024

DEPARTMENT OF STATISTICS
SCHOOL OF PHYSICAL SCIENCES
SHAHJALAL UNIVERSITY OF
SCIENCE AND TECHNOLOGY, SYLHET

Shahjalal University of Science and Technology, Sylhet
Department of Statistics
Curriculum for the Graduate Program
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Part A

1. **Title of the Academic Program:** Graduate program

2. **Name of the University:** Shahjalal University of Science and Technology, Sylhet

3. **Vision of the University:** To be a leading university of excellence in Science and Technology with a strong national commitment and significant international impact

4. **Mission of the University:**

UM1: To advance learning and knowledge through teaching and research in science and technology.

UM2: To serve as a center for knowledge creation, technological innovation and transfer among academia, industry, and society.

UM3: To assist in transferring Bangladesh a country with sustainable economic growth and equitable social development.

5. **Name of the Program Offering Entity:** Department of Statistics

6. **Vision of the Department:** Evolving expertise in statistics to serve nationally and internationally

7. **Mission of the Department:**

M1: Achieve excellence and expansion of knowledge in Statistics as well as in data science

M2: Maintain the quality of teaching and research at international standard

M3: Collaborate with stakeholders for planning, statistical analysis and research

M4: Promote and tailor research for taking appropriate decision to achieve development goals of the country

8. **Objectives of the Department:**

a. Disseminate fundamental and advance statistical knowledge to adopt and validate data analysis technique

b. Contribute to the theoretical and practical development of statistical methods addressing substantive problems

c. Organizing workshops, seminars, conferences with stakeholders to improve quality of research and implement the statistical techniques

d. Provide adequate and relevant guidelines of statistics to make planning and decision making for achieving Sustainable Development Goals of Bangladesh

9. **Name of the Degree:**

Master of Science in Statistics (Course work),
Master of Science in Statistics (Mixed mode),
Master of Philosophy in Statistics (Research),
Doctor of Philosophy in Statistics (Doctoral Research)

10. **Description of the Program:**

Shahjalal University of Science and Technology (SUST), Sylhet was established in 1986. It is the first science and technology university in Bangladesh. The Department

of Statistics at SUST, under the school of physical sciences, is one of the pioneer departments of the university, established in 1990. Its academic function started from the session 1991-92 with the undergraduate program: Bachelor of Science (B.Sc.) with Honours in Statistics. The academic activities of graduate started from the session 1994-1995.

The department as per rules of university conducts the academic activities of graduate program based on a syllabus structure up to session 2021-2022. The department has developed OBE curriculum from 2022-2023 session following 'Bangladesh National Qualifications Framework (BNQF) for Higher Education' and 'Semester System Ordinance' of the university under the guidance of Institutional Quality Assurance Cell (IQAC), SUST.

The graduate program is an advanced stage of learning to be pursued after the successful completion of B.Sc.(Honours) degree. The curriculum for the Graduate Program covers the requisite courses for the following degrees:

Table: Credit requirements and duration of each of the postgraduate programs

Program Type	**Credit Requirement**				**Program Duration**			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	**Total (Min.)**	Semester (Min.)	Year (Min.)	Semester (Max.)	Year (Max.)
Master's by Coursework	40	-	-	**40**	02	1.0	04	2.0
Master's by Mixed Mode	40	12	-	**52**	3.0	1.5	06	3.0
Master's by Research	Non-credit (if offered)	56	-	**56**	4.0	2.0	06	3.0
Doctoral by Research	-	72	-	**72**	6.0	3.0	14	7.0

Rationale of the Program

After completion of the Graduates program, the students are expected to apply their reasoning and theoretical knowledge to establish their own contributions in planning and decision making globally.

(i) Master of Science in Statistics (Course work) Program

The courses for Masters (Course work) in Statistics are spread over two semesters with 21 credit courses offered in first semester and 19 credit courses offered in second semester. A student of Master of Science in Statistics (Course work) will have to take all the courses of Semester – I and II. A student must complete minimum 40 credits for the Master of Science in Statistics (Course work) degree. Codes of the courses of each semester are arranged according to BNQF guidelines and the courses are divided into Core, General Education, Elective or Optional courses.

(ii) Master of Science in Statistics (Mixed mode) Program

The courses for Master of Science in Statistics (Mixed mode) in Statistics are spread over three semesters with 40 credit courses in Semester – I and II, and 12 credits Thesis in Semester – III. A student of Master of Science in Statistics (Mixed mode) will have to complete Semester – III to carry out the dissertation. Selection of optional courses must be approved by the Graduate Studies Committee (GSC). A student must complete minimum 52 credits for the Master of Science in Statistics (Mixed mode) degree. Codes of the courses of each semester are arranged according to BNQF guidelines and the courses are divided into Core, General Education, Elective or Optional courses.

(iii) Master of Philosophy in Statistics (Research)

For the Master of Philosophy in Statistics (Research) program, the GSC may suggest the theory courses for the fellows if necessary. The selection of the courses will be made by the GSC in consonance with the research field of the fellow. The GSC may waive all or some of the theory courses for the fellows if the courses have already been done by the fellows. A student must complete minimum 56 credits for the Master of Philosophy in Statistics (Research)**.**

(iv) Doctor of Philosophy in Statistics (Doctoral Research)

For the Doctor of Philosophy in Statistics (Doctoral Research) program, the GSC may suggest the theory courses for the fellows if necessary. The selection of the courses will be made by the GSC in consonance with the research field of the fellow. The GSC may waive all or some of the theory courses for the fellows if the courses have already been done by the fellows. A student must complete minimum 72 credits for the Doctor of Philosophy in Statistics (Doctoral Research)**.**

11. Graduate Attributes (based on need assessment):

Code	Graduate Attributes	Domain
GA 01	Knowledge of advanced statistical techniques	Fundamental skills
GA 02	Employ advanced knowledge on beyond-discipline fields.	Fundamental skills
GA 03	Convey advanced knowledge of communication skills using appropriate methods to the peers.	Social skills
GA 04	Establish expert knowledge on contemporary issues for environmental sustainability at a regional and international level.	Social skills
GA 05	Capacity for analyzing general and advanced range of specialized theories, concepts, principles and complex methods.	Thinking skills
GA 06	Capacity for decision-making on complex problematic issues within the academic, professional or technical settings.	Thinking skills
GA 07	Ability to self-development through constant academic and professional development.	Personal skills
GA 08	Awareness of ethical issues and capable to take full responsibility for overall management of the research.	Personal skills

12. Program Educational Objectives (PEOs):

PEO1	To provide advanced frontiers of knowledge of statistics
PEO2	To promote innovative thinking on complex theories in statistics as a basis for research
PEO3	To guide students for design and implement advanced research methodologies on contemporary research issues
PEO4	To enhance leadership quality to support critical analysis and decision making
PEO5	To assist students as a preparation for improving professional development including for the betterment of the nation.

13. Program Learning Outcomes (POs): After successful completion of the program, the graduates are expected to come up with the ability to-

A. Fundamental Skills	
PO1	Demonstrate analytical abilities using advanced statistical techniques to solve real world problems.
B. Social Skills	
PO2	Employ appropriate statistical methods to solve social problems at the national and global levels.
C. Thinking Skills	
PO3	Analyze big data using advanced statistical methods and applying data science tools.
PO4	Address complex situations in academic, professional, and technological settings.
D. Personal Skills	
PO5	Work independently on contemporary research issues of national interest, and adhere to legal, ethical, and professional codes of conduct.
PO6	Demonstrate self-advancement through continuous professional development and enhance leadership qualities.

14. Mapping mission of the university with PEOs

PEOs	UM1	UM2	UM 3
PEO 1	√	√	
PEO 2	√	√	
PEO 3		√	√
PEO 4	√	√	√
PEO 5		√	√

15. Mapping POs with the PEOs

	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5
PO 1	√	√	√		
PO 2			√		√
PO 3	√	√			
PO 4		√		√	√

PO 5				√	√
PO 6		√		√	√

16. Mapping courses with the POs

Courses	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
STA 0542 1161	√	√			√	
STA 0542 1162	√	√			√	
STA 0542 1163	√	√	√	√		
STA 0542 1164	√	√	√	√	√	
STA 0542 1165	√	√	√		√	
STA 0542 1166	√	√	√		√	
SPS 0314 1167	√	√		√	√	√
SPS 0314 1168	√	√		√	√	√
STA 0542 1170	√	√	√	√	√	√
STA 0311 1261	√	√	√	√		
STA 0311 1262	√	√	√	√		
STA 0542 1263	√	√	√	√	√	
STA 0542 1264	√	√	√			
STA 0542 1270	√	√	√	√	√	√
STA 0542 1273	√		√	√	√	√
STA 0542 1274	√		√	√	√	√
STA 0542 1275	√	√	√		√	√
STA 0542 1276	√	√	√		√	√
STA 0542 1277	√	√	√	√		
STA 0542 1278	√	√	√			

STA 0542 1279	√	√	√		√	√
STA 0542 1280	√	√	√		√	√
STA 0542 1390	√	√	√	√	√	√

STA: Statistics; GED: General Education; SPS: School of Physical Sciences; 0542 indicates Statistical courses;

Part B

17. Structure of the Program

a) Duration of the program:

Year/Semester : Min. 1 Year/ 2 Semester (Master's by Course work)
Max. 2 Year/4 Semester (Master's by Course work);
Year/Semester : Min. 1.5 Year/ 3 Semester (Master's by Mixed mode)
Max. 3 Year/ 6 semester (Master's by Mixed mode);
Year/Semester: Min. 2 Year/ 4 Semester (Master's by Research)
Max: 3 Year/ 6 Semester (Master's by Research);
Year/Semester : Min. 3 Year/ 6 Semester (Doctoral by Research)
Max: 7 Year/ 14 Semester(Doctoral by Research);

b) Admission Requirements:

Provided by the academic council rules of SUST as follows:

Master's by Couresework and Mixed mode	Master's by Research and Doctoral Research
Master's by Couresework: A1.1 Graduates with a bachelor's degree in a relevant discipline from SUST are eligible to apply for the Master's by Coursework program. A2.1 The candidate for this program must submit the following documents: (i) application in the prescribed form, (ii) academic transcript, and (iii) consent letter from the employer, if applicable. A2.2 After selecting the candidate for this program, the Graduate Study Committee will then send all the documents mentioned in Clause A2.1 to the Board of Advanced Studies through the Dean of the school for subsequent approval by the Academic Council. A3.1 A student enrolled in this program must	**Master's by Research:** C1.1 Graduates with a Bachelor's degree in a relevant discipline from SUST or any other university or equivalent foreign university, with a minimum CGPA of 3.25, are eligible to apply for the Master's by Research program. C1.2 A candidate holding a Master's by Coursework (General) degree in a relevant discipline from SUST is eligible for admission to the Master's by Research program, provided s/he has achieved a minimum CGPA of 3.25 in his or her Master's by Coursework program. C1.3 A candidate currently enrolled in a Master's by Coursework program at SUST, who has already completed 18 credits of coursework with a CGPA of 3.25 or higher, is eligible to apply for

register for a minimum of 10 (ten) credits and a maximum of 20 (twenty) credits per semester.

A3.2. A SUST faculty member may be admitted to this program with prior approval from the University Authority.

A3.3 The registration for this program will remain valid for a maximum of 4 (four) semesters.

A3.4 The period of candidature for this program will remain valid for a maximum of 2 (two) academic years.

A6.1 Duration: Minimum duration for this degree is 2 (two) semesters.

A6.2 Credit Requirement: To attain the Master's by Coursework degree, students are required to fulfill a minimum of 40 credits through coursework instruction.

A6.3 Course Requirement: Students enrolled in the Master's by Coursework program must complete a minimum of 40 credit hours of instructional coursework. The GSC may recommend required courses, but not more than 12 (twelve) credits, at the graduate and/or undergraduate levels from other disciplines.

Master's by Mixed Mode

B1.1 Graduates with a Bachelor's degree in a relevant discipline from SUST or any other university or equivalent foreign university, with a minimum CGPA of 3.25, are eligible to apply for the Master's by Mixed Mode program.

B1.2 A candidate holding a Master's by Coursework degree in a relevant discipline from SUST is eligible for admission to the Master's by Mixed Mode program, provided s/he has achieved a minimum CGPA of 3.25 in his/her Master's by Coursework program.

B1.3 A candidate currently enrolled in a Master's by Coursework program at SUST, who has already completed 18 credits of coursework with a CGPA of 3.25 or higher, is eligible to apply for the conversion from his/her current program to this program. In such cases, the candidate will be granted a waiver for theory courses completed in the Master's by Coursework program.

B1.4 A candidate who has graduated under the course system and has achieved at least a second division/class in all previous examinations is eligible for admission to this program. In such cases, the candidate must provide evidence that this degree will enhance his/her professional career.

B1.5 A candidate with a bachelor's degree in engineering from a university or institution other than SUST, who has completed 160 credits as his/her degree requirements with a minimum CGPA of 3.25, is eligible to apply for the Master's by Mixed Mode program.

B.2.1 The candidate applied for this program must submit the following documents: (i) application in the prescribed form, (ii) academic transcript, (iii) a research proposal, (iv) one reference letter, (v) consent letter from a potential Supervisor, and (vi) consent letter from the employer, wherever applicable.

B2.2 Candidates will be selected for admission based on the performance in a written and/or viva voce examination conducted by the Graduate Studies Committee (GSC). However, full-time university teachers will be exempted from the written examination.

B2.3 The GSC will assign a Supervisor and, if applicable, a Co-Supervisor for the thesis work from among the teachers in the same discipline at SUST. However, the Co-Supervisor can be selected from other disciplines of SUST or from home and abroad. Both the Supervisor and Co-Supervisor must meet the required qualification criteria outlined in clause C2.3.1

C3.1 Every admitted candidate must register with the registrar's office and pay the required fees for the program.

C3.2 Date of registration and duration of the Candidature: Registration takes effect on the date approved by BAS and successively endorsed by AC. The duration of the registered Master's by research program will be counted from the date of registration.

C3.3 A student enrolled in this program must register for a minimum of 8(eight) credits and a maximum of 16(sixteen) credits per semester.

C3.4 The candidature of the registered candidate will remain valid for a maximum of 6 (six) semesters.

Doctoral by Research Program:

D1.1 A candidate with a Master's by Mixed Mode degree with CGPA 3.25 or with a Master's by Research degree is eligible to apply for a PhD. program as regular student. D1.2 A candidate currently enrolled in a Master's by Research program at SUST is eligible to apply for the conversion from a Master's by Research to a PhD. program, subject to the fulfillment of the following conditions: (i) the candidate must have authored at least two published articles in peer-reviewed journal(s) derived from his/her research work within the first two semesters, provided that s/he appears as the first or corresponding author, (ii) the supervisor must certify that the candidate possesses the potential to successfully complete the PhD program, and (iii) the Graduate Studies Committee (GSC) confirms that the progress achieved is solely attributable to the candidate. The proposal for this conversion requires approval from the Board of Advanced Studies (BAS) and subsequently from the Academic Council (AC). From the date of conversion at AC, the PhD candidature will starts. The title of the

C1.4 A candidate who has graduated under the course system and has achieved at least a second division/class in all previous examinations is eligible for admission to this program. In such cases, the candidate must provide evidence that this degree will enhance his/her professional career.

C1.5 A candidate with a bachelor's degree in engineering from a university or institution other than SUST, who has completed 160 credits as his/her degree requirements with a minimum CGPA of 3.25, is eligible to apply for the Master's by Research program.

C.2.1 The candidate applied for this program must submit the following documents: (i) application in the prescribed form, (ii) academic transcript, (iii) a research proposal, (iv) one reference letter, (v) consent letter from a potential Supervisor, and (vi) consent letter from the employer, wherever applicable.

C2.2 Candidates will be selected for admission based on the performance in a written and/or viva voce examination conducted by the Graduate Studies Committee (GSC). However, full-time university teachers will be exempted from the written examination.

C2.3 The GSC will assign a Supervisor and, if applicable, a Co-Supervisor for the thesis work from among the teachers in the same discipline at SUST. However, the Co-Supervisor can be selected from other disciplines of SUST or from home and abroad. Both the Supervisor and Co-Supervisor must meet the required qualification criteria outlined in clause C2.3.1

from among the teachers
in the same discipline at SUST. However, the Co-Supervisor can be selected from other disciplines of SUST or from home and abroad. Both the Supervisor and Co-Supervisor must meet the required qualification criteria outlined in clause B2.3.1

B3.2 A student enrolled in this program must register for a minimum of 8(eight) credits and a maximum of 16(sixteen) credits per semester.

B3.3 The candidature of the registered candidate will remain valid for a maximum of 6 (six) semesters.

B6.1 Duration: Minimum duration for the degree is 3 (three) semesters.

B6.2 Credit Requirement: To obtain the Master's by Mixed Mode degree, a student must complete a minimum of 40 (forty) credits through a combination of taught coursework and a dissertation.

B6.3 Course Requirement: Students enrolled in this program must complete a minimum of 18 credit hours of instructional coursework, complemented by a research component of 12–18 credits. The GSC may recommend required courses, but not more than 12 (twelve) credits, at the graduate and/or undergraduate levels from other disciplines.

B6.4 **Dissertation**
Requirement: To obtain the degree, a student must complete a dissertation of 12–18 credits, as assigned by the GSC as a mandatory degree requirement. Upon completing the entire research work, the student will prepare a dissertation as a comprehensive piece of work. It should be evaluated for its theoretical, scientific and methodological soundness using a prescribed

PhD thesis along with a research proposal must be submitted to GSC.

D1.3 A candidate who has graduated in Masters (by research) under the course system (other than semester system) and is seeking admission to the PhD program must hold a minimum of a second division or class in all previous examinations. Additionally, the candidate is required to attain a score of at least 50% in his/her Master's (Research) examination.

D1.4 Candidates eligible for direct admission to the PhD. program as regular students include the following: (i) university or college teachers possessing a Master's by Mixed Mode or Master's by Research degree; (ii) university teachers with a minimum of three (3) years of teaching experience at the university level; (iii) college teachers (teaching in graduate programs) with a minimum of six (6) years of teaching experience at the college level; and (iv) researchers affiliated with recognized research organizations, provided they have a minimum of six (6) years of research experience being appointed as a research scholar or associate. It is pertinent to note that candidates falling under categories (ii) through (iv) are required to have at least two research articles published in a Web of Science or SCOPUS-indexed journal where they appear as the first or corresponding author.

D2.1 A candidate possessing all required qualifications for admission to the PhD. program is needed to submit an application to the Head of the discipline or the Director of the institute. The institute should offered the degree under a specific School of study. The application must be accompanied by the following documents: (i) a completed application form; (ii) academic transcripts; (iii) a comprehensive research proposal; (iv) a reference letter; (v) a letter of consent from a potential Supervisor (as per the

rubric as outlined in Clause B6.4.1.

2.1.1 Any student with a Bachelor's degree from SUST is eligible for admission to the Master of Science in Statistics (General) Program.

2.1.2 Any student with a CGPA of 3.25 or more from SUST is eligible for admission to the Master of Science in Statistics (Thesis).

2.1.3 Four-year Graduates from other recognized universities and institutions with a CGPA of 3.25 or more can apply for admission to the Master of Science in Statistics (Thesis).

2.1.6 The GSC of a discipline will decide if a student from a related discipline will be allowed to apply to the graduate program of that discipline. In these cases if necessary the GSC may ask the candidate to take extra under-graduate/graduate courses to ensure the basic foundation.

3.1.1 If a SUST graduate has the required qualifications he/she can be admitted to the Master's program (General, Thesis) as per the recommendation of the GSC.

3.1.2 The candidates for Master of Science in Statistics (Thesis) will be selected for admission after a written and/or viva voce examination conducted by the GSC. Full time teachers of SUST are not required to sit for the admission test. GSC will then recommend the candidates for admission to the academic council through the BAS. During the process of admission each candidate shall be assigned by the appropriate GSC and approved by BAS a supervisor from among the teachers of the relevant discipline/institute not below the rank of an associate professor or an assistant professor with a Ph.D. / M.Phil. / M.S.

provision stated in clause D4.1); and (vi) a letter of consent from the employer, if applicable. In cases where the candidate does not propose a specific Supervisor, the Graduate Studies Committee (GSC) retains the authority to assign a Supervisor from among the faculty members within the same discipline or any other discipline at SUST, relevant to the proposed topic.

D2.2 Candidates aspiring to enroll in the PhD. program, possessing the qualifications outlined in Clauses D1.1– D1.3, shall undergo a selection process facilitated by the GSC. This process may involve written and/or viva voce examinations, wherein the GSC will assess and select the suitable candidates for admission. GSC may arrange a presentation for the candidate to clarify his/her research proposal.

D2.3 Following the selection of the candidate for the PhD. program, the GSC will provide a recommendation supported by a summary sheet and the subsequent documents including (i) a provisional title for the dissertation; (ii) proposed Supervisor and Co-Supervisor, (if applicable) (iii) a research proposal endorsed by the GSC; (iv) academic records of the candidate; (v) an assessment sheet detailing the candidate's qualifications; (vi) statements confirming the qualifications and consent of the Supervisor and Co-Supervisor (if any) and (vii) evidence of accommodating the student in the institution of the Co-Supervisor external to SUST, where applicable.

D2.4 The Chairman of the GSC will then send all the documents mentioned in Clause D2.3 to the Board of Advanced Studies (BAS) through the respective Dean for subsequent approval by the Academic Council (AC).

D2.5 If deemed necessary, the GSC has the prerogative to suggest non-credit courses at the

	bachelor's or master's levels, aiming to fortify the candidate's academic foundations pertinent to their specific research endeavors. D3.1 Every candidate must register for the degree of Doctor of Philosophy (PhD) as a full-time student for the first year. By the end of the year the student needs to confirm his/her candidature defending his/her research work with satisfactory progress assessed by GSC. After successful confirmation of the candidature the candidate can continue his/her study with full time status or may apply for part time status. D3.1.1 After the confirmation of candidature, a PhD student i) who is in a full-time employment in a research supportive environment and expect to continue in the employment situation, and ii) who could not attend the university and participate in a full-time basis due to assignable causes may apply to register as a part-time student. The GSC will confirm the part-time studentship status with the approval of BAS and AC. D3.1.2 Date of registration and duration of the Candidature: Registration takes effect on the date approved by BAS and successively endorsed by AC. The duration of the registered PhD program will be counted from the date of registration. D3.2 A candidate enroll in the PhD program must register for a minimum of 8(eight) credits and a maximum of 16(sixteen) credits per semester. D3.3 The registration for the PhD program will remain valid for a maximum of 12(twelve) semesters. D3.4 The period of candidature for this program will remain valid for a maximum of 6(six) academic years.

c) Graduating credits: Minimum 40 Credits (for Course work)
Minimum 52 Credits (for Mixed mode)
d) Total class weeks in a semester: 14
e) Minimum CGPA requirement for graduation: 2.00
f) Maximum academic years of completion:
Course work: 2 Years
Mixed mode: 3 Years
g) Category of Courses:

Course Category	Course Type	Course Title	Credits
General Education (GED) Courses	Theory	1. Advanced Demography	3.0
	Lab	1. Advanced Demography Lab	2.0
	Total		**5.0**
Core Courses	Theory	1. Advanced Statistical Inference	3.0
		2. Advanced Multivariate Analysis	3.0
		3. Time Series Analysis	3.0
		4. Econometrics	3.0
		5. Advanced Biostatistical methods	3.0
	Lab	1. Advanced Statistical Inference Lab	2.0
		2. Advanced Multivariate Analysis Lab	2.0
		3. Time Series Analysis Lab	2.0
		4. Econometrics Lab	1.5
		5. Advanced Biostatistical methods Lab	1.5
		6. Presentation and Viva-voce	2.0
	Total		**26.0**
Optional/ Elective Courses	Theory	1. Data Mining & Machine learning	3.0
		2. Actuarial Statistics	3.0
		3. Bioinformatics	3.0

		4. Categorical Data Analysis	3.0
		5. Advanced Probability Theory	3.0
	Lab	1. Data Mining & Machine learning Lab	1.5
		2. Actuarial Statistics Lab	1.5
		3. Bioinformatics Lab	1.5
		4. Categorical Data Analysis Lab	1.5
		5. Advanced Probability Theory Lab	1.5
	Total credits of theory courses with relevant labs (Optional)		**9.0**
Total (Optional + compulsory)	**17 Courses**	**credits**	**40.0**
Capstone Courses		1. Mater's by Mixed Mode 2. Master by Research 3. Doctoral by Research	12.0 48.0 72.0

18. Year/Semester wise distribution of courses

Semester – I

Course Code	Course Title	**Course Category**	Hours/Week		Credits
			Theory	Lab	
STA 0542 1161	Advanced Statistical Inference	Core	3	0	3.0
STA 0542 1162	Advanced Statistical Inference Lab	Core	0	4	2.0
STA 0542 1163	Advanced Multivariate Analysis	Core	3	0	3.0
STA 0542 1164	Advanced Multivariate Analysis Lab	Core	0	4	2.0
STA 0542 1165	Time Series Analysis	Core	3	0	3.0
STA 0542 1166	Time Series Analysis Lab	Core	0	4	2.0
SPS 0314 1167	Advanced Demography	General Education	3	0	3.0
SPS 0314 1168	Advanced Demography Lab	General Education	0	4	2.0

STA 0542 1170	Presentation and Viva-voce	Core	0	0	1.0
Total			12	16	**21.0**

Semester – II

Course Code	Course Title	**Course Category**	Hours/Week		Credits
			Theory	Lab	
STA 0311 1261	Econometrics	Core	3	0	3.0
STA 0311 1262	Econometrics Lab	Core	0	3	1.5
STA 0542 1263	Advanced Biostatistical Methods	Core	3	0	3.0
STA 0542 1264	Advanced Biostatistical Methods Lab	Core	0	3	1.5
Choose two theory and related lab courses from optional / elective courses		Core	6	0	6.0
			0	6	3.0
STA 0542 1270	Presentation and Viva-voce	Core	0	2	1.0
Total			12	14	**19.0**
Optional Courses					
STA 0542 1271	Actuarial Statistics	Optional	3	0	3.0
STA 0542 1272	Actuarial Statistics Lab	Optional	0	3	1.5
STA 0542 1273	Data Mining & Machine learning	Optional	3	0	3.0
STA 0542 1274	Data Mining & Machine learning Lab	Optional	0	3	1.5
STA 0542 1275	Bioinformatics	Optional	3	0	3.0
STA 0542 1276	Bioinformatics Lab	Optional	0	3	1.5
STA 0542 1277	Categorical Data Analysis	Optional	3	0	3.0
STA 0542 1278	Categorical Data Analysis Lab	Optional	0	3	1.5

STA 0542 1279	Advanced Probability Theory	Optional	3	0	3.0
STA 0542 1280	Advanced Probability Theory Lab	Optional	0	3	1.5
Total (Optional two courses)			**6**	**6**	**9.0**
Total (Core + GED + Optional) 18 Courses			**18**	**20**	**40.0**

Semester – III

Course Code	Course Title	**Course Category**	Hours/Week		Credits
			Theory	Lab	
STA 0542 1390	Dissertation	Core		24	12.0

Part C

19. Description of all courses of the program including the following information for each course:

Detailed Course Curriculum 2023-2024

Master of Science in Statistics First Semester Course Details

Course Code: STA 0542 1161	**Credit:** 3.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Advanced Statistical Inference		**Course Status:** Theory	

Rationale of the Course: Building capability of the students on estimating the parameters and evaluating the properties of estimators in order to find the best estimators and performing tests for simple and composite hypotheses.

Course Objectives:

- Acquiring knowledge on point and interval estimation of parameters using classical and Bayesian approach
- Developing the test criteria for both simple and composite hypotheses

Course Content

Point estimation: Classical approach, sufficiency and completeness, minimal sufficient statistic & ancillary statistics. Different methods of obtaining UMVUE. Rao-Blackwell theorem and Lehmann-Scheffe theorem. Asymptotic properties of maximum likelihood estimators. Fisher's information.

Bayesian approach: conjugate family of prior densities, vague prior knowledge, informative, non-informative, least informative priors. Loss function (symmetric and asymmetric loss function) and risk function, Bayes' risk, Bayes' estimation.

Location and scale invariance, Pitman estimator for location and scale parameters.

Robust estimation: robust L-M-R -estimations, estimation of the parameters using Huber Ψ function.

Interval estimation: central and non-central confidence intervals. General method of finding confidence intervals. Confidence interval for large samples. Joint intervals for several parameters. Bayesian interval.

Test of hypothesis: Most powerful test, UMP test, Unbiasedness and consistency of tests. Principles of LR test and its applications. Asymptotic distribution of LR statistic. Sequential probability ratio test. Comparison with fixed sample size test. OC function. ASN function.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Find the UMVUEs using the concept of sufficient statistics;
CO2	Determine along with comparison the Pitman and Bayes estimators of the location and scale parameters;
CO3	Derive the Classical and Bayesian interval;
CO4	Develop the test criteria for both simple and composite hypothesis;
CO5	Determine the best test for both fixed sample and random sample.

Mapping Course Learning Outcomes (COs) with the Pos

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3				
CO2	3	3				

CO3	3	3				
CO4	3	3		3		
CO5	3	3		3		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Semester-end examination
CO 2	Lecture using board	Midterm Examination 1 Semester-end examination
CO 3	Lecture using board	Semester-end examination
CO 4	Lecture using board, assignment	Assignment (Individual/group) Midterm Examination 2 Semester-end examination
CO 5	Lecture using board	Semester-end examination

Books Recommended:

Main Text:

1. Mukhopadhyay, N. (2000). Probability and Statistical Inference. CRC Press.
2. Rohatgi, V.K. (2013). Statistical Inference. Courier Corporation.
3. Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). Introduction to the theory of statistics. McGraw-Hill series in probability and statistics. Kogakusha Ltd, Tokyo.
4. Sahu, P.K., Pal, S. R., Das, A. K., (2015), Estimation and Inferenetial Statistics, 1st Edition, Springer.

Reference Books:

1. Barnett, V. (1999). *Comparative statistical inference* (Vol. 522). John Wiley & Sons.
2. Beaumont, G. P. (2012). *Intermediate mathematical statistics*. Springer Science & Business Media.
3. Blackwell, D. A., & Girshick, M. A. (1979). *Theory of games and statistical decisions*. Courier Corporation.
4. Chernoff, H., & Moses, L. E. (2012). *Elementary decision theory*. Courier Corporation.
5. Conover, W. J. (1999). *Practical nonparametric statistics* (Vol. 350). john wiley & sons.
6. Gibbons, J. D., & Chakraborti, S. (2014). *Nonparametric statistical inference*. CRC press.
7. Hogg, R. V., Tanis, E. A., & Zimmerman, D. L. (1977). *Probability and statistical inference* (Vol. 993). New York: Macmillan.
8. Larson, H. J. (1982). Introduction to probability and statistical inference. John Wiley & Sons.
9. Romano, J. P., & Lehmann, E. L. (2005). Testing statistical hypotheses.
10. Lehmann, E. L., & Casella, G. (2006). *Theory of point estimation*. Springer Science & Business Media.
11. Rao, C. R., Rao, C. R., Statistiker, M., Rao, C. R., & Rao, C. R. (1973). *Linear statistical inference and its applications* (Vol. 2, pp. 263-270). New York: Wiley.
12. Saxena, H. C., & Surendran, P. U. (1967). *Statistical inference*. 3rd Ed. S Chand & Company. India
13. Siegel, S., & Castellan, N. J., Jr. (1988). *Nonparametric statistics for the behavioral sciences* (2nd ed.). Mcgraw-Hill Book Company.
14. Wald, A. (2004). *Sequential analysis*. Courier Corporation.
15. Weiss, L. (1961). *Statistical decision theory*. McGraw Hill. NY.
16. Zacks, S. (1971). *The theory of statistical inference*. 1st Ed, Wiley. NY

Course Code: STA 0542 1162	**Credit:** 2.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Advanced Statistical Inference Lab		**Course Status:** Lab	

Rationale of the Course: Building capability of the students on applying different techniques of statistical inference in real world.

Course Objectives:

- Generating knowledge on estimating the parameters of different distributions and construction of confidence interval and Bayesian interval of the parameters
- Performing statistical tests for both simple and composite hypotheses

Course Content

Estimation of parameters (with estimated standard error) by different methods under classical and Bayesian approaches, construction of confidence interval and Bayesian interval, power function and power curves, SPRT, OC function, ASN.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Find the estimated value of the parameters using both classical and Bayesian approaches;
CO2	Construct the classical and Bayesian interval;
CO3	Analyze the test criteria for both simple and composite hypotheses.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3		3		
CO2	3	3		3		
CO3	3	3		3		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Semester-end examination
CO 2	Lecture using board	
CO 3	Lecture using board	

Books Recommended:

Main Text:

1. Mukhopadhyay, N. (2000). Probability and Statistical Inference. CRC Press.
2. Rohatgi, V.K. (2013). Statistical Inference. Courier Corporation.
3. Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). *Introduction to the theory of statistics*. McGraw-Hill series in probability and statistics. *Kogakusha Ltd, Tokyo*.

Reference Books:

1. Barnett, V. (1999). *Comparative statistical inference* (Vol. 522). John Wiley & Sons.
2. Beaumont, G. P. (2012). *Intermediate mathematical statistics*. Springer Science & Business Media.
3. Blackwell, D. A., & Girshick, M. A. (1979). *Theory of games and statistical decisions*. Courier Corporation.
4. Chernoff, H., & Moses, L. E. (2012). *Elementary decision theory*. Courier Corporation.
5. Conover, W. J. (1999). *Practical nonparametric statistics* (Vol. 350). john wiley & sons.
6. Gibbons, J. D., & Chakraborti, S. (2014). *Nonparametric statistical inference*. CRC press.
7. Hogg, R. V., Tanis, E. A., & Zimmerman, D. L. (1977). *Probability and statistical inference* (Vol. 993). New York: Macmillan.
8. Larson, H. J. (1982). Introduction to probability and statistical inference. John Wiley & Sons.
9. Romano, J. P., & Lehmann, E. L. (2005). Testing statistical hypotheses.
10. Lehmann, E. L., & Casella, G. (2006). *Theory of point estimation*. Springer Science & Business Media.
11. Rao, C. R., Rao, C. R., Statistiker, M., Rao, C. R., & Rao, C. R. (1973). *Linear statistical inference and its applications* (Vol. 2, pp. 263-270). New York: Wiley.
12. Saxena, H. C., & Surendran, P. U. (1967). *Statistical inference*. 3rd Ed. S Chand & Company. India
13. Siegel, S., & Castellan, N. J., Jr. (1988). *Nonparametric statistics for the behavioral sciences* (2nd ed.). Mcgraw-Hill Book Company.
14. Wald, A. (2004). *Sequential analysis*. Courier Corporation.
15. Weiss, L. (1961). *Statistical decision theory*. McGraw Hill. NY.
16. Zacks, S. (1971). *The theory of statistical inference*. 1st Ed, Wiley. NY

Course Code: STA 0542 1163	**Credit: 3**.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Advanced Multivariate Analysis		**Course Status:** Theory	

Rationale of the Course: Acquiring advanced knowledge of the analysis and interpretation of multivariate techniques.

Course Objectives:

- To understand the main features of multivariate data,
- To be able to use exploratory and confirmatory multivariate statistical methods properly,
- To be able to carry out multivariate statistical techniques and methods efficiently and effectively.

Course Content:

Distributional methods: Tests for covariance and correlation patterns and multivariate normality. Simulation of multivariate normal variate. Correspondence analysis: basic concepts and definitions, reduction of dimensionality and its criteria, interpretation.

Principal component analysis: Derivation of components, choosing principal components, properties, large sample inferences. **Factor analysis:** explanatory and confirmatory factor analysis, factor models, estimation, loadings and communalities, factor rotation and factor scores. **Canonical correlation analysis:** Canonical variates and canonical variate analysis, canonical correlations, population canonical variables, sample canonical variables. **Discrimination and classification:** separation and classification for two populations, classification functions, Fisher's discriminant function, Fisher's method for discrimination. **Distribution free methods:** Similarities and dissimilarities: concept, uses in multivariate analysis. Independent component analysis (ICA). Multidimensional scaling: principal coordinate analysis, metric and non-metric multidimensional scaling, goodness of fit. Cluster analysis: hierarchical and nonhierarchical clustering methods.

Multivariate Bayesian regression.

Multivariate mixture model.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Apply distributional methods to test covariance and correlation patterns as well as simulation of multivariate normal variates for analysis;
CO2	Analyze dimension reduction techniques including correspondence analysis, principal component analysis, factor analysis, and canonical correlation analysis;
CO3	Apply Fisher's discriminant function and classification techniques for separating and classifying data from two or more populations;
CO4	Assess with implementation of distribution-free methods, such as ICA, multidimensional scaling, and cluster analysis, to analyze data similarities and dissimilarities;
CO5	Evaluate the effectiveness of multivariate Bayesian regression and mixture modeling techniques in addressing complex data structures.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3		3		
CO2	3	3	3			
CO3	3		3			
CO4	3			3		
CO5	3			3	2	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Quiz/ Semester-end examination
CO 2	Lecture using board, assignment	Assignment/ Presentation (Individual/group) Semester-end examination
CO 3	Lecture using board	Semester-end examination
CO 4	Lecture using board, assignment	Quiz/ Assignment/ Presentation (Individual/group) Semester-end examination
CO 5	Lecture using board, assignment	Quiz/ Assignment/ Presentation (Individual/group) Semester-end examination

Books Recommended:

Main Text:

1. Johnson, R. A., & Wichern, D. W. (2002). Applied multivariate statistical analysis. 6th Ed, Prentice Hall, New Jersey.

Reference Books:

1. Afifi, A., May, S., & Clark, V. A. (2011). *Practical multivariate analysis*. Chapman and Hall/CRC.
2. Anderson, T. W. (1958). Introduction to multivariate statistical analysis. 3rd Ed., John Wiley, NY.
3. Bhuiyan, K. C. (2005). Multivariate Analysis. Central Publications. Bangladesh
4. Chatfield, C. & Collins, A. J. (1980). *Introduction to Multivariate Analysis*. Springer, London.
5. Krzanowski, W. J. (1988). *Principles of Multivariate analysis: A User's Perspective*. Revised Ed, Oxford University Press, USA.
6. Manly, B. F., & Alberto, J. A. N. (2016). *Multivariate statistical methods: a primer*. Chapman and Hall/CRC.
7. Mardia, K. V., *et al.* (1979). *Multivariate Analysis*. 7th Ed, Academic Press, NY.
8. Morrison, D. F. (2016). *Multivariate Statistical Methods*. 4th Ed, Duxbury Press, USA
9. Timm, N. H. (Ed.). (2002). *Applied multivariate analysis*. New York, NY: Springer New York.
10. Rencher, A. C. (2002). *Methods of Multivariate Analysis*. 2nd Ed, John Wiley & Sons, USA

Course Code: STA 0542 1164	**Credit:** 2.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Advanced Multivariate Analysis Lab		**Course Status:** Lab	

Rationale of the Course: Apply acquired advanced knowledge of the analysis and interpretation of real-life multivariate data.

Course Objectives:

- To facilitate necessary skills to analyze multivariate data,
- To acquaint students with the data reduction techniques,
- To develop the ability to apply unsupervised learning techniques.

Course Content:

Distributional methods: Tests for covariance and correlation patterns and multivariate normality. Simulation of multivariate normal variate. **Principal component analysis:** Derivation of components, large sample inferences. **Factor analysis:** explanatory and confirmatory factor analysis, factor rotation and factor scores. **Canonical correlation analysis:** canonical variates and canonical variate analysis, canonical correlations. **Discrimination and classification:** separation and classification for two populations, classification functions, Fisher's discriminant function, Fisher's method for discrimination. **Distribution free methods: Multidimensional scaling:** principal coordinate analysis, metric and non-metric multidimensional scaling, goodness of fit. **Cluster analysis:** hierarchical and nonhierarchical clustering methods. **Correspondence analysis:** reduction of dimensionality and interpretation.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Perform tests for covariance and correlation patterns along with the assessment of multivariate normality through simulation of multivariate normal variates;
CO2	Analyze data reduction techniques such as PCA, factor analysis, canonical correlation analysis, and correspondence analysis, focusing on component derivation, large sample inferences, and interpretation of reduced dimensions;
CO3	Evaluate discrimination and classification techniques for separating data from two populations using Fisher's discriminant function;
CO4	Apply distribution-free methods, for instance, multidimensional scaling and clustering for data analysis;
CO5	Derive meaningful insights along with formulation of valid conclusions to evaluate and synthesize complex multivariate data.

Mapping Course Learning Outcomes (Cos) with the Pos

3: Strong 2: Moderate 1: Weak

Course Learning	Fundamental Skill	Social Skill	Thinking Skill	Personal Skill

Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1		
CO2	3	1	3			
CO3	3	1	3			
CO4	3	1	2	3	2	
CO5	2	1	3	3	2	2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Semester-end examination
CO 2	Lecture using board, assignment	Assignment, Semester-end examination
CO 3	Lecture using board, assignment	Assignment, Semester-end examination

Reference Books:

1. Johnson, R. A., & Wichern, D. W. (2002). Applied multivariate statistical analysis. 6th Ed, Prentice Hall, New Jersey.
2. Afifi, A., May, S., & Clark, V. A. (2011). *Practical multivariate analysis*. Chapman and Hall/CRC.
3. Rencher, A. C. (2002). *Methods of Multivariate Analysis*. 2nd Ed, John Wiley & Sons, USA

Course Code: STA 0542 1165	**Credit: 3**.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Time Series Analysis		**Course Status:** Theory	

Rationale of the Course: This course is designed to have the concepts and uses of time series, ARIMA models, seasonality, dynamic regression, model building and diagnostics using an interactive computer package, forecasting and intervention analysis. Students can apply obtained knowledge in econometrics, business, and other areas.

Course Objectives:

- To analyze experimental data that have been observed at different points in time leads to new and unique problems in statistical modeling and inference,
- To handle time-correlated modeling,
- To forecast the trends and make decisions for development.

Course Content

Introduction: Concepts and uses of time series; Objectives of time series analysis, approaches to time series analysis, some descriptive techniques, examples. **Stationary time series models:** Autoregressive processes, moving average processes, the dual relationship between AR(p) and MA(q) processes, autoregressive moving average ARMA(p, q) processes. **Nonstationary time series models:** Non-stationarity in the mean, autoregressive integrated moving averages ARIMA models, non-stationarity in the variance and the autocovariance. **Forecasting:** Introduction, minimum mean square error forecasts, computation of forecasts, the ARIMA forecast as a weighted average of previous observations, updating forecasts, eventual forecast functions. **Model identification:** Steps for model identification, inverse autocorrelation function (IACF), extended sample autocorrelation function and other identification procedures. Parameter estimation, diagnostic checking, and model selection: the method of moments, maximum likelihood method, non-linear estimation, ordinary least squares (OLS) estimation, diagnostic checking, model selection criteria. **Spectral theory of stationary processes:** Basic concept of Fourier series, the spectrum, the spectrum of some common processes, the spectrum of linear filters, aliasing. **Estimation of the spectrum:** Periodogram analysis, the sample spectrum, the smoothed spectrum, ARMA spectral estimation. **State-space models and the Kalman filter:** Introduction, the relationship between state space and ARMA models, state space model fitting and canonical correlation analysis, the Kalman filter.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO 1	Perform time domain analysis with various time-series models (AR, MA,

	ARMA, ARIMA, ARCH, GARCH);
CO 2	Model fitting and parameters estimation along with diagnostics;
CO 3	Compare various time series forecasting techniques;
CO 4	Differentiate Box-Jenkin's algorithm with other algorithms;
CO5	Explain frequency domain analysis.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3					
CO2	3					
CO3	3	2	3			
CO4	2	2	3		2	
CO5	2	2	3		2	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Quiz, Semester-end examination
CO 2	Lecture using board, assignment	Quiz/ Assignment/ Presentation (Individual/group) Midterm Examination 1 Semester-end examination
CO 3	Lecture using board, assignment	Quiz/ Assignment/ Presentation (Individual/group) Midterm Examination 2 Semester-end examination
CO 4	Lecture using board	Assignment/ Presentation (Individual/group)
CO5	Lecture using board	Assignment/ Presentation (Individual/group)

Books Recommended:

Main Text:

1. Hamilton, J. D., (2020). Time series analysis. Princeton university press.
2. Shumway, R. H., Stoffer, D. S., & Stoffer, D. S. (2000). *Time series analysis and its applications* (Vol. 3). New York: springer.
3. Brockwell, P. J., & Davis, R. A. (Eds.). (2002). *Introduction to time series and forecasting*. New York, NY: Springer New York.

Reference Books:

1. Basu, A. K. (2003). *Introduction to stochastic process*. Alpha Science Int'l Ltd..
2. Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). *Time series analysis: forecasting and control*. John Wiley & Sons.
3. Chatfield, C. (2003). *The analysis of time series: an introduction*. Chapman and hall/CRC.
4. Fuller, W. A. (2009). *Introduction to statistical time series*. John Wiley & Sons.
5. Makridakis, S., et al. (1998). *Forecasting: Methods and Applications*. 3rd Ed, John Wiley and Sons, NY.
6. Wei, W. W. S. (2006). *Time Series Analysis: Univariate and Multivariate Methods*. 2nd Ed, Addison-Wesley, UK

Course Code: STA 0542 1166	**Credit: 2**.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Time Series Analysis Lab		**Course Status:** Lab	

Rationale of the Course: This course is designed to be useful for the practitioners facing the real data analysis of time-correlated data in the different fields, for instances statistics, economics, and medicine.

Course Objectives:

- To have practical knowledge of various time series techniques to analyze statistics, economics, and medicine data

Course Content

The detail syllabus will be prepared by the course teacher.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO 1	Investigate various time series approaches;
CO 2	Compute the model parameters including appropriate conclusions;
CO 3	Validate the results in newly adopted settings to execute independent research projects.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3					
CO2	3	3	3			
CO3			3		3	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Semester-end examination
CO 2	Lecture using board /statistical software R	Assignment (Individual/group) Semester-end examination
CO 3	Lecture using board /statistical software R	Assignment/ Presentation (Individual/group) Semester-end examination

Reference Books:

1. Hamilton, J. D., (2020). Time series analysis. Princeton university press.

2. Shumway, R. H., & Stoffer, D. S. (2017). *Time series analysis and its application with R examples*. 2nd Ed, Springer, USA.

Course Code: SPS 0314 1167	**Credit: 3**.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Advanced Demography		**Course Status:** Theory (General Education)	

Rationale of the Course: Demography is an important course in Statistics as a multidisciplinary concept. Undergraduate students have acquired basic knowledge on statistical demography. It is very essential to prepare students for modeling demographic data. This course has been designed to focus mathematical demographic approach for achieving this target. It will be helpful for the students to make them skilled graduate to serve the social science discipline.

Course Objectives:

- Acquaint students with advanced conceptual issues in demography,
- Provide mathematical knowledge for modeling demographic data,
- Facilitate students with the knowledge of interconnecting components of population change for modeling demographic data.

Course Content

Fertility: Indirect method of estimation viz P/F ratio method, parity progression ratio, Gompertz model. Bongaart`s proximate determinants of fertility and estimation of its indices. Fecundability: types and methods. **Morbidity and mortality:** Basic concepts of morbidity and its different measures. Mathematical models in mortality. Graduation of mortality curves. **Life table:** UN model life tables, Coale-Demeny model life table. Brass-logit life table system. **Stable population theory:** Concept of stable, semi stable and stationary population. Stable age distribution. Interrelationships of demographic variables in stable population. Intrinsic rate of natural increase. Mean length of generation. Lotka's integral equation and solution for intrinsic rate of growth. **Population projection:** Computational procedure for projecting population by component method. Development of Leslie projection matrix, forward and backward operation of population projection. **Some**

demographic models: Nuptiality models – Coale's parameters of nuptiality, Coale-McNicol model. Migration models – push-pull hypothesis, Mathematical model of migration; Micro, macro and meso models of migration, Gravity models of migration, probability models of migration. **Aging:** Concept of aging, types of aging, population aging: concepts and socio-economic implication. Conventional measures, Functional measures of aging.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Explain the demographic events of fertility, mortality, migration, stable population, population projection and demographic aging with contemporary social phenomena;
CO2	Demonstrate the behavior and consequences of demographic components;
CO3	Model fertility, mortality, migration, stable population, population projection;
CO4	Formulate different fertility, mortality and demographic aging measures;
CO5	Criticize different types of direct and indirect demographic techniques.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3		2	3	3
CO2	2	3		2	3	
CO3	2	2		2	3	3
CO4	3					
CO5	3				2	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board, Quiz	Quiz, Semester-end examination
CO 2	Lecture using board	Mid-term Examination-1
CO 3	Lecture using board	Quiz/Assignment Semester-end examination
CO 4	Lecture using board	Quiz Mid-term Examination-2,
CO 5	Lecture using board, assignment	Assignment/Presentation (individual/group), Semester-end examination

Books Recommended:

Main Text:

1. Preston, S. H., *et al.* (2000). *Demography: Measuring and modeling population process*. Blackwell Publishers, USA.
2. Biswas, S. (1988). *Stochastic processes in demography and applications*. Wiley Eastern, India.

Reference Books:

1. Barclay, G. W. (1958). *Techniques of Population Analysis*. John Wiley & Sons, NY.
2. Bouge, D. J. (1969). *Principles of Demography*. John Wiley & Sons, NY.
3. Coale, A. J., Demeny, P., & Vaughan, B. (2013). *Regional model life tables and stable populations: studies in population*. Elsevier.
4. Cox, P. R. (1976). *Demography*. Cambridge University Press, Cambridge.
5. Keyfitz, N., & Caswell, H. (2005). *Applied mathematical demography* (Vol. 47). New York: Springer.
6. Keyfitz, N. (1968). *Introduction to the Mathematics of Population* (No. HB885. K49 1968.).
7. Pollard, J. H. (1975). *Mathematical models for the growth of human populations*. Cambridge: Cambridge University Press.
8. Rogers, A. (1975). *Introduction to multiregional mathematical demography*. Krieger Publishing Company.
9. Shryock, H., & Siegel, J. (1976). *The Method and Materials of Demography*. Academic Press, NY.

10. UN publications, Manual IV and Manual X, Population Bulletins, Population Debate
11. UNFPA, Population Research Methodology, Volumes: 1-10, Chicago

Course Code: SPS 0314 1168	**Credit:** 2.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Advanced Demography Lab		**Course Status:** Lab (General Education)	

Rationale of the Course: Application of statistical knowledge is very essential to make a decision in social science areas. This course is designed to acquit students to analyze and solve the real life demographic problems. Then the graduate will be able to contribute in the society providing insights for making sustainable population policy.

Course Objectives:

- Prepare the students able to apply and compare direct and indirect demographic estimates,
- Help the students to select appropriate methods for solving demographic issues,
- Facilitate graduates to model demographic events occur in the society.

Course Content

Application of various indirect techniques for estimating fertility and mortality through demographic modeling. Problems and issues related to model population growth using stable, quasi stable and stationary population model. Population projection using ratio and cohort component method, Direct and indirect estimation of migration, Micro and macro modeling of migration. Application of various measures of demographic aging.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Compute the direct and indirect demographic rates and ratios;
CO2	Measure various effects in fertility, mortality and migration;
CO3	Fit a model of demographic indicators through stable, quasi-stable and stationary population techniques and human migration;
CO4	Project population with different demographic scenario;
CO5	Argue with proper explanation on demographic aging scenario.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3		2	3	3
CO2	3	3		3	3	
CO3	3	3		3	3	3
CO4	3	3		3	2	3
CO5	3	3		3	3	3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board, Quiz	Quiz, Semester-end examination
CO 2	Lecture using board	Semester-end examination
CO 3	Lecture using board	Quiz/Assignment Semester-end examination
CO 4	Lecture using board	Quiz Semester-end examination
CO 5	Lecture using board, assignment	Assignment/Presentation (individual/group), Semester-end examination

Books Recommended:

1. Preston, S. H., *et al.* (2000). *Demography: Measuring and modeling population process*. Blackwell Publishers, USA.

2. Coale, A. J., Demeny, P., & Vaughan, B. (2013). *Regional model life tables and stable populations: studies in population*. Elsevier.
3. Biswas, S. (1988). *Stochastic processes in demography and applications*. Wiley Eastern, India.
4. Keyfitz, N., & Caswell, H. (2005). *Applied mathematical demography* (Vol. 47). New York: Springer.
5. Pollard, J. H. (1975). *Mathematical models for the growth of human populations*. Cambridge: Cambridge University Press.
6. Shryock, H., & Siegel, J. (1976). *The Method and Materials of Demography*. Academic Press, NY.
7. UN publications, Manual IV and Manual X, Population Bulletins, Population Debate
8. UNFPA, Population Research Methodology, Volumes: 1-10, Chicago

Course Code: STA 0542 1170	**Credit: 1**.0	**Year: Master of Science in Statistics**	**Semester: 1st**
Course Title: Presentation and Viva-voce		**Course Status:** Lab	

Rationale of the Course: Presentation and verbal communication skills are essentials for the students to pursue further higher education and build future career. Therefore, students should get the opportunity to communicate their learning through presentation and viva-voce in order to develop confidence and to have deep understating on the core courses.

Course Objectives:

- Help students gain confidence in their own ability to present and explain the basic concepts of the courses,
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

Course Contents: Comprehensive contents of all the underlying courses of the semester.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Explain key concepts of the core courses both visually and verbally to the experts in the pertinent subject area;
CO2	Communicate their learning effectively and appropriately to formal audiences;
CO3	Interpret the findings of data analysis along with the justification of their arguments logically to non-statisticians;
CO4	Exhibit good performance in professional oral examinations and job interviews;

Mapping Course Learning Outcomes (COs) with the POs
3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3			
CO2	3		3		3	
CO3	3	3			3	3
CO4					3	3
CO5				3	3	3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Self-learning using reference book/lecture notes/research articles/other online materials/group study	Semester-end oral examination
CO 2		
CO 3		
CO 4		
CO 5		

Reference Books

- Reference books referred for all the underlying courses of the semester.

Master of Science in Statistics Second Semester Course Details

Course Code: STA 0311 1261	**Credit:** 3.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Econometrics		**Course Status:** Theory	

Rationale of the Course: At undergraduate level, the students were acquainted with the traditional regression models. However, most of the cases, traditional approaches are not applicable to explain or measure the relationship of economic variables based on economic theories. Therefore, this course is designed to provide comparison among different econometric models with the estimation methods for the advanced econometric studies.

Course Objectives :

- To have in-depth knowledge of various econometric models applied to analyze economic relationships and verifying econometric theories,
- To gain knowledge of the computational techniques applied in the econometric models and ability to forecast in developing such models.

Course Content

Introduction: Classical linear regression model, Assumptions, OLS estimation, Properties of OLS estimators. Econometrics, Types of econometrics, Classical econometric methodology, Evaluation of estimates of an econometric model: economic *a priori*, statistical, econometric criteria; Forecasting ability and desirable properties of the model, Data for econometric analysis: time series, cross-sectional, pooled data.

Dynamic econometric model: Autoregressive and distributed-lag models, The role of time or lag in economics, The reasons for lag, Estimation of distributed-lag models: Ad Hoc estimation, The Koyck approach; Rationalization of the Koyck model: The adaptive expectations model, The partial adjustment model; Combination of adaptive expectations and partial adjustment models, Estimation of autoregressive models-The method of instrument variables; Detecting autocorrelation in autoregressive models-Durbin *h* test, The Almon approach to distributed-lag models, Causality in Economics: The Granger test.

Models of simultaneous relationships: Single-equation models, Multiple-equation models, Simultaneous-equation models, Simultaneous dependence of economic variables, Endogenous and exogenous variables, Simultaneous equations bias, Consequence of simultaneous relations, Structural models, Reduced form models, Recursive models.

Identification: The problem of identification, Under identification, Just or exact identification, Over-identification, Formal rules (conditions) for identification-The order condition and the rank condition for identification, Identifying restrictions, Identification and multicollinearity, Implications of the identification state of a model. **Simultaneous-equation methods:** Single-equation and system-methods of estimation: Reduced form method or Indirect least squares (ILS), The method of instrumental variables (IV), Two-stage least squares (2SLS), Three-stage least squares (3SLS)- Assumptions, Estimation procedures, Properties of the estimators, Relative merits and demerits.

Time series econometrics: Concept of stochastic time series and realization, Stationarity, Test of stationarity based on correlogram, The unit root test of stationarity-Dickey-Fuller (DF) test, augmented Dickey-Fuller (ADF) test, Trend-stationary process (TSP), Difference-stationary process (DSP), Spurious regression, Cointegrating regression, Engle-Granger (EG) and Augmented Engle-Granger (AEG) test for cointegration, Cointegrating regression Durbin-Watson (CRDW) test, Error correction mechanism (ECM), Forecasting with Autoregressive Integrated Moving Average (ARIMA) model, The Box-Jenkins (BJ) methodology, Concept of Seasonal ARIMA (SARIMA), Autoregressive Conditional Heteroscedasticity (ARCH), Generalized ARCH (GARCH), Exponential GARCH (EGARCH), Integrated GARCH (IGARCH), Threshold GARCH (TGARCH), Vector autoregression (VAR), Vector error correction (VEC) models.

Nonlinear least squares: Nonlinear models, Principles of nonlinear least squares estimation, Properties of the nonlinear least squares estimator.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Explain the concept of identification problem, order and rank conditions for identification, simultaneous equations bias, endogenous variable, exogenous variable, instrumental variable, stochastic time series, realization, stationarity, correlogram, DF and ADF tests, spurious regression, cointegrating regression, error correction model, VEC model, nonlinear model;
CO2	Describe Ad Hoc estimation, Koyck approaches to estimate the distributed-lag models; ILS, IV, 2SLS, 3SLS methods to estimate the simultaneous-equation models; Box-Jenkins methodology to forecast with ARIMA modeling, nonlinear least squares estimation;
CO3	Determine the properties of regression estimators, coefficient of determination, model selection criteria, test statistics and their distributions using mathematical/algebraic operations;
CO4	Distinguish among classical regression, static model, dynamic model, econometric model, auto-regressive model, distributed-lag model, single-equation model, multiple-equation model, simultaneous-equation model, structural model, reduced-form model, recursive model; ARMA, ARIMA, ARCH, GARCH, EGARCH, IGARCH, TGARCH, VAR models;
CO5	Choose the suitable model based on economic, statistical, econometric criteria, model selection criteria, and test statistics results.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3		3		
CO2		3	3	3		
CO3	3					
CO4		3	3	2		
CO5	3		3	2	2	2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board/ projector Assignment	Assignment/evaluation/class test/quiz test Mid-semester examination 2 Semester-end examination
CO 2	Lecture using board/ projector Assignment	Assignment/evaluation/class test/quiz test Semester-end examination
CO 3	Lecture using board/ projector Assignment	Assignment/evaluation/class test/quiz test Semester-end examination
CO 4	Lecture using board/ projector Assignment	Assignment/evaluation/class test/quiz test Mid-semester examination 1 Semester-end examination
CO 5	Lecture using board/ projector Assignment	Assignment/evaluation/class test/quiz test Semester-end examination

Books Recommended:

Main Text:

1. Johnston, J., & Dinardo, J. (1996). *Econometric Methods*. 4th Ed, McGraw Hill, NY.

Reference Books:

1. Koutsoyiannis, A. (1977). *Theory of Econometrics.* 2nd Ed., Macmillan Press.
2. Enders, W. (2008). *Applied econometric time series*. John Wiley & Sons.
3. Gregory, C. (1983). *Econometrics*. McGraw Hill, NY.
4. Griffiths, W. E., Hill, R. C., & Judge, G. G. (1993). *Learning and practicing econometrics*. John Willey & Sons.
5. Gujarati, D. N. (2003). Basic Econometrics 4th edition McGraw Hill: New York.

6. Judge, G. G., *et al. (1988). Introduction to the Theory and Practice of Econometrics*. 2nd Ed, John Wiley & Sons, NY.
7. Kmenta, J. (1997). *Elements of Econometrics*. 2nd Ed, Macmillan, NY.
8. Maddala, G. S. (1992). *Introduction to Econometrics*. 2nd Ed, Prentice Hall, Sydney.
9. Pindyck, R. S., & Rubinfeld, D. L. (1991). *Econometric Models and Economic Forecasts*. 3rd Ed, McGraw Hill, NY.

Course Code: STA 0311 1262	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Econometrics Lab		**Course Status:** Lab	

Rationale of the Course: Familiarize the students with the application of familiar econometric models to execute independent research projects.

Course Objectives:

- To have practical knowledge of econometric method applied to analyze econometric data,
- To estimate various single and simultaneous-equation models and interpret the results to gain knowledge of the computational aspects.

Course Content

Review of application of OLS method in two and three variables classical linear regression model, calculation of standard error of the estimators, Coefficient of determination, test of individual regression coefficients, and overall significance of regression. Interpretation of the estimated results.

Fitting distributed-lag models, detecting autocorrelation in distributed lag models.

Test for order condition and rank condition. Fitting of simultaneous-equation models using ILS and 2SLS methods. Interpretation of the estimated parameters. Comparing the findings obtained from ILS and 2SLS methods.

Tests of stationarity of economic time series data- informal and formal tests: Graphical display, Calculation of ACF and PACF, Correlograms associated with ACF and PACF; DF and ADF tests. Estimating co-integrating regression, Tests for co-integration, Fitting error correction model. Interpretation of the findings.

Fitting of ARIMA models, Selecting the best model using different model evaluation criteria to forecast.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Examine the identification state of each equation of simultaneous-equation models applying order and rank conditions; the stationarity of an economic time series applying time series plot, correlogram, DF and ADF tests;
CO2	Analyze the data using different statistical methods, tools and test statistics;
CO3	Estimate the two and three variables classical linear regression models, infinite lag distributed-lag model, each equation of simultaneous-equation models using economic data;
CO4	Develop cointegrating regression model, error correction model, and ARIMA model using economic time series data.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2				
CO2		3	3	3		
CO3			2	3		
CO4		3				

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board/ projector Assignment	Assignment/evaluation/class test

		(Individual/group) Semester-end examination
CO 2	Lecture using board/ projector	Assignment/evaluation/class test (Individual/group) Semester-end examination
CO 3	Assignment	Assignment/evaluation/class test (Individual/group) Semester-end examination
CO 4	Lecture using board/ projector	Assignment/evaluation/class test (Individual/group) Semester-end examination

Books Recommended:
Main Text:

- Johnston, J., & Dinardo, J. (1996). *Econometric Methods*. 4th Ed, McGraw Hill, NY.

Reference Books:

1. Koutsoyiannis, A. (1977). *Theory of Econometrics.* 2nd Ed., Macmillan Press.
2. Enders, W. (2008). *Applied econometric time series*. John Wiley & Sons.
3. Gregory, C. (1983). *Econometrics*. McGraw Hill, NY
4. Griffiths, W. E., Hill, R. C., & Judge, G. G. (1993). *Learning and practicing econometrics*. John Willey & Sons.
5. Gujarati, D. N. (2003). Basic Econometrics 4th edition McGraw Hill: New York.
6. Judge, G. G., *et al. (1988). Introduction to the Theory and Practice of Econometrics*. 2nd Ed, John Wiley & Sons, NY.
7. Kmenta, J. (1997). *Elements of Econometrics*. 2nd Ed, Macmillan, NY.
8. Maddala, G. S. (1992). *Introduction to Econometrics*. 2nd Ed, Prentice Hall, Sydney.
9. Pindyck, R. S., & Rubinfeld, D. L. (1991). *Econometric Models and Economic Forecasts*. 3rd Ed, McGraw Hill, NY.

Course Code: STA 0542 1263	**Credit: 3**.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Advanced Biostatistical methods		**Course Status:** Theory	

Rationale of the Course: Acquiring knowledge to understand and contribute to survival/time-to-event and correlated data analysis methods.

Course Objectives

- To introduce students advanced statistical methods for analyzing correlated and survival data,
- To be able to apply a range of different methods such as Cox proportional hazard model and parametric survival models, for analyzing survival data,
- To have a general understanding of conceptualize basic theories of competing risk with competing outcomes,
- To help students to conceptualize basic theories of randomized controlled trials (RCTs),
- To provide detail concept of the methods (e.g. linear mixed models, generalized estimating equation, generalized linear mixed model) for analyzing longitudinal or cluster data,
- To have a general understanding of how each method represents different kinds of longitudinal processes.

Course Content:

Parametric survival methods: Likelihood construction for censored and truncated data, inference procedures for exponential, gamma, Weibull, log-normal and extreme value distributions for complete and censored data. Accelerated life tests: fitting accelerated failure time models and interpretation of results. **Cox proportional hazards (PH) models:** Proportional hazards models, application and limitations, conditional, marginal and partial likelihoods. Diagnostics procedure for the Cox PH model. **Competing risks theory:** Concepts, crude, net, partial crude probabilities, their interrelationships and estimation. Application of competing risks to current mortality data. **Correlated survival data including frailty model:** Basic concept of correlated survival data. Definition, importance, and historical development of frailty models. Types of frailty models such as shared, clustered, univariate, multivariate and

their mathematical foundations. Estimation techniques like parametric and semi-parametric methods, and the EM algorithm.

Models for correlated and longitudinal data analyses: Linear and generalized linear mixed models (LMM, GLMM), and Generalized estimating equations (GEE).

Clinical trials (Randomized Controlled Trial, RCT): Concept of RCT, objectives, protocol of clinical trials, randomization, blinding, bias, error, sample size and power, parallel, crossover, sequential design and pragmatic trial. Drug trials: phase I, phase II, phase III and phase IV. **Introduction to Meta analysis:** Fundamental concepts, methodologies, steps involved in conducting meta-analysis, advantages, challenges, applications.

Course Learning Outcomes: By the end of the course, students will be expected to-

CO1	Explain fundamental concepts of advanced biostatistics, including survival, correlated, and clinical trials data;
CO2	Master advanced models for analyzing survival and correlated data;
CO3	Evaluate survival and correlated data across various fields, particularly in the medical and engineering sectors;
CO4	Determine the necessity and rationale for implementing randomized controlled trials (RCTs);
CO5	Appraise the theoretical foundations of survival and longitudinal data analysis within public health and biomedical research.

Mapping Course Learning Outcomes (COs) with the Pos

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3			
CO2	3	3	3		1	
CO3				3		
CO4				2		
CO5	3	1		1		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board/LCD projectors/ Assignment/ Self-learning using reference book	Quiz/ Assignment (Individual/group) Semester-end examination
CO 2	Lecture using board/LCD projectors/ Assignment/ Self-learning using reference book	Quiz/ Assignment (Individual/group) Semester-end examination
CO 3	Lecture using board/LCD projectors/ Assignment/ Self-learning using reference book	Quiz/ Assignment (Individual/group) Midterm Examination 1 Semester-end examination
CO 4	Lecture using board/LCD projectors/ Assignment/ Self-learning using reference book	Quiz/ Assignment (Individual/group) Semester-end examination
CO 5	Lecture using board/LCD projectors/ Assignment/ Self-learning using reference book	Quiz/ Assignment/ Presentation (Individual/group) Midterm Examination 2 Semester-end examination

Main Text:

1. Kleinbaum, David G., Klein, Mitchel (2005), Survival Analysis: A Self-Learning Text, 3rd Edition, Springer-Verlang, NewYork.
2. Xian Liu (2012), Survival Analysis: Models and Applications, Wiley.
3. Lawless J F, Statistical Models and Methods for Lifetime Data, 2nd Ed, John Wiley & Sons, NY
4. Kleinbaum D G, *et al*, Epidemiologic Research: Principles and Quantitative Methods, Wiley & Sons, NY

Reference Books:

1. Altman D G, Practical Statistics for Medical Research, 1stEd, Chapman and Hall/CRC, NY
2. Collett D, Modelling Survival Data in Medical Research, 4th Ed, Chapman and Hall, Florida
3. Cox D R & Oakes D, Analysis of Survival Data, Reprint Ed, Chapman and Hall/CRC, NY
4. Dobson A J, An Introduction to Generalized Linear Models, 3rdEd, Chapman and Hall, UK
5. Elandt-Jhonson R C &Jhonson N L, Survival Models and Data Analysis, Wiley, NY
6. Johnson R C E & JohnsonN L, Survival Models and Data Analysis, Wiley, NY
7. Kalbfleisch J D & Prentice R L, The Statistical Analysis of Failure Time Data, 2ndEd, Wiley & Sons, USA
8. Klein J P & MoeschbergerM L, Survival Analysis: Techniques for Censored and Truncated Data, 2ndEd, Springer
9. Lee E T, Statistical Method for Survival Data Analysis, 3rdEd, Wiley & Sons, NY
10. McCullagh P & NelderJ A, Generalized Linear Models, 2ndEd, Chapman and Hall/CRC, NY
11. Piantadosi S, Clinical trials: A Methodological Perspective, 2ndEd, Wiley, NY

Course Code: STA 0542 1264	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Advanced Biostatistical methods Lab		**Course Status: Lab**	

Rationale of the Course: Acquiring knowledge to perform survival/time-to-event and correlated data analysis using a statistical software package.

Course Objectives:

- Recognize the characteristics of correlated and survival data,
- Determine the proper method to be used in analyzing survival and other time to event data (e.g. parametric survival model, Cox proportional hazard model or non-parametric method, competing risk with competing outcomes data)

- Apply mathematical and graphical methods to check goodness of fit of the different survival models.
- Determine the proper method to be used in analyzing longitudinal or cluster data (e.g. linear mixed models, generalized estimating equation, generalized linear mixed model),
- Interpret computer outputs

Course Content:

Nonparametric methods: Reduced sample, actuarial and product-limit methods, estimation and tests. **Fitting of parametric models with complete and censored samples:** Exponential, gamma, Weibull distributions, graphical methods for survival distribution, accelerated failure time models, estimation and tests, goodness of fit tests. **Fitting Cox proportional hazards (PH) models:** Proportional hazards models, estimation and tests, goodness of fit tests. **Competing risks:** Estimation of crude, net and partial crude probabilities, application of competing risks to current mortality data. Application cumulative incidence function methods and so on.
Correlated survival data including frailty model: application of frailty models. **Fitting advanced models for analyzing correlated or cluster data:** Linear and generalized linear mixed models (LMM, GLMM), and Generalized estimating equations (GEE). **Introduction to Meta analysis.**

Course Learning Outcomes: By the end of the course, students will be expected to-

CO1	Demonstrate skills in independent/correlated survival data or longitudinal data management to handle a variety of practical problems using different survival and longitudinal data analysis methods;
CO2	Utilize advanced parametric and semi-parametric methods for survival data;
CO3	Implement analytical tools for competing risk data analyses;
CO4	Employ advanced models for longitudinal data or correlated survival data for continuous and/or binary outcomes.

Mapping Course Learning Outcomes (COs) with the Pos

3: Strong 2: Moderate 1: Weak

Course Learning	Fundamental Skill	Social Skill	Thinking Skill	Personal Skill

Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2				
CO2	3	2	3			
CO3	2		3			
CO4	2	3	2			

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board/LCD projectors/ Lab report/computer /Self-learning using reference book	Problem-solving tasks / Presentation/project/lab report (Individual/group)/ Semester-end examination (open book/close book)
CO 2		
CO 3		
CO 4		
CO 5		

Main Text:

5. Kleinbaum, David G., Klein, Mitchel (2005), Survival Analysis: A Self-Learning Text, 3rd Edition, Springer-Verlang, NewYork.
6. Xian Liu (2012), Survival Analysis: Models and Applications, Wiley.
7. Lawless J F, Statistical Models and Methods for Lifetime Data, 2nd Ed, John Wiley & Sons, NY
8. Kleinbaum D G, *et al*, Epidemiologic Research: Principles and Quantitative Methods, Wiley & Sons, NY

Reference Books:

12. Altman D G, Practical Statistics for Medical Research, 1stEd, Chapman and Hall/CRC, NY
13. Collett D, Modelling Survival Data in Medical Research, 2ndEd, Chapman and Hall, Florida
14. Cox D R & Oakes D, Analysis of Survival Data, Reprint Ed, Chapman and Hall/CRC, NY
15. Dobson A J, An Introduction to Generalized Linear Models, 3rdEd, Chapman and Hall, UK
16. Elandt-Jhonson R C &Jhonson N L, Survival Models and Data Analysis, Wiley, NY
17. Johnson R C E & JohnsonN L, Survival Models and Data Analysis, Wiley, NY
18. Kalbfleisch J D & Prentice R L, The Statistical Analysis of Failure Time Data, 2ndEd, Wiley & Sons, USA
19. Klein J P &MoeschbergerM L, Survival Analysis: Techniques for Censored and Truncated Data, 2ndEd, Springer
20. Lee E T, Statistical Method for Survival Data Analysis, 3rdEd, Wiley & Sons, NY
21. McCullagh P &NelderJ A, Generalized Linear Models, 2ndEd, Chapman and Hall/CRC, NY
22. Piantadosi S, Clinical trials: A Methodological Perspective, 2ndEd, Wiley, NY

Course Code: STA 0542 1270	**Credit:** 1.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Presentation and Viva-voce		**Course Status:** Lab	

Rationale of the Course: Presentation and verbal communication skills are essentials for the students to pursue further higher education and build future career. Therefore, students should get the opportunity to communicate their learning through presentation and viva-voce in order to develop confidence and to have deep understating on the core courses.

Course Objectives:

- Help students gain confidence in their own ability to present and explain the basic concepts of the courses,
- Provide the knowledge of oral communication and presentation skills that are essential for later professional career.

Course Contents: Comprehensive contents of all the underlying courses of the semester.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Explain key concepts of the core courses both visually and verbally to the experts in the pertinent subject area;
CO2	Communicate their learning effectively and appropriately to formal audiences;
CO3	Interpret the findings of data analysis along with the justification of their arguments logically to non-statisticians;
CO4	Exhibit good performance in professional oral examinations and job interviews;

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3			
CO2	3		3		3	
CO3	3	3			3	3
CO4					3	3
CO5				3	3	3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Self-learning using reference book/lecture notes/research articles/other online materials/group study	Semester-end oral examination
CO 2		
CO 3		
CO 4		
CO 5		

Reference Books

- Reference books referred for all the underlying courses of the semester.

Optional courses

Course Code: STA 0542 1273	**Credit: 3**.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Data Mining & Machine learning		**Course Status:** Theory	

Rationale of the Course: To know the characteristics of a large dataset, it is very important to know the proper statistical tools on classification and clustering of the data. This course is assigned for acquiring the ability to analyze and construct knowledge from a large dataset.

Course Objectives:

- Help students conceptualize basic theories statistical learning (supervised and unsupervised) techniques and their applications in different scientific fields
- Provide solid knowledge regarding classification and clustering the data

Course Content

Overview: Meaning of data mining and knowledge discovery basic, data mining tasks: classification, regression, time series analysis, prediction, clustering, summarization, association, rules, sequence discovery. Development of data mining, data mining issue and mining metrics, social implications of data mining. **Related concepts of data mining:** Fuzzy sets: introduction, classical sets, set operation, Boolean logic, basic concepts of fuzzy sets, other representations of fuzzy sets, determination of member ship functions, fuzzy sets properties, operations on fuzzy sets, logic operations, algebraic operations on fuzzy sets. **Fuzzy relations:** Classical relations, classical reasoning, fundamentals of fuzzy relations, operations on binary fuzzy relations, types of fuzzy relations, fuzzy reasoning concluding remarks, bibliography, web resources. Data base/OLTP systems, logic, information retrieval, decision support systems, dimensional modeling, multidimensional schemas, indexing, data warehousing, OLAP, web search engines, statistics, machine learning, pattern matching. **Data mining techniques:** Statistical perspective on data mining: point estimation, models based on summarization, Bayes' theorem, hypothesis testing, regression and correlation. Similarity measures; decision tree; genetic

algorithms. **Neural networks:** background, learning, the basic neuron model, the perception, the multiplayer perception recurrent network, Hopfield, networks, Boltzanann machine network, Kohonen self-organizing networks, background, description, determining the winning neuron, learning algorithm. **Classification:** Issues in classification, statistical-based algorithms, regression, Bayesian classification, distance-based algorithms, K. Nearest neighbors, decision tree-based algorithms, ID3, C4.5 and C5.0, cart, neural network-based algorithms, propagation, NN supervised learning, radial basis function networks, perceptions, rule-based algorithms, generating rules from a DT, generating rules from a neural net. **Clustering:** similarity and distance measures, outliers, hierarchical algorithms, agglomerative algorithms, divisive clustering, partitional algorithms, minimum spanning tree, squared error clustering algorithm, k-means clustering, nearest neighbor algorithm, pam algorithm, bond energy algorithm, clustering with genetic algorithms, clustering with neural networks, clustering large databases, clustering with categorical attributes. **Association rules:** Meaning of association large item sets, basic algorithms, *a priori* algorithm, sampling algorithm, partitioning, parallel and distributed algorithms, data parallelism, task parallelism, advanced association rule techniques, quantitative association rules, correlation rules, measuring the quality of rules. **Web mining:** Web content mining, crawlers, harvest system, virtual web view, personalization, web structure mining, page rank, clever, web usage mining, preprocessing, data structures, pattern discovery, pattern analysis.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Gain an insight of what data mining is all about;
CO2	Demonstrate basic machine learning algorithmic methods;
CO3	Apply appropriate tools for prediction, classification and clustering;
CO4	Become proficient with data mining tools.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3					
CO2	3		3	3	3	
CO3	3		3	3	3	
CO4	2		3	3	3	2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Quiz/ semester end examination
CO 2	Lecture using board, demonstration using computer software	Mid-term Examination-1
CO 3	Lecture using board, assignment	Assignment, Quiz, semester end examination
CO 4	Lecture using board	Mid-term Examination-2

Recommended Readings

1. Gareth, J., Daniela, W., Trevor, H., & Robert, T. (2013). *An introduction to statistical learning: with applications in R*. Springer.

Supplementary Readings

1. Larose, D. T. (2006). *Data mining methods and models*. John Willey & Sons. Inc. New Jersey.
2. Schalkoff, R. J. (1992). *Pattern Recognition: Statistical, Structural, and Neural Approaches*. John Willey & Sons, Inc., New York.
3. Dunham, M. H. (2006). *Data mining: Introductory and advanced topics*. Pearson Education India.
4. Ibrahim, A. (2004). *Fuzzy logic for embedded systems applications*. Newnes.

Course Code: STA 0542 1274	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Data Mining & Machine learning Lab		**Course Status:** Lab	

Rationale of the Course: It is very essential to apply the prediction, classification and clustering tools on large dataset for collecting essence of the data. This Lab course is assigned for acquiring the ability to analyze and construct knowledge from a large dataset.

Course Objectives:

- Help students conceptualize basic theories statistical learning (supervised and unsupervised) techniques and their applications in different scientific fields
- Provide solid knowledge regarding classification and clustering the data

Course Content

Determination of partition of set of data by sum of squares of errors, clustering criteria, hierarchical clustering by nearest neighbor, further neighbor, k-means method or algorithm, determination of minimum distance decision boundary, performing K-NN classification using the Euclidean and statistical matrix. Application of different rules of data mining, classification by regression tree, decision tree, Bayesian approach, Random Forest and neural network. Different clustering techniques- k means clustering, hierarchical clustering, PCA, PLS techniques. Association rules, Text and web mining

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Gain an insight of what data mining is all about;
CO2	Demonstrate basic machine learning algorithmic methods;
CO3	Apply appropriate tools for prediction, classification and clustering;
CO4	Become proficient with data mining tools;
CO5	Analyze data along with the interpretation of results in different fields of research.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3		3	3	3	2
CO2	3		3	3	2	2
CO3	3		3	3	3	3
CO4	2		2	3	3	3
CO5	3		3	3	3	3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Quiz/ semester end examination
CO 2	Lecture using board	Quiz/ semester end examination
CO 3	Lecture using board, assignment	assignment/presentation (individual/group), semester end examination
CO 4	Lecture using board	Quiz/ semester end examination
CO 5	Lecture using board, assignment	assignment/presentation (individual/group), semester end examination

Main Text:

Gareth, J., Daniela, W., Trevor, H., & Robert, T. (2013). *An introduction to statistical learning: with applications in R*. Springer.

Reference Books:

1. Larose, D. T. (2006). *Data mining methods and models*. John Willey & Sons. Inc. New Jersey.
2. Schalkoff, R. J. (1992). *Pattern Recognition: Statistical, Structural, and Neural Approaches*. John Willey & Sons, *Inc.*, New York.
3. Dunham, M. H. (2006). *Data mining: Introductory and advanced topics*. Pearson Education India.
4. Ibrahim, A. (2004). *Fuzzy logic for embedded systems applications*. Newnes.

Course Code: STA 0542 1271	**Credit:** 3.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Actuarial Statistics		**Course Status:** Theory	

Rationale of the Course: Acquiring knowledge on fundamental actuarial models.

Course Objectives:

- Acquaint students with the fundamental concepts related to different types of insurance
- Make students conceptualize basic actuarial models

Course Content

Basic concepts: introductory concepts of actuarial science – nature and type of insurance, risk transfer concepts, claim management including handling, loss adjusting, aggregation, settlement, claims information system and reporting, reinsurance – definition, purpose, advantages and disadvantages. Models for individual claims and their sums, survival function, curate future lifetime, force of mortality. **Premiums:** Premiums, general premiums, natural premiums, office premiums, loading for expenses, with profit and without profit premiums, adequacy of premiums, relative consistency. **Life insurance:** Insurance payable at the moments of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance recursions, commutation functions. **Actuarial models:** Survival models – models, estimating the lifetime distribution Fx(t), Cox regression model, Markov models. **Probability models:** Multiple decrement models, deterministic and random survivorship groups,

associated single decrement tables, central rates of multiple decrement, net single premium and their numerical evaluations. Distribution of aggregate claims compounds Poisson distribution and its applications. **Applied actuarial statistical methods:** Decision theory, loss distribution, run off triangles and experience rating systems. Introduction to generalized linear models, risk models, ruin theory, credibility theory – estimation of credibility with Bayesian and non-Bayesian technique. **Loss model:** Models for loss severity, macro methods of run-off analysis, chain-ladder, least squares, separation, payment per claim incurred.

Course Learning Outcomes (COs): At the end of the course, students will be able to-

CO1	Explain the fundamental concepts related to insurance;
CO2	Distinguish among different types of insurance;
CO3	Formulate appropriate actuarial model for available data;
CO4	Apply appropriate actuarial method to given actuarial problem.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3				
CO2	3	2				
CO3	3	3		2		
CO4		3		2	3	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

Cos	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Quiz/Midterm Examination 1
CO 2	Lecture using board	Quiz/ Semester-end examination
CO 3	Lecture using board, assignment	Assignment/ Presentation (Individual/group)

		Semester-end examination
CO 4	Lecture using board, assignment	Assignment/ Presentation (Individual/group) Midterm Examination 2

Main Text:

1. Atkinson, D. B., & Dallas, J. W. (2000). *Life insurance products and finance: charting a clear course*. Society of Actuaries.
2. Jordan, C. W. (1991). *Life Contingencies*. 2nd Ed, Society of Actuaries, Illinois, USA.

Reference Books:

1. Benjamin, B., Pollard, J. H., & Haycocks, H. W. (1980). *The analysis of mortality and other actuarial statistics* (Vol. 3). London: Heinemann.
2. Bowers, N. L., et al. (1997). *Actuarial Mathematics*. 2nd Ed, Society of Actuaries, Illinois, USA
3. Donald, D. W. A. (2016). *Compound interest and annuities-certain*. Cambridge University Press.
4. Federation of Insurance Institutes Study Courses: Mathematical Basis of Life Assurance, Federation of Insurance Institutes, Bombay
5. Gerber, H. U. (2013). *Life insurance mathematics*. Springer Science & Business Media.
6. Klugman, S. A., Panjer, H. H., & Willmot, G. E. (2012). *Loss models: from data to decisions* (Vol. 715). John Wiley & Sons.
7. Neill, A. (1977). *Life Contingencies*. Heinemann
8. Panjer, H. H., Dufresne, D., Gerber, H. U., Mueller, H. H., Pedersen, H. W., Pliska, S. R., ... & Tan, K. S. (1998). *Financial Economics: With Applications to Investments, Insurance, and Pensions*. P. P. Boyle, & S. H. Cox (Eds.). Schaumburg, Ill.: Actuarial Foundation.
9. Spurgeon, E. F. (2011). *Life contingencies*. Cambridge University Press.

Course Code: STA 0542 1272	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Actuarial Statistics Lab		**Course Status:** Lab	

Rationale of the Course: Apply acquired knowledge on fundamental actuarial models to solve relevant actuarial problems.

Course Objectives:

- Help students identify and formulate appropriate actuarial model under specific circumstances
- Make students capable to estimate and fit appropriate actuarial model

Course Content

Determining Premiums: Premiums, general premiums, natural premiums, office premiums, loading for expenses, with profit and without profit premiums. **Calculating Claim Amount:** Insurance payable at the moments of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance recursions, commutation functions. **Fitting Actuarial Models:** Actuarial models: survival models – models, estimating the lifetime distribution Fx(t), Cox regression model, Markov models. Probability models: multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premium and their numerical evaluations. Distribution of aggregate claims, compounds Poisson distribution and its applications. **Applied actuarial statistical methods:** Decision theory, loss distribution, run off triangles and experience rating systems. Introduction to generalized linear models, risk models, ruin theory, credibility theory – estimation of credibility with Bayesian and non-Bayesian technique. **Loss model:** Models for loss severity, macro methods of run-off analysis, chain-ladder, least squares, separation, payment per claim incurred.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Calculate premium for various insurance policies;
CO2	Determine claim amount for different insurance policies;
CO3	Fit appropriate actuarial model for given data set.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning	Fundamental Skill	Social Skill	Thinking Skill	Personal Skill

Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3				
CO2	3	2				
CO3	3	3		2	2	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Quiz/ Semester-end examination
CO 2	Lecture using board	Quiz/ Semester-end examination
CO 3	Lecture using board, demonstration using computer software	Semester-end examination

Main Texts:

1. Atkinson, D. B., & Dallas, J. W. (2000). *Life insurance products and finance: charting a clear course*. Society of Actuaries.
2. Jordan, C. W. (1991). *Life Contingencies*. 2nd Ed, Society of Actuaries, Illinois, USA.

Reference Books:

1. Benjamin, B., Pollard, J. H., & Haycocks, H. W. (1980). *The analysis of mortality and other actuarial statistics* (Vol. 3). London: Heinemann.
2. Bowers, N. L., et al. (1997). *Actuarial Mathematics*. 2nd Ed, Society of Actuaries, Illinois, USA
3. Donald, D. W. A. (2016). *Compound interest and annuities-certain*. Cambridge University Press.
4. Federation of Insurance Institutes Study Courses: Mathematical Basis of Life Assurance, Federation of Insurance Institutes, Bombay
5. Gerber, H. U. (2013). *Life insurance mathematics*. Springer Science & Business Media.

6. Klugman, S. A., Panjer, H. H., & Willmot, G. E. (2012). *Loss models: from data to decisions* (Vol. 715). John Wiley & Sons.
7. Neill, A. (1977). *Life Contingencies*. Heinemann
8. Panjer, H. H., Dufresne, D., Gerber, H. U., Mueller, H. H., Pedersen, H. W., Pliska, S. R., ... & Tan, K. S. (1998). *Financial Economics: With Applications to Investments, Insurance, and Pensions*. P. P. Boyle, & S. H. Cox (Eds.). Schaumburg, Ill.: Actuarial Foundation.
9. Spurgeon, E. F. (2011). *Life contingencies*. Cambridge University Press.

Course Code: STA 0542 1275	**Credit:** 3.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Bioinformatics		**Course Status:** Theory	

Rationale of the Course: To apply statistical tools, it's very important to know the background of the related field/s. This course is designed to acquire knowledge on biological and genomic data, as well as suitable tools/theories that are used in biological and genomic field.

Course Objectives:

- Help students conceptualize basic theories to analyze biological and genomic data.
- Provide an overview of the application areas of bioinformatics

Course Content

Introduction to molecular biology of the cell: DNA, RNA, chromosome, gene and central dogma. Basic concepts of protein and metabolism. Statistical methods for gene expression (transcriptomics) data analysis: introduction to microarrays and microarray data, image analysis, preprocessing: transformation and normalization. Identification of differential expressed genes in two or more groups using statistical tools: fold change, t-test, ANOVA. Uses of several *bioconductor* packages in r program, *e.g.* SAM, LIMMA *etc*. Multitest problems, remedial measures: the family-wise error rate (FWER) and the false discovery rate (FDR). Concepts of q-value. Introduction of RNA-seq data and its analytical procedures. Discuss statistical methods for protein and metabolomics data analysis. Gene clustering and classification. Inferring genetic regulatory networks from microarray experiment with Bayesian networks. Modeling gene expression profile, clustering time course data

using k-means, stem (short time series expression miner) algorithm and principal component analysis (PCA). Integration of molecular datasets: basic concepts of integrating multi-block datasets of genomics data (gene, protein, and metabolism) and environmental data. Basic concepts of top-down and bottom-up systems biology.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Define core biological concepts with emphases on the cellular and molecular scale of biology;
CO2	Work proficiently in a group on biological concepts in relation to bioinformatics using different bio-conductor packages;
CO2	Extract data from key bioinformatics databases. Also integrate the datasets in the concept of top-down and bottom-up systems biology.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3		3	2
CO2	3	3	3		3	2
CO3		3	3		3	2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO1	Lecture using board	Semester end examination
CO2	Lecture using board	Assignment / presentation (individual/group),
		semester end examination
CO3	Lecture using board, demonstration using computer software	semester end examination

Books Recommended:

Main Text:

1. Neale, B., Ferreira, M., Medland, S., & Posthuma, D. (2007). *Statistical genetics: gene mapping through linkage and association*. Taylor & Francis.

Reference Books:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular biology of the cell, 5th edn. Garland Science. New York.
2. Foulkes, A. S. (2009). *Applied Statistical Genetics with R for Population Based Association Studies*. Springer.
3. Husmeier, D., Dybowski, R., & Roberts, S. (Eds.). (2006). *Probabilistic modeling in bioinformatics and medical informatics*. Springer Science & Business Media.
4. Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press, NY.
5. Wu, R., Ma, C., & Casella, G. (2007). *Statistical genetics of quantitative traits: linkage, maps and QTL*. Springer Science & Business Media.
6. Ewens, W. J., & Grant, G. R. (2005). *Statistical methods in bioinformatics: an introduction* (Vol. 2). New York: Springer.

Course Code: STA 0542 1276	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Bioinformatics Lab		**Course Status:** Lab	

Rationale of the Course: Without applying the statistical tools on the genomic and biological data, the theoretical knowledge is not being understood properly. This Lab course is assigned for acquiring the ability to analyze and construct knowledge from biological and genomic data.

Course Objectives:

- Help students conceptualize basic theories to analyze biological and genomic data.

- Provide an overview of the application areas of bioinformatics

Course Content

Statistical methods for gene expression (transcriptomics) data analysis: introduction to microarrays and microarray data, image analysis, preprocessing: transformation and normalization. Identification of differential expressed genes in two or more groups using statistical tools: fold change, t-test, ANOVA. Uses of several *Bioconductor* packages in r program, *e.g.* SAM, LIMMA *etc*. Multitest problems, remedial measures: the family-wise error rate (FWER) and the false discovery rate (FDR). Concepts of q-value. Introduction of RNA-seq data and its analytical procedures. Discuss statistical methods for protein and metabolomics data analysis. Gene clustering and classification. Inferring genetic regulatory networks from microarray experiment with Bayesian networks. Modeling gene expression profile, clustering time course data using k-means, stem (short time series expression miner) algorithm and principal component analysis (PCA). Integration of molecular datasets: integrating multi-block datasets of genomics data (gene, protein, and metabolism) and environmental data. Basic concepts of top-down and bottom-up systems biology.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Define core biological concepts with emphases on the cellular and molecular scale of biology;
CO2	Analyze and evaluate bioinformatics data to discover patterns, critically evaluate conclusions and generate predictions for subsequent experiments;
CO3	Work proficiently in a group on biological concepts in relation to bioinformatics using different bio-conductor packages;
CO4	Extract data from key bioinformatics databases. Also integrate the datasets in the concept of top-down and bottom-up systems biology.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning	Fundamental Skill	Social Skill	Thinking Skill	Personal Skill

Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3		2	2
CO2	3	3	3		2	2
CO3	3	3	3		2	2
CO4	3	3	3		2	2

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	semester end examination
CO 2	Lecture using board	semester end examination
CO 3	Lecture using board	assignment/presentation (individual/group), semester end examination
CO 4	Lecture using board	demonstration using computer software;semester end examination

Main Text:

1. Neale, B., Ferreira, M., Medland, S., & Posthuma, D. (2007). *Statistical genetics: gene mapping through linkage and association*. Taylor & Francis.

Reference Books:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular biology of the cell, 5th edn. Garland Science. New York.
2. Foulkes, A. S. (2009). *Applied Statistical Genetics with R for Population Based Association Studies*. Springer.

3. Husmeier, D., Dybowski, R., & Roberts, S. (Eds.). (2006). *Probabilistic modeling in bioinformatics and medical informatics*. Springer Science & Business Media.
4. Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press, NY.
5. Wu, R., Ma, C., & Casella, G. (2007). *Statistical genetics of quantitative traits: linkage, maps and QTL*. Springer Science & Business Media.
6. Ewens, W. J., & Grant, G. R. (2005). *Statistical methods in bioinformatics: an introduction* (Vol. 2). New York: Springer.

Course Code: STA 0542 1277	**Credit:** 3.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Categorical Data Analysis		**Course Status:** Theory	

Rationale of the Course: Acquiring knowledge to understand and application of statistical methods for categorical data analyses.

Course Objectives

- To introduce statistical methods for analyzing categorical data when linear model is not appropriate,
- To demonstrate students both theoretical rationale and important applications of categorical data analysis methods,
- To be able to apply a range of different methods such as generalized linear regression model such as logistic regression, multinomial logistic regression, log-linear model and so on.
- To be able to apply a range of different methods for repeated categorical data such as generalized estimating equations, generalized linear mixed models.
- To have a general understanding of conceptualize of mixture models for categorical data,
- To have a general understanding of asymptotic theory for parametric models and alternative estimation theory for parametric models

Course Content:

Distributions and inference for categorical data: Distributions for categorical data, statistical inference for categorical data, statistical inference for Binomial Multinomial Parameters. **Describing Contingency Table:** Probability structure for contingency tables, comparing two proportions, partial association in stratified 2 by 2 tables, and Extensions for I by J tables, two-way tables with ordered classifications, comparing proportions, two proportions, stratified 2 by 2 tables, measuring association, odds ratio, confidence intervals for association parameters, McNemar's Gart's test, Chi-squared tests, Exact tests for small samples, likelihood test, linear-by-linear association. Relative measure of association: Lamda, Gamma, and Somer's D measures. **Generalized linear models:** *Logistic regression I:* Inference, multiple predictors, fitting, interpretation categorical predictors, summarizing effects, strategies in model selection, model diagnostics, Mantel-Haenszel statistic, quasi and complete separation. *Logistic regression II:* Other links, conditional logistic regression, generalized additive models, ROC curves & discrimination, and Bayesian inference. *Logistic regression III:* Multinomial regression: baseline-category logits, ordinal regression, discrete choice models. *Loglinear models for* two-way, three-way, and multi-way tables, inference, and fitting, model building and interpretation, conditional independence graphs and collapsibility. ***Model for matched pairs:*** Repeated measures on a proportion, conditional logistic regression, marginal models for square contingency tables, symmetry, dependency measures, measuring agreement between observers, marginal models and quasi-symmetry models for matched sets. **Repeated categorical response data:** Analysing repeated categorical response data: comparing marginal distributions: multiple responses, marginal modelling: maximum likelihood approach, marginal modelling: generalized estimating equations approach quasi-likelihood and its gee multivariate extension: details, Markov chains: transitional modelling. random effects: generalized linear mixed models for categorical responses. **Mixture models for categorical data:** Latent class models, nonparametric random effects models, beta-binomial models, negative binomial regression, Poisson regression with random effects. **Asymptotic theory for parametric models:** Delta method, asymptotic distributions of estimators of model, parameters and cell probabilities, asymptotic distributions of residuals and goodness of-fit statistics, asymptotic distributions for logit/loglinear models. **Alternative estimation theory for parametric models:** Weighted least squares for categorical data, Bayesian inference for categorical data, other methods of estimation.

Course Learning Outcomes: By the end of the course, students will be expected to-

CO1	Identify contingency table designs and suggest appropriate association measures and statistical tests;
CO2	Compare the distinctions between logistic, and loglinear models as well as the ability to fit and evaluate the results;
CO3	Gain knowledge on statistical inference for proportions, including the use of likelihood, Wald, score, and likelihood-ratio procedures;
CO4	Analyze dependent categorical data models using both classical approaches and mixed effects models;
CO5	Interpret and communicate categorical data methods to a technical audience.

Mapping Course Learning Outcomes (COs) with the Pos

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3			
CO2	3	3	3			
CO3				3		
CO4				2		
CO5	3	1		1		

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Semester-end examination
CO 2	Lecture using board	Quiz, Semester-end examination
CO 3	Lecture using board	Midterm Examination 1
CO 4	Lecture using board, Assignment	Assignment (Individual/group) Semester-end examination
CO 5	Lecture using board	Quiz, Midterm Examination 2

Main Texts:

1. Agresti, A. (2012). *Categorical data analysis*. 3rd Edition, Wiley, NY.
2. Everitt, B. S. (2019). *The analysis of contingency tables*. 2nd Edition, Chapman & Hall, CRC Press.

Reference Books:

1. Bilder, C. R., & Loughin, T. M. (2014). *Analysis of categorical data with R*. Chapman & Hall/ CRC.
2. Fienberg, S. E. (1989). *The analysis of cross-classified categorical data*. 2nd Ed, The MIT Press, London.
3. Lawal, B. (2003). *Categorical data analysis with SAS® and SPSS applications*. Lawrence Erlbaum Associates, NJ.
4. Stokes, M. E., & Davis, C. S. (2012). *Categorical data analysis using SAS*. 3rd Ed, SAS Press.

Course Code: STA 0542 1278	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Categorical Data Analysis Lab		**Course Status:** Lab	

Rationale of the Course: Acquiring knowledge to analyze categorical data using appropriate statistical methods.

Course Objectives

- To demonstrate different types categorical data, their distributions, and contingency table including test statistic,
- To be able to apply in practical data a range of different methods such as generalized linear regression model such as logistic regression, multinomial logistic regression, log-linear model and so on.
- To be able to apply a range of different methods for repeated categorical data such as model for matched pair data, generalized estimating equations, generalized linear mixed models.

Course Content:

Contingency Table: Calculate the proportion for a contingency table, comparing two proportions, partial association in stratified 2 by 2 tables, and extensions for I by J tables, two-way tables with ordered classifications, comparing proportions, two proportions, stratified 2 by 2 tables, measuring association, odds ratio, confidence intervals for association parameters, perform the test like McNemar's Gart's test, Chi-squared tests, exact tests for small samples, likelihood test, linear-by-linear association. Estimate the relative measure of association: Lamda, Gamma, and Somer's D measures. **Fitting Generalized linear models for categorical data:** *Logistic regression I:* fitting the logistic regression model, strategies in model selection, model diagnostics, Mantel-Haenszel statistic, quasi and complete separation. *Logistic regression II:* fitting conditional logistic regression, generalized additive models, ROC curves & discrimination, and Bayesian inference. *Logistic regression III:* fitting multinomial regression: baseline-category logits, ordinal regression, discrete choice models. *Loglinear models for:* two-way, three-way, and multi-way tables, inference, and fitting models, model building and interpretation, conditional independence graphs and check collapsibility. *Model for matched pairs:* fitting models for repeated measures (conditional logistic regression, marginal models for square contingency tables), estimates measuring agreement between observers, marginal models and quasi-symmetry models for matched sets. **Repeated categorical response data:** Analysing repeated categorical response data: comparing marginal distributions: multiple responses, marginal modelling: maximum likelihood approach, marginal modelling: generalized estimating equations approach quasi-likelihood and its gee multivariate extension: details, Markov chains: transitional modelling. random effects: generalized linear mixed models for categorical responses. **Mixture models for categorical data:** Fitting latent class models, nonparametric random effects models, beta-binomial models, negative binomial regression, Poisson regression with random effects.

Course Learning Outcomes: By the end of the course, students will be expected to-

CO1	Analyze contingency table designs and suggest appropriate association measures and statistical tests;
CO2	Apply several types of logistic, and loglinear models in their appropriate application in different situations;
CO3	Assess using likelihood ratio test, Wald procedures, score procedures;
CO4	Analyze and interpret dependent categorical data models using both classical approaches and mixed effects models;
CO5	Interpret and communicate categorical data methods' results to a technical audience.

Mapping Course Learning Outcomes (COs) with the Pos

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1				
CO2	3	2	1			
CO3	3	2				
CO4	3		3			
CO5			2		2	1

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Semester-end examination
CO 2	Lecture using board, assignment	Lab report (individual/group), Semester-end examination
CO 3	Lecture using board	Semester-end examination
CO 4	Lecture using board, assignment	Lab report (individual/group), Semester-end examination,
CO 5	Lecture using board	Semester-end examination

Main Texts:

1. Agresti, A. (2012). *Categorical data analysis*. 3rd Edition, Wiley, NY.
2. Everitt, B. S. (2019). *The analysis of contingency tables*. 2nd Edition, Chapman & Hall, CRC Press.

Reference Books:

1. Bilder, C. R., & Loughin, T. M. (2014). *Analysis of categorical data with R*. Chapman & Hall/ CRC.

2. Fienberg, S. E. (1989). *The analysis of cross-classified categorical data*. 2nd Ed, The MIT Press, London.
3. Lawal, B. (2003). *Categorical data analysis with SAS® and SPSS applications*. Lawrence Erlbaum Associates, NJ.
4. Stokes, M. E., & Davis, C. S. (2012). *Categorical data analysis using SAS*. 3rd Ed, SAS Press.

Course Code: STA 0542 1279	**Credit:** 3.0	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Advanced Probability Theory		**Course Status:** Theory	

Rationale of the Course: Advanced Probability theory open in new is a branch of mathematics focusing on the analysis of random phenomena. It is an important skill for data scientists using data affected by chance. With randomness existing everywhere, the use of probability theory allows for the analysis of chance events.

Course Objectives:

- Acquire the concepts of measurable space, product measure, Fubini's theorem, Brownian motion, stochastic calculus, and beyond, discrete-time martingales.
- Acquaint knowledge to apply the tools and techniques of queuing systems to optimize the use of resources
- Derive advanced probability-theoretic results of importance for statistical inference
- Develop essential skills required to pursue further studies in the areas of mathematics dealing with modelling of random phenomena.

Course Content

Queueing theory: Introduction. Preliminaries: cost equations, steady-state probabilities. Exponential models: a single-server exponential queueing system, a single-server exponential system having finite capacity. Network of queues: open systems, closed systems, the system M/G/I. Variations on the M/G/I. The model G/M/I. **Multiserver queues:** Erlang's loss system. The M/M/K queue, the G/M/K queue, the M/G/K queue. **Renewal processes:** Introduction, distribution of N(t), limit theorems and their applications, renewal reward processes, semi-Markov processes, the inspection paradox, computing the renewal function. **Brownian motion:** Definition and basic properties, increments of Brownian motion, sample paths, geometric Brownian motion, integrated Brownian motion, Brownian motion with drift. **Martingales and its stochastic calculus:** Filtration, martingales, sub-martingales, super-martingales, Doob's martingale inequalities, Doob's martingale convergence theorem. Ito stochastic integral: definition. Properties of the stochastic integral.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Demonstrate mastery of the principles of probability theory and some of its important applications
CO2	Apply advanced techniques used in probability theory and contiguous areas;
CO3	Analyze and construct mathematical arguments in the context of probability theory;
CO4	Independently prove important theorems and solve advanced problems in probability theory.

Mapping Course Learning Outcomes (COs) with the POs

3: Strong 2: Moderate 1: Weak

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3				
CO2		3	3		3	
CO3		3	3		3	
CO4	2		3		3	

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Quiz/ Semester-end examination
CO 2	Lecture using board, assignment	Assignment/ Presentation (Individual/group) Midterm Examination 1
CO 3	Lecture using board	Midterm Examination 2
CO 4	Lecture using board, assignment	Assignment/ Presentation (Individual/group) Semester-end examination

Assessment Strategy

COs	Teaching-Learning Strategy	Assessment Strategy
CO 1	Lecture using board	Quiz, Midterm Examination-I, Semester-end examination
CO 2	Lecture using board/ Assessment	Quiz/ Assignment/ Presentation (Individual/group) Semester-end examination
CO 3	Lecture using board	Quiz, Midterm Examination-II, Semester-end examination
CO 4	Lecture using board, Assignment	Assignment/ Presentation (Individual/group) Semester-end examination

Books Recommended:

Main Text:

1. Karlin, S., & Taylor, H. M. (1975). *A First Course in Stochastic Processes*. 2nd Ed, Academic Press, NY

Reference Books:

1. Ash, R. B. (2014). *Real analysis and probability: probability and mathematical statistics: a series of monographs and textbooks*. Academic press.
2. Bailey, N. T. (1991). *The elements of stochastic processes with applications to the natural sciences* (Vol. 25). John Wiley & Sons.
3. Bartlett, M. S. (1978). *An Introduction to Stochastic Processes*. Wiley Series, NY.
4. Bhat, U. N., & Miller, G. K. (2002). *Elements of Applied Stochastic Processes*. 3rd Ed, John Wiley & Sons, NY.
5. Billingsley, P. (1995). *Probability and Measure*. 3rd Ed, Wiley Series, NY.
6. Brzezniak, Z. & Zastawniak, T. (2000). *Basic Stochastic Processes*. Springer, Verlag.
7. Chung, K. L. (2012). *Elementary Probability Theory with Stochastic Processes*. 3rd Ed, Springer, Verlag.
8. Cox, D. R., & Miller, W. (1965). *The Theory of Stochastic Processes*. Chapman and Hall, UK.
9. Evans, L. C. (2012). *An introduction to stochastic differential equations*. Version 1.2, Department of Mathematics, UC Berkley.
10. Grimmett, G. R., & Stirzaker, D. R. (2001). *Probability and Random Processes*. 3rd Ed, Oxford Science Publications.
11. Karatzas, I., & Shreve, S. E. (1998). *Brownian Motion and Stochastic Calculus*. Springer, Verlag.
12. Ross, S. M. (2014). *Introduction to Probability Models*. 9th Ed, Academic Press, NY.
13. Ross, S. (1996). *Stochastic Processes*. 2nd Ed, John Wiley & Sons, Canada.
14. Shreve, S. (1996). *Stochastic Calculus and Finance*. Lecture Notes.
15. Pinsky, M., & Karlin, S. (2010). *An introduction to stochastic modeling*. Academic press.

Course Code: STA 0542 1280	**Credit:** 1.5	**Year: Master of Science in Statistics**	**Semester: 2nd**
Course Title: Advanced Probability Theory Lab		**Course Status:** Lab	

Rationale of the Course: This course is essential to many human activities that involve quantitative analysis of large sets of data. Methods of probability theory also apply to description of complex systems and ability to solve advanced real-life problems such as weather forecast, sports and gaming strategies, buying or selling insurance, online shopping, and online games etc.

Course Objectives:

- Covers the contents of fundamentals of probability theory using measure theoretical concepts
- Facilitates necessary skills to solve queueing problems, limit theorem and applications,
- Helping the students to develop stochastic Ito integral and its applications.

Course Contents

Queueing theory: Exponential models: a single-server exponential queueing system, a single-server exponential system having finite capacity. The model G/M/I. **Multiserver queues:** Erlang's loss system. The M/M/K queue, the G/M/K queue, the M/G/K queue. **Renewal processes:** Limit theorems and their applications, semi-Markov processes, computing the renewal function. **Brownian motion:** Increments of Brownian motion, sample paths, Brownian motion with drift. **Martingales and its stochastic calculus:** Martingales, sub-martingales, super-martingales, Ito stochastic integral.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Identify the concepts of queuing theory and renewal process;
CO2	Solve the queuing problems and give the applications of limit theorem;
CO3	Determine the non-deterministic systems with semi-Markov chains and renewal functions in environment and business sectors;
CO4	Solve the engineering and economic problems based on stochastic Ito integrals.

Mapping Course Learning Outcomes (COs) with the POs

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	2			
CO2			3		3	
CO3		3	3		2	
CO4			3		2	3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lecture using board	Quiz, Semester-end examination
CO 2	Lecture using board, Assessment	Quiz/ Assignment/ Presentation (Individual/group) Semester-end examination
CO 3	Lecture using board	Quiz, Semester-end examination
CO 4	Lecture using board, Assignment	Assignment/ Presentation (Individual/group) Semester-end examination

Books Recommended:

1. Brzezniak, Z. & Zastawniak, T. (2000). *Basic Stochastic Processes*. Springer, Verlag.
2. Chung, K. L. (2012). *Elementary Probability Theory with Stochastic Processes*. 3rd Ed, Springer, Verlag.
3. Cox, D. R., & Miller, W. (1965). *The Theory of Stochastic Processes*. Chapman and Hall, UK.
4. Karatzas, I., & Shreve, S. E. (1998). *Brownian Motion and Stochastic Calculus*. Springer, Verlag.
5. Shreve, S. (1996). *Stochastic Calculus and Finance*. Lecture Notes.

6. Pinsky, M., & Karlin, S. (2010). *An introduction to stochastic modeling*. Academic press.

Master of Science in Statistics (Thesis) Third Semester Course Details

Course Code: STA 0542 1390	**Credit:** 12.0	**Year: Master of Science in Statistics**	**Semester: 3rd**
Course Title: Dissertation		**Course Status:** Lab	

Rationale of the Course: In addition to learning advanced theories in statistical science, graduate students in statistics should get the opportunity to undertake a thesis, involving an original piece of research work, allowing the students to dig into a topic in statistics and produce research findings that demonstrates how their knowledge has grown throughout the degree program.

Course Objectives:

- Help students to build an excellent foundation in advanced statistical theories (the science of statistics) and data analysis (the practice of applying statistics),
- Provide students the rigorous research training so that they can pursue a higher degree (such as MPhil/PhD) in statistical sciences or secure a research position in academia and industry.

Course Contents

Each thesis student will be assigned to a principal supervisor and one or more co-supervisors by the department. The thesis students will determine the topic of the thesis in consultation with their supervisor and co-supervisors.

Course Learning Outcomes (COs): By the end of the course, students will be expected to-

CO1	Examine and evaluate advanced knowledge in an area of statistical science;
CO2	Review existing literature in an area of statistical science and appraise critically the body of evidence;
CO3	Formulate the statistical research problems independently and in a team;
CO4	Write independent scientific report to present an original statistical research work;
CO5	Present independent scientific statistical work.

Mapping Course Learning Outcomes (COs) with the POs

Course Learning Outcomes (CO)	Fundamental Skill	Social Skill	Thinking Skill		Personal Skill	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	2	2	2	2
CO2	2	2	3	3	1	1
CO3	1	2	1	1	3	3
CO4	1	2	1	1	3	3
CO5	2	2	2	2	3	3

Mapping Course Learning Outcomes (COs) with the Teaching-Learning& Assessment Strategy

COs	**Teaching-Learning Strategy**	**Assessment Strategy**
CO 1	Lectures and books that cover thesis topic	Semester-end examination
CO 2		Semester-end examination
CO 3		Semester-end examination
CO 4		Semester-end examination
CO 5		Semester-end examination

Part D

20. Grading/Evaluation: According to the ordinance of the university

1) Grading Scale and Grades:

Letter Grade and corresponding Grade-Point for a course will be awarded from the roundup marks of individual courses as follows:

Numerical Grade	Letter Grade	Grade Point
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00

55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	C-	2.00
Less than 40%	F	0.00