UNIVERSITY OF RAJSHAHI
Rajshahi – 6205, Bangladesh

Outcome-based Curriculum
for
Master of Science (M.Sc.) in Statistics

Session: 2023 – 2024

Examination Year : 2024

DEPARTMENT OF STATISTICS
www.ru.ac.bd/stat/

Outcome-based Curriculum

for
M. Sc. in Statistics
Session: 2023–2024
Department of Statistics
Faculty of Science, University of Rajshahi

1. University of Rajshahi

The University of Rajshahi is one of the largest universities in the country and the largest with the highest seat of learning in the northern region of Bangladesh. After its foundation on July 6, 1953, the university has passed 71 years providing higher education and research. The university is located on a 753-acre campus on the green premises of Motihar, which is very close to the mighty river Padma and seven km east of the Rajshahi City Center.

The necessity of a university in the northern part of East Pakistan was felt immediately after the creation of Pakistan. These areas were comparatively lagging behind in higher education, and the University of Dhaka, then the only university of its kind in the country, being situated in the capital, was not very easily accessible to the students of this part. Following a popular demand for a university in this region, the government prepared a feasibility report, and Rajshahi was found suitable for establishing the same. The Rajshahi University Act 1953 (East Bengal Act XV of 1953) was passed by the East Pakistan provincial assembly on March 31, 1953. Bara Kuthi, an 18th century Dutch trading house, was made the administration building. Dr. Itrat Hossain Zuberi was the first Vice-Chancellor of the University. Its normal academic activities began in 1954. During the early days of its inception, classes were held at Rajshahi Government College. In 1961, the university moved to its present campus.

The university's 59 departments are organized into twelve faculties. It has six institutes, of which two (IBA and IER) have undergrad and postgraduate programs. The University of Rajshahi is considered as one of the top research universities in Bangladesh. Recently, researchers from this university have made substantial contributions and played a key role in bringing back the ancient Bangladeshi Muslin fiber. The researchers of this university have also created the country's first and only "snake database," including snakes' venom and their toxicity. The university has a strong alumni community around Bangladesh and abroad.

2. Vision of the University

To pursue enlightenment and creativity for producing world-class human resources to cater for the needs of changing time.

3. Mission of the University (MU)

MU1	To ensure a world-class curriculum with talented academicians and conducive academic and research environment for generation and dissemination of knowledge.
MU2	To maintain international standards in education with focus on both knowledge and skills, and humanitarian and ethical values to meet the needs of the society and state.
MU3	To develop strategic partnerships with leading national and international universities, and organizations for academic as well as research collaborations.

4. Name of the Program Offering Entity

Department of Statistics, University of Rajshahi

5. Department of Statistics: At a glance

The Department of Statistics of the University of Rajshahi was established in 1961 by Professor K. M. Hossain, a distinguished statistician who was the first Head of the Department. At present, there are 22 full-time teachers and 17 office staff. The present enrolments of the students are about 80 and 350 in the graduate and undergraduate programs, respectively. The department has a seminar library with many Textbooks, Journals, and Scientific Literature. A Computer Unit was established in the department in 1990. It is equipped with more than 180 modern personal computers of various models. The department has a modern conference room.

The department offers B.Sc. Honors, M.Sc., M.Phil., and Ph.D. degrees in Statistics. It also offers researchers, professionals, and students a statistical computing certificate course. The department has concentrated on research works mainly in the areas of Anthropometric Statistics, Bayesian Inference, Biostatistics, Bioinformatics, Biochemical Engineering and Statistical Signal Processing, Bootstrap Techniques, Computer Programming and Simulation, Data Science, Demography, Earthquake Prediction Modeling, Econometrics, Environmental Statistics, Geo-Statistics, Human Growth, Human Morphology, Industrial Statistics, Linear programming, Machine Learning, Optimization, Order Statistics, Probability, Regression Diagnostics, Reliability Theory, Robust Statistics, Sample re-use Techniques, Social & Educational Statistics, Statistical Data Mining, Statistical Inference, Stochastic Modeling, etc.

The department organizes Seminar/Conferences regularly. It has successfully organized seven international conferences during the last three decades. The department publishes an annual journal named the International Journal of Statistical Sciences (IJSS). For over the last 20 years, this department has had a collaboration program with Indian Statistical Institute, Kolkata. In recent years, the department has launched link programs with Kyoto Gakuen University, Japan, The University of Electro-Communications, Tokyo, Japan, and Soochow University, Suzhou, China.

The department has an association called “Parishankan Samity.” Recently, the alumni of this department have formed Rajshahi University Statistics Alumni (RUSA) in Dhaka to incorporate all ex-statistics students of the University of Rajshahi. To enhance the department's research activities, 16 different research groups have been working with all their efforts.

6. Vision of the Entity

The vision of the program offering entity, the Department of Statistics, is to create a center of excellence in statistical learning for quality education and research to produce skilled and competent human resources who will adapt swiftly to the challenges of the 21st century.

7. Mission of the Entity (ME)

ME1	To achieve the highest quality education with a strong foundation for promoting statistical learning to address global challenges.
ME2	To develop a strong bond with the industry for project-based learning, internships, and placements.
ME3	To create academic excellence, international exposure to students to make them globally competitive statisticians.
ME4	To develop professionalism with strong foundations adapting to changing technology.

8. Objectives of the Entity (OE)

OE1 Provide professional graduates in the field of statistics and multidisciplinary areas according to the requirements of contemporary job markets.

OE2 Publish in leading professional journals to contribute to the theoretical development and application of statistics addressing substantive problems through scholarly research.

OE3 Disseminate statistical knowledge to ensure effective applications of statistics in real-life practices.

OE4 Deliver adequate, relevant, and timely statistics to facilitate research, planning, and decision-making processes for the government and the community to achieve the Sustainable Development Goals (SDGs) of Bangladesh.

9. Faculty list with their Research Interest of the Entity

No.	Name	Designation	Research Areas
1.	Dr. Md. Asaduzzaman Shah	Professor	Probability, Stochastic Modeling
2.	Dr. Anjuman Ara Begum	Professor	Demography, Statistical Inference, Order Statistics, Computer Programming
3.	Dr. Md. Ripter Hossain (PRL)	Professor	Demography, Sample Survey, Econometrics, Industrial Management and Health Statistics
4.	Dr. Md. Ayub Ali	Professor	Time Series Analysis and Forecasting, Anthropometric Study, Physical Health and Human Growth, Statistical Modeling, Econometrics, Environmental Statistics, Descriptive Statistics and Applied Statistics
5.	Dr. Md. Golam Hossain	Professor	Human Morphology, Mathematical Modeling, Health & Medical Statistics, Physical Anthropometry, Epidemiology
6.	Dr. Md. Rezaul Karim	Professor	Reliability and survival analysis, Multivariate analysis, Biostatistics, Statistical inference, Simulation and modeling, Statistical computing, Machine learning, Data science
7.	Dr. Md. Monsur Rahman	Professor	Reliability, Bio-Statistics, Statistical Inference
8.	Dr. Dulal Chandra Roy	Professor	Sample Survey, Estimation, Operation Research, Quality Control, Applied Statistics
9.	Dr. Md. Nurul Haque Mollah	Professor	Robust Statistical Inference, Multivariate Statistics, Optimization, Data Mining, Statistical Signal Processing, Biostatistics, Statistical Genomics and Bioinformatics

No.	Name	Designation	Research Areas
10.	Dr. Saroje Kumar Sarkar	Professor	Multivariate analysis, Reliability, and Design of experiments
11.	Dr. M. Mahmudul Alam	Professor	Distribution Fitting, Geo-Statistics, Environmental Statistics, Earthquake Prediction Modeling, Computer Programming & Simulation, Data Mining
12.	Dr. Md. Aminul Hoque	Professor	Bioinformatics, Medical Informatics, Systems Biology, Biochemical Engineering, Dynamic Metabolomics Analysis, Survival Analysis
13.	Dr. Provash Kumar Karmokar	Professor	Econometrics, Time Series Analysis and Forecasting, Statistical Modeling of Climatic variables, Computational Statistics, Simulation and Modeling, Agriculture Statistics
14.	Dr. Mst. Papia Sultana	Professor	Semiparametric and Nonparametric Modelling, Medical Diagnostics, Epidemiology
15.	Dr. Md. Mesbahul Alam	Professor	Reliability Data Analysis, Survival Analysis, Bio-statistics, Optimization, Mathematical Statistics, Robust Statistics, Regression Diagnostics, Computer Programming and Data Mining
16.	Dr. Md. Monimul Huq	Professor	Time Series Analysis and Forecasting, Econometrics, Robust Regression and Diagnostics, Multivariate Analysis, Health Statistics, Machine Learning, Meta Analysis
17.	Dr. Md. Sabiruzzaman	Professor	Time Series Analysis, Econometrics, Robust Statistics, Estimation, Simulation and Modeling, Socio-demographic and Health Statistics
18.	Dr. Abu Sayed Md. Al Mamun	Professor	Regression Diagnostics, Statistical Modeling, and Public Health
19.	Dr. Md. Abdul Khalek	Professor	Groundwater Modeling, Environmental Statistics, Statistical computing, Data Science
20.	Dr. Md. Kamruzzaman	Professor	Demography, Health Statistics
21.	Dr. Farhana Hasan	Professor	Demography, Mathematical Economics, Probability Theory, Reliability, Health Statistics.

No.	Name	Designation	Research Areas
22.	Dr. Md. Hadiul Kabir	Professor	Biomedical Statistics, Bioinformatics, Time Series Analysis, Data Mining
23.	Dr. Md. Mostafizur Rahman	Associate Professor	Machine learning, Statistical Data Mining, Financial time series analysis, Volatility Modelling and Applied Statistics, Environmental science and Actuarial Science

Detail Program

M.Sc. in Statistics
Session: 2023-2024
Examination Year: 2024

10. Name of the Program

Master of Science (M. Sc.) in Statistics

11. Description of the Program

The M. Sc. program in Statistics shall be spread over one academic year. The program is divided into two groups - General Group and Thesis Group. The Examinees shall take the examination either in the General Group or in the Thesis Group. The thesis shall be offered subject to the approval of the Departmental Academic Committee. The examination (General or Thesis) shall be of 900 Marks (36 Credits). A candidate should be awarded an M. Sc. degree in Statistics if the candidate obtains 32 credit points out of 36. The aim of the program is to foster an interest in theoretical and applied statistics and equip students as a professional statistician. This degree offers the opportunity to the students who enjoy statistics to build on their interests and learn how to apply their knowledge in the real world by analyzing and critically interpreting data, building statistical models of real situations, and using cutting-edge programming tools and software packages.

12. Vision of the Program

Students will acquire knowledge of statistical theory and its applications within data science. The ability to formulate suitable statistical models for new problems, fitting of models to real data, and interpretation of the results

13. Mission of the Program

M1	To emphasize on highest quality education with a strong foundation for promoting statistical learning to address global challenges;
M2	To provide in-depth knowledge regarding the theory and application of modern statistical techniques that are commonly used for (big) data analytics;
M3	To provide effective supervisory training for the basic and applied research that pushes forward the frontier of knowledge in the field of statistics and data science;
M4	To develop professionalism with strong foundations adapting to changing technology.

14. Program Educational Objectives (PEOs)

PEO1	The program is intended to produce high-quality graduates who are intellectually and technically competent in building careers in various fields of statistics;
PEO2	Provide basic understanding of statistical theory and analytical tools that can be used in the statistics decision-making process;
PEO3	Facilitate learners linking statistical theories and practice with a view to solving real-life problems and contributing to socio-economic and community development;
PEO4	To bring to their careers the self-assurance, integrity, and technical strengths that drive innovation, and collaboration skills;
PEO5	Comply with employability needs to meet demands for high-quality graduates.

15. Mapping the mission of the university with PEOs

Program Educational Objectives (PEOs)	**Mission of the University (MU)**		
	MU1	MU2	MU3
PEO1	3	1	2
PEO2	1	2	3
PEO3	3	2	2
PEO4	2	1	3
PEO5	1	3	2

Note: 3 - High, 2 - Medium, 1 – Low

16. Mapping between Mission & PEOs

Missions	**PEO1**	**PEO2**	**PEO3**	**PEO4**	**PEO5**
M1	3	2	1	1	2
M2	2	3	2	2	1
M3	3	1	2	1	2
M4	2	1		2	3

Note: 3 - High, 2 - Medium, 1 – Low

17. Program Learning Outcomes (PLOs)

The following is the list of Program Learning Outcomes (PLOs) that students must achieve after successfully completing their degree.

PLO1	**Statistical knowledge:** Explain the key statistical, mathematical, computer programming, and economics concepts to have a strong knowledge base in the statistical domain and their applications.
PLO2	**Problem investigation:** Ability to domain selection and problem investigation in a statistical way, including literature survey, design and conduct of experiments, the basic principles and theories relevant to statistics, and their applications to derive valid conclusions.

PLO3	**Statistical computation program:** Apply mathematical foundations, simulation algorithmic principles, and computer programming to demonstrate comprehension of the tradeoffs involved in statistical computations.
PLO4	**Statistical Modelling:** Model real-world phenomena into statistical model formulations, develop the statistical models, and subsequently interpret the solutions back to the real world as applicable recommendations.
PLO5	**Project implementation:** Deploy a rich portfolio of advanced statistical techniques using contemporary software tools to solve real-life problems by doing projects.
PLO6	**Data science and analytics:** Apply the concepts of data science and analytics, with an emphasis on their applications in actuarial science, agriculture, the environment, health, and industry.
PLO7	**Communication and teamwork:** Develop good oral and written communication skills, which will help them work effectively as individuals or in teams in their future careers.
PLO8	**Ethics:** Address professional, ethical, and social issues and responsibilities concerning diversified discipline.

18. Mapping PEOs with PLOs

Program Educational Objectives (PEOs)	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
PEO-1	2	1	2	3	1		1	
PEO-2	3	1	2	1	2		2	
PEO-3	2	3	1	2		1		3
PEO-4	2	1		2			1	3
PEO-5	2	2	3	1	2	1	1	2

Note: 3- High, 2-Medium, 1-Low

19. Graduate Attributes

1.	**Scholars**: Our graduates are expected to have a broad knowledge base and disciplinary expertise.
2.	**Problem Solvers**: With an adequate knowledge of disciplinary expertise and problem domain, our graduates will be in a position to formalize any problem and solve it methodically.
3.	**Innovators**: We want our graduates to be focused on future-proof solutions. They will be critical thinkers, creative designers, and efficient makers. They are capable of developing unique and sustainable solutions to real-world problems.
4.	**Leaders**: Graduates of our department will take personal responsibility and seek opportunities to work with others to advance thinking and achievement in all spheres of their lives. They will be confident, inclusive, inspiring, and influential.
5.	**Global Citizens**: Our graduates are locally produced but globally in demand. They are aware of global issues and act with integrity, sensitivity and fluency across cultures and perspectives, and are committed to the betterment of the society as a whole.

20. Ordinance

The M.Sc. (Master of Science) Final Course in Statistics shall spread over One Academic year. The Course is divided into Two Groups - The General Group and the Thesis Group. The Examinees shall take Examination either in the General Group or in the Thesis Group. The Thesis shall be offered subject to the approval of the Departmental Academic Committee. The examination (General or Thesis Group) shall be of 900 Marks (9 Course Units: 36 Credits).

M.Sc. Degree: A candidate should be awarded M.Sc. degree in Statistics, if he obtains 32 credit points out of 36.

Course Improvement: A candidate obtaining a GPA of less than 3.00 shall be allowed to improve the result by reappearing in the exam up to 12 credits with F grade within consecutive next three years. Also, a promoted student earning of a GPA less than 3.00 individual course(s) shall be allowed to improve the grade(s).

General Group: The Examination shall consist of Eight Theory Courses of 600 marks (6 Units: 24 Credits), Eight Practical Sessions of 150 Marks (1.5 units, 6 Credits; Spread over Eight days, 30% of the total Practical marks shall be allotted for continuous laboratory assessment), Viva-voce Examination of 100 marks (1.0 unit, 4 Credits), excursion and Fieldwork & research project 50 marks (0.5 unit, 2 credit). Each course contains 60 theory marks and 15 in-course marks (Tutorial/Terminal 11.25 and Attendance 3.75).

Thesis Group: The Examination shall consist of Eight Theory Courses of 600 Marks (6 units: 24 Credits) and Viva Voce Examination of 100 Marks (1.0 unit: 4 Credits), a Thesis/ Dissertation carrying 100 marks (1.0 units: 4 Credits) and Thesis Defense (Seminar and Viva voce on Thesis) of 50 marks (0.5 unit: 2 Credits) and excursion & in-plant training of 50 marks (0.5 unit: 2 Credits). The breakdown of marks, units, and credits are as follows:

General Group						
Category	**Theory**	**Viva**	**Practical/Excursion**			**Total**
			Practical	**Field Work /Excursion**	**Total**	
Course / Session	8 Courses	-	8 Sessions	-	-	
Total Marks	600	100	150	50	200	900
Units	6.0	1.0	1.5	0.5	2.0	9.0
Credits	24	4	6	2	8	36

Thesis Group							
Category	**Theory**	**Viva**	**Thesis**			**In-plant Training /Excursion**	**Total**
			Written	**Defense**	**Total**		
Courses / Sessions	8 Courses	-	-	-		-	-
Total Marks	600	100	100	50	150	50	900
Units	6.0	1.0	1.0	0.5	1.5	0.5	9
Credits	24	4	4	2	6	2	36

The Paper-wise Title of Courses (Both for General and Thesis Groups), Marks, Course Unit, Credits, and Duration of Examination are as follows:

Courses M.Stat.	Title of Paper	Exam.	In Course		Full Marks	Unit	Credit	Exam. Hours
			Tutorial	CA				
Compulsory								
501	Advanced Statistical Inference	60	11.25	3.75	75	0.75	3	4
502	Advanced Experimental Design and Sampling Techniques	60	11.25	3.75	75	0.75	3	4
503	Advanced Multivariate Analysis	60	11.25	3.75	75	0.75	3	4
504	Time Series Analysis and Forecasting	60	11.25	3.75	75	0.75	3	4
505	Data Mining and Machine Learning	60	11.25	3.75	75	0.75	3	4
	Total				**375**	**3.75**	**15**	**20**
Optional: ***Any one course from each group should be chosen subject to the Approval of the Academic Committee.***								
Group 1								
506	Advanced Bioinformatics	60	11.25	3.75	75	0.75	3	4
507	Advanced Demography	60	11.25	3.75	75	0.75	3	4
508	Environmental Statistics	60	11.25	3.75	75	0.75	3	4
509	Advanced Actuarial Statistics	60	11.25	3.75	75	0.75	3	4
Group 2								
510	Biomedical Informatics	60	11.25	3.75	75	0.75	3	4
511	Health and Epidemiology	60	11.25	3.75	75	0.75	3	4
512	Statistical Methods in Industrial Management	60	11.25	3.75	75	0.75	3	4
513	Statistical Methods for Reliability Data	60	11.25	3.75	75	0.75	3	4
	Group 3							
514	Physical Health and Human Growth Modeling	60	11.25	3.75	75	0.75	3	4
515	Advanced Stochastic Modeling	60	11.25	3.75	75	0.75	3	4
516	Advanced Biostatistics	60	11.25	3.75	75	0.75	3	4
517	Planning, Monitoring and Evaluation of Research	60	11.25	3.75	75	0.75	3	4
518	Data Science and Big Data Analytics	60	11.25	3.75	75	0.75	3	4
	Optional Paper Total				**225**	**2.25**	**9**	**12**

Courses M.Stat.	Title of Paper	Exam.	In Course		Full Marks	Unit	Credit	Exam. Hours
			Tutorial	CA				
519	Viva-voce				100	1.0	4	-

Courses M.Stat.	Title of Paper	Exam.	In Course	Full Marks	Unit	Credit	Exam. Hours
General Group							
520	Practical Examination			150	1.5	6	40
521	Excursion and Fieldwork & research project			50	0.5	2	
Thesis Group							
522	(a) Thesis Written			100	1.0	4	-
	(b) Thesis Defense			50	0.5	2	-
	Thesis (a + b)			150	1.5	6	-
523	Excursion and In-plant Training			50	0.5	2	-
Grand Total				**900**	**9**	**36**	**72**

21. Mapping Courses with PLOs

Courses	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
Compulsory								
M.Stat. 501	3		1	2	2	1		3
M.Stat. 502	2	3			1	1		2
M.Stat. 503		3	2	2		1	1	2
M.Stat. 504	1	2	3	3	2			2
M.Stat. 505	3	2	2	2	1	1	2	
Group 1								
M.Stat. 506		2			2	1		
M.Stat. 507	3		3		1	1		3
M.Stat. 508	3		2	2	1	1	1	3
M.Stat. M09	3	2	1	2			2	2
Group 2								
M.Stat. 510	3		1	2	2	1		3
M.Stat. 511	3		1	2	2	1		3
M.Stat. 512	3		1	2	2	1		3
M.Stat. 513	3		1	2	2	1		3
Group 3								
M.Stat. 514	3		1	2	2	1		3
M.Stat. 515	3		1	2	2	1		3
M.Stat. 516	3		1	2	2	1		3
M.Stat. 517	3		1	2	2	1		3
M.Stat. 518	1	2	3	3	2	2	1	3

Note: 3- High, 2-Medium, 1-Low

M.Stat. 501: Advanced Statistical Inference

Course Code : M.Stat. 501
Course Title : Advanced Statistical Inference
Course Type : Compulsory
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any) : B. Stat.-302, B. Stat.-303
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course provides the students with theoretical foundations in statistics and the theory of statistical inference. It consists of five parts. 1. Statistics, sufficiency and completeness; Unbiased Estimation: Uniform minimum variance unbiased estimators (UMVUE) in advance setup; 2. Estimation in Parametric Models: Bayes estimators, maximum likelihood estimators and the properties of estimators such as invariance, minimaxity, admissibility and asymptotic efficiency, EM algorithm; 3. U-statistic, V-statistic, L-M-R statistic, statistical functional, bootstrap method. Asymptotic properties. 4. statistical decision theory for composite hypothesis; Local powerful test, Similar Region test, SPRT for three hypothesis and composite hypothesis; 5. Non-parametric test procedures.

COURSE OBJECTIVES:

1. This course is designed to aid the interpretation of data that are subject to appreciable haphazard variability and to give a comprehensive statistical basis for the analysis of such data, excluding considerations specific to particular subject matter;
2. This course will give students a view of the nature of advanced statistical methods and to nurture advanced statistical thinking.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	know how attain the complex inferential targets using general statistical inference;
CLO2	explain the properties of different estimators;
CLO3	handle various real problem by parametric and nonparametric test procedure.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
CLO1	3	2	1	1	1	2	1	2
CLO2	3	3	2	2	1	1	2	1
CLO3	1	2	3	2	1	2	1	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Course Content	Teaching-learning strategy	Assessment strategy	Number of Lectures
CLO1	**Sufficiency and unbiasedness**: Different types of statistical models, parametric, semi-parametric and non-parametric models, Group and exponential family of distribution, Sufficiency, minimal sufficient, completeness and their relations-applications, Lehman-Scheffe Theorem, UMVU estimates, LMVU estimates, Necessary and sufficient condition of UMVUE.	Class lecture, class test, assignment, Q/A session	Final exam, class test and class attendance	10
CLO1	**Asymptotic estimation**: Types of consistency and their relations, Asymptotic normality, Asymptotic efficiency, properties of U and V statistic, Different examples and application of U and V statistic. Bootstrap bias and estimation.			5
CLO1	**Parametric estimation**: Bayes decision and estimators, equivariance and pitman estimators, minimaxity and admissibility, loss function optimality; Maximum, quasi-maximum and conditional likelihood methods of estimation, asymptotically efficient estimators; Confidence region, Fiducial and tolerance limits, Bayesian and bootstrap intervals, EM algorithm.			5
CLO2	**Non-parametric estimation and robust estimation**: Distribution estimators, density estimators, different concept of robustness, statistical functional differentiability and asymptotic normality, L-M-R estimators, robustness vs efficiency, variance estimation, robust estimation of multivariate location functional and scatter matrix.			5
CLO2	**Testing composite hypothesis**: Review of simple hypothesis and test criteria, generalized Neyman Pearson Lemma, Locally UMPU test, Similar region and Neyman structure, Sufficient statistics and SR test, MPSR test, UMPSR test, Asymptotic efficiency of a test.			10
CLO2	**Sequential test**: Review of SPRT, OC and ASN functions. SPRT for three hypotheses. Sobel and Wald test. Armitage method for composite hypothesis. Wald theory of weight function. Cox's theorem. Sequential t-test, Sequential c2 test, Asymptotic Sequential t-test, Sequential analysis of variance, Sequential Multivariate Analysis.			5

CLOs	Course Content	Teaching-learning strategy	Assessment strategy	Number of Lectures
CLO3	**Nonparametric test**: Introduction. ARE and Robustness of a non-parametric test. McNemar test in 2×2 contingency analyses. Cox & Stuart test for trend. Cramer's contingency coefficient. Cochran test for related observations. ARE of Mann-Whitney test and Sign test. Kruskal-Wallis test & CRS design. Square rank test for variances. Quantile test. Friedman test. Kolmogorov one sample & two samples test.			5

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Cox and Hinkley (1996). *Theoretical statistics*, Chapman & Hall.
2. Shao, J. (1999). *Mathematical statistics*. Springer.

References:

1. Bickel, P.J. and Doksum, K.A. (2001). *Mathematical Statistics: Basic Ideas and Selected Topics*. Prentice-Hall, Inc.
2. Govindarajulu, Z. (2004). *Sequential Analysis*, World Scientific Publishing Ltd.
3. Efron, B. & Tibshirani, R.J. (1993). *An Introduction to Bootstrap*.
4. Ashraf Ali, M. (1974). *Theory of Statistics*, Nilkhet, Dhaka.
5. Barnet, V. (1982). *Comparative Statistical Inference*, Wiley, N.Y
6. Efron, B. (1984). *The Jackknife, the Bootstrap and Other Re-sampling Plans*.
7. George Casella and Roger L. Berger (2002). *Statistical Inference*, Thomson Learning Asia and China Machine Press.
8. Kalbfleisch, J. (2007). *Probability & Statistical Inference*, Springer-Verlag, N.Y.
9. Lehman, E.L. (1986). *Testing Statistical Hypotheses*, Wiley, N.Y
10. Lehman, E.L. (1989). *Theory of Point Estimation*, Wiley, N.Y.
11. Noreen, E.W. (1982). *Computer Intensive Methods for Testing Hypothesis*.
12. Rohatgi, V.K. & Ehsanes Saleh, A.K.M. (2001). *An Introduction to Probability and Statistics*. John Wiley and Sons, N.Y
13. Shao, J. & Tu, D. (2000). *Jackknife and Bootstrap*, Springer-Verlag, N.Y
14. Zacks, S (1971). *Theory of Statistical Inference*, Wiley, N.Y

M.Stat. 502: Advanced Experimental Design and Sampling Techniques

Course Code **:** M.Stat. 502
Course Title **:** Advanced Experimental Design and Sampling Techniques
Course Type **:** Compulsory
Level/Term and Section: M.Sc. Final
Academic Session **:** 2023 - 2024
Course Instructor **:**
Pre-requisite (If any**)** **:**
Credit Value **:** 3
Total Marks **:** 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

Situations often call for collection of data which are to be analyzed to obtain answer to certain problem of interest. Advanced experimental design is a well-defined act or an investigation conducted to discover the underlying facts about a phenomenon, which are utilized to test some hypotheses of interest, to verify the results of previous investigations or to study the effect of new conditions on the system. Very often an experiment is conducted as a change in the routine operation of a system in order to measure the effect of change or intervention. Another part of this course is designed to enhance some sampling methods which include probability proportion to size sampling, two stages and multistage sampling, two phase and multiphase sampling & non-response.

COURSE OBJECTIVES:

1. Students may identify the causes of variation and sort out corresponding components of variation with associated degrees of freedom;
2. Students may able to perform test of significance based on F distribution properly;
3. On the basis of advanced experimental design the learners may able to collect maximum amount of necessary information for the problems under consideration, at a minimum cost in terms of time and resources;
4. How to select a sample and obtain estimates of parameters from a given population by using different sampling scheme;
5. To find the reliability of the estimates derived from the sample, which can be done by computing the standard error of the statistic.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	identify the sources of variations and test their impact on the total variation;
CLO2	explain main effects , interaction effects and their impacts in the field experimentation and interpret the concept of variability, its causes and methods of reducing it;
CLO3	describe possible causes of bias and ways of alleviating it;
CLO4	increase the accuracy of the results of an experiment;
CLO5	know the selection procedures of drawing sample;

CLO6	choose the estimators using auxiliary information and without auxiliary information;
CLO7	find the estimates of the variance of the different estimators, compare them and make inference;
CLO8	analyze data and define the estimators in case of nonresponse.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	1		3		3	2	2
CLO2		3		1	3	2	3	2
CLO3	1		2	3		2	1	2
CLO4	3	2		2		2	2	2
CLO5	3	1	2	2		3	2	2
CLO6								
CLO7	3	2		1	3	2		3
CLO8	2	2	2		3		3	3

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**S^k Factorial Experiments, Mixed Factorial Experiment and Split-split Plot Design:** Review of factorial experiment with levels 2, 3, 5 etc., confounding in a factorial experiments, confounding in 3^m factorial experiments, Mixed factorial experiments, fractional replication and analysis of related plans. Analysis of orthogonal plans, Split-split plot design. Basic concept of weighing design.	Lecturers will be delivered with multi-media tools, Interactive brainstorming and Q/A session	Group discussion, Assignments, Sudden class tests, Tutorial, Final examination	10
CLO1	**Analysis of Non-Orthogonal Designs:** Non-Orthogonal two-way classification with disproportionate and unequal number of observations per cell and no interaction, incomplete block designs, balanced incomplete block design, Lattice design, Partially balanced incomplete block design. Construction of balanced incomplete			6

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	block design, relative efficiency of balanced incomplete block design.			
CLO2	**Nested Design**: Introduction, Two-stage nested design, Three stage nested design			4
CLO3	**Response Surface Design**: Introduction, First order design, Second order design, Method of Steepest Ascent, Difference between Response Surface Design and usual design.			3
CLO3	**Sampling with Varying Probabilities**: Unequal probability sampling with and without replacement, Methods of selecting a PPS sample, Estimation of population parameters with PPSWR sampling, PPSWOR sampling, Des Raj's ordered, Murthy's unordered and Horvitz-Thompson estimation methods.			7
CLO4	**Two Stage and Multistage Cluster Sampling:** Two stage with equal and unequal cluster sizes, Three stage and multistage sampling, Estimation of mean and variance, Optimum allocation of sample size.			5
CLO4	**Double Sampling and Multiphase Sampling:** Introduction, Double sampling for stratification, Ratio, Difference, Regression, Product, Optimum allocation, Multiphase sampling, Sampling on two and more occasions, Repetitive surveys.			6
CLO5	**Non-Sampling Errors:** Sources and types of non-sampling errors, Effect of non-response, Technique for adjustment of non-response: Hansen and Hurwitz technique, Politz-Semons techniques, Randomized response technique.			4

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: As per ordinance of RU.

Main Books:

1. Montgomery, D. C. (2005). *Design and Analysis of Experiment*, John Wiley, N. Y.
2. Mukhopadhyay, P. (2009). *Theory and methods of survey sampling*. PHI Learning Pvt. Ltd.

References:

1. Cohran and Cox (2000). *Experimental Design*. John Wiley, N. Y.
2. Federer, W. T. (1955). *Experimental Design*, McMillan, New York.
3. Fisher, R. A. (1995). *Design of Experiment*, Hafner, N. Y.
4. John and Quenouille (1977). *Experiments: Design and Analysis*, Charles Griffin, London.
5. Cochran, W. G. (2007). *Sampling techniques*. John Wiley & Sons.
6. Chaudhuri, A., & H. Stenger (2010). *Survey sampling: theory and methods*. CRC Press.
7. Lohr, S. L. (2010). *Sampling: Design and Analysis*, 2nd ed., Books Cengage Learning, Australia.
8. Nassiuma, D. K. (2001). *Survey sampling: Theory and methods*.
9. Pedhazur, E. J., & L. P. Schmelkin (2013). *Measurement, design, and analysis: An integrated approach*. Psychology Press.
10. Raj, D. and P. Chandhok (1998). *Sample Survey Theory*, Norosa Publishing House, New Delhi.
11. Singh, R. and S. M. Naurang (1996). *Elements of Survey Sampling*, Kluwer Academic Publishers, London.
12. Sukhatme, P. V., B. V. Sukhatme, S. Sukhatme, and C. Ashok, (1997). *Sampling Theory of Surveys with Application*, Indian Society of Agricultural Statistics, New Delhi.

M.Stat. 503: Advanced Multivariate Analysis

Course Code	:	M.Stat. 503
Course Title	:	Advanced Multivariate Analysis
Course Type	:	Compulsory
Year/Level and Semester	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	B. Stat.-401 (Multivariate Analysis)
Credit Value	:	3
Total Marks	:	75 (Examination 60, Class test/Assignment 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course explores advanced multivariate analysis methods such as multivariate multiple regressions, corresponding analysis, multivariate mixture distribution, clustering, independent component analysis, and Bayesian multivariate regression and factor analysis.

COURSE OBJECTIVES:

Students will

1. understand all the features of multivariate multiple regression analysis;
2. learn all the features of multivariate mixture distributions;
3. improve their ability to perform clustering and data mining approaches;
4. learn how to apply Bayesian methods in regression and factor analyses;
5. understand to separate the mixing signals through independent component analysis.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	Describe the basic concepts and applications of multivariate regression analysis, corresponding analysis, multivariate mixture modelling, clustering and data mining.
CLO2	Apply Bayesian inference approach in multivariate regression and factor analyses.
CLO3	Apply independent component analysis for source separation.

Mapping CLOs with PLOs

CLOs	**Program Learning Outcomes (PLOs)**							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	2	2	2	3	3	2		2
CLO2	3	2	2	3	2	2		1
CLO3	3	2	2	3	1	1		

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Multivariate Regression Analysis:** Simple, multiple and multivariate multiple linear regression models. Assumptions. Parameter estimations and multivariate prediction. The distribution of likelihood ratio for the multivariate multiple regression model. Likelihood ratio test (LRT) including other multivariate test procedures. Relationship with canonical correlation analysis (CCA). Interpretation and conclusion.	Lecturing with multimedia tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Final examination	6
CLO1	**Correspondence Analysis:** Concept of correspondence analysis (CA). Algebraic development of correspondence analysis. Multiple correspondence analysis (MCA). Validation techniques in MCA. Similarities of CA and MCA with Categorical PCA and non-linear PCA. Application of CA for multiple factor analysis with contingency tables. Multiple factor analysis of mixed tables of metric and categorical data. Multi-block canonical correlation analysis for categorical variables. MCA and classification.			6
CLO1	**Multivariate Mixture Model:** Definition and properties of finite mixture model. Maximum likelihood (ML) fitting of finite mixture models via EM algorithm. Multivariate Normal Mixture models: definition, properties and ML estimation via EM algorithm. Multivariate t Mixture models: definition, properties and ML estimation via EM algorithm. Mixture of principal component analyzers and mixture of factor analyzers.			6
CLO2	**Clustering and Data Mining:** Classification, clustering and data mining. Some clustering methods: Fuzzy clustering, regression-wise clustering and clustering by finite mixture models. Data recovery models by averaging, linear regression, PCA, factor analysis and K-mean clustering.			6
CLO2	**Bayesian Fundamentals:** Statistical distributions (scalar, vector and matrix distributions). Prior distributions (vague, conjugate, generalized and correlation priors). Hyper-parameter Assessment (binomial, scalar normal, multivariate normal and matrix normal			5

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	likelihoods). Bayesian Estimation Methods (marginal posterior mean, maximum a posteriori).			
CLO2	**Bayesian Multivariate Regression**: Bayesian regression model, likelihood, conjugate priors and posterior, conjugate estimation and inference, generalized priors and posterior, generalized estimation and inference, interpretation and discussion.			6
CLO3	**Bayesian Factor Analysis:** Bayesian factor analysis model, likelihood, conjugate priors and posterior, conjugate estimation and inference, generalized priors and posterior, generalized estimation and inference, interpretation and discussion.			5
CLO3	**Introduction to ICA/BSS:** Independent component analysis (ICA) or blind source separation (BSS) model, PCA versus ICA. Estimation and inference, interpretation and discussion, Application.			5

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Greenacre, M. (2007). *Correspondence Analysis in Practice*, London: Chapman & Hall/CRC.
2. Johnson, R. A & Wichern, D. W. (2002). *Applied Multivariate Statistical Analysis*, Prentice-Hall, N.Y.

References:

1. Anderson, T.W. (1984). *An Introduction to Multivariate Statistical Analysis*, Wiley, N.Y.
2. Rowe, D. B. (2003). *Multivariate Bayesian Statistics*, Chapman & Hall /CRC.
3. Hyvarinen, A., Karhunen, J. & Oja, E. (2001). *Independent Component Analysis*, Wiley, N.Y.
4. Izenman, A.J. (2008). *Modern Multivariate Statistical Techniques: Regression, Classification and Manifold Learning*, Springer, N.Y.
5. Jajuga, K., Sokolowski, A. & Bock, H.-H. (2002). *Classification, Clustering and Data Analysis: Recent Advances and Application*s, Springer. N.Y.
6. Jolliffe, I. T. (2002). *Principal Component Analysis*, Springer, N.Y.
7. Kaufman, L. & Rousseeuw, P. J. (2005). *Finding Groups in Data: An Introduction to Cluster Analysis*, Wiley, N.Y.
8. McLachlan, G. & Peel, D. (2000). *Finite Mixture Models*, Wiley, N.Y.
9. Mirkin, B. (2005). *Clustering for Data Mining: A Data Recovery Approach*, Chapman & Hall, N.Y.

M.Stat. 504: Time Series Analysis and Forecasting

Course Code **:** M.Stat. 504
Course Title **:** Time Series Analysis and Forecasting
Course Type **:** Compulsory
Level/Term and Section: M.Sc. Final
Academic Session **:** 2023 - 2024
Course Instructor **:**
Pre-requisite (If any**)** **:**
Credit Value **:** 3
Total Marks **:** 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

The aim of this course is to get acquainted with important concepts of time series analysis and its applications on economic, financial, environmental, demographic, geological, astrophysical and policy variables. This course is heavily oriented towards the formulation of mathematical models for signal processing, forecasting and risk analysis and assessing interdependence of real-world data.

COURSE OBJECTIVES:

Students should know how to
1. solve difference equations of a system with time series operator;
2. model and forecast time series data properly;
3. analyze data and signals in frequency domain and compute spectral density;
4. model volatility of financial time series;
5. perform multivariate time series analysis and discover interdependence.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	apply statistical theory and methods of time series regression applicable to in economic business, environmental, geological and astrophysical problems
CLO2	explore trends of social and economic indicators
CLO3	estimate models for time-series data
CLO4	interpret the results of an implemented time series analysis
CLO5	aware of limitations and possible sources of errors in the analysis

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
CLO1	3	2	2	3	3	3	3	3
CLO2	3	2	2	2	2	2	2	3
CLO3	3	1	2	3	2	2	1	3
CLO4	3	2	2	2	3	2	2	3
CLO5	3	3	2	2	3	3	2	3

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Introduction:** Components of time series, Stationarity, Ergodicity, White noise, Autocorrelation function, Partial autocorrelation function, Difference equations and their solution, Basic ARMA models and their extension. Box-Jenkins modeling philosophy and forecasting	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Presentation and Final examination	10
CLO2	**Spectral Analysis:** Introduction, Fourier transformation. Periodogram, Spectral representation, Spectral density, Spectral densities for ARMA processes.			8
CLO3	**Non-stationary time series:** Trend stationary and difference stationary time series, Integrated process, Unit roots, Unit root tests, Structural changes and their consequences, Filtering, ARIMA, SARIMA, ARFIMA modeling.			9
CLO4	**Multivariate time series:** Structural, recursive and reduced form vector autoregressive (VAR) models, Granger causality, Impulse response functions, Forecast error variance decomposition. Spurious regression and cointegration, Tests for cointegration: Engle-Granger methodology and Johansen's methodology, Error correction models.			10
CLO5	**Time Series Model of heteroskedasticity:** Stylized facts of financial time series. Volatility clustering, Detection of autoregressive conditional heteroskedasticity (ARCH) effects, Modeling volatility, ARCH model, Extension of ARCH model: GARCH, TARCH, GJR-GARCH, FIGARCH, EGARCH, IGARCH, PARCH, NARCH models.			8

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Hamilton, J.D. (1994). *Time Series Analysis*, Princeton University Press, N.J.
2. Tsay, R. S. (2010). *Analysis of Financial Time Series*, Wily & Sons, N.J.

References:

1. Andersen, T. G. and A. R. Davis (2009). *Handbook of Financial Time Series*, Jens-Peter Kreifs and Thomas Mikosch edition, Springer-Verlag.
2. Anderson, T.W. (1971). *The Statistical Analysis of Time Series*, Wiley, N.Y
3. Box, G.E.P. and Jenkins, G.M. (1976). *Time Series Analysis: Forecasting and Control*, Holden-Day, Sun Francisco.
4. Cryer, J. D. and K. Chan (2008). *Time Series Analysis: with applications in R*, Spinger, N.Y.
5. Findley, D.F. (1981). *Applied Time Series*, Academic press, N.Y.
6. Lűtkepohl, H. (2005). *New Introduction to multiple Time Series Analysis*, Springer, N.Y.
7. Reinsel, G. C. (2003). *Elements of Multivariate Time Series Analysis*, Springer, N.Y.
8. Shumway, R. H. and D. S. Stoffer (2006). *Time Series analysis and its Applications with R Examples*.

M.Stat. 505: Data Mining and Machine Learning

Course Code : M.Stat. 505
Course Title : Data Mining and Machine Learning
Course Type : Compulsory
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any**)** :
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

Data relevant to managerial decisions is accumulating incredibly due to various technological advances. From this flood of digital data, we have to extract meaningful information and knowledge to develop business, government, and scientific communities. Data mining is a class of analytical techniques that examine a large amount of data to discover new and valuable information. Machine learning (ML) is a branch of artificial intelligence (AI) that focuses on developing systems to learn from and make decisions or predictions based on data. ML algorithms use statistical techniques to identify patterns in data and improve their performance over time. This course introduces the core concepts of data mining and ML algorithms.

COURSE OBJECTIVES:

Students will be able to

1. understand the basic concept of data mining;
2. explore categorical and numerical data and also apply proper techniques for preprocessing the data;
3. enlighten fundamental concepts and algorithms for supervised learning, unsupervised learning, and semi-supervised learning to provide the students with the necessary background for the application of data mining to real problems;
4. develop and apply critical thinking, problem-solving, and decision-making skills using ML algorithms.

COURSE LEARNING OUTCOMES (CLOs):

Upon successful completion of this course, a student will be able to

CLO1	Describe the definition of data mining and the data mining process.
CLO2	Apply different data pre-processing techniques.
CLO3	Understand several supervised and unsupervised machine learning algorithms.
CLO4	Apply and compare different classification methods.
CLO5	Understand the regularization of modeling techniques.

CLO6	Implement various statistical machine learning algorithms in real-world data mining applications.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	1	2	2	2	1	2	
CLO2	2	2	2	2	2	2	2	1
CLO3	2	1	3	3	2	3	2	2
CLO4	1	1	2	2	3	3	2	1
CLO5	2	1	2	2	2	3	3	2
CLO6	1	2	3	3	3	3	1	1

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Introduction:** Data mining, Need for human direction of data mining**,** Fallacies of data mining**,** Data mining tasks, Data mining process, Data preprocessing, Data cleaning, Handling missing data**,** Identifying misclassifications**,** Graphical methods for identifying outliers, Data transformation and numerical methods for identifying outliers.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Final examination	6
CLO2	**Exploratory Data Analysis:** Introduction, Hypothesis testing versus exploratory data analysis**,** Getting to know the data set, Dealing with correlated variables, Exploring categorical variables**,** Using EDA to uncover anomalous fields exploring numerical variables, Exploring multivariate relationships, Selecting interesting subsets of the data**,** Binning based on predictive value.			6
CLO2	**Association Rules:** Affinity analysis and market basket analysis, Data representation for market basket analysis, Support, Confidence, Frequent Item sets, the a Priori property, and algorithm, Information-theoretic approach.			4

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO3	**Introduction to Machine Learning:** Journey from statistics to machine learning (ML), Statistical learning and machine learning, How machine learn, Aspects of developing a learning system, Understanding data, Classification vs. Regression, Types of machine learning and their applications.			4
CLO3 CLO4 CLO6	**Supervised Learning:** Overview, Classification, Linear regression, Logistic regression, Linear discriminant analysis (LDA), Bayes' theorem for classification, Quadratic discriminant analysis (QDA), Decision tree, Random forests, Artificial Neural Network (ANeeN), K-nearest neighbors (KNN), Support Vector Machine (SVM), Naïve Bayes, Applications and comparison of classification and supervised learning methods.			7
CLO3 CLO5 CLO6	**Deep Learning:** Introduction to Deep Learning, Perceptron and Multilayer Perceptron (MLP), Feedforward Neural Networks, Backpropagation Algorithm, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs). Introduction to Frameworks: TensorFlow, PyTorch, Keras basics.			6
CLO3 CLO4 CLO6	**Unsupervised Learning and Clustering:** Techniques to reduce the dimension of data, principal components analysis, Clustering methods (K-Means, Fuzzy C-means, and Hierarchical clustering), and Practical issues in clustering.			5
CLO6	**Combining Multiple Learners:** Combine many learners, ways to achieve diversity, model combination schemes, ensemble learning, random forest, bagging, boosting.			3
CLO6	**Reinforcement Learning:** Introduction to reinforcement learning and basic characteristics. Application to automatic systems and robotics.			4

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Dasgupta, N. (2018). *Practical Big Data Analytics: Hands-on techniques to implement enterprise analytics and machine learning using Hadoop*, Spark, NoSQL and R. Packt Publishing.
2. Favero, L.P., Belfiore, P., Souza, R.D.F. (2023). *Data Science, Analytics and Machine Learning with R*, Elsevier Inc.
3. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013). *An Introduction to Statistical Learning: with Applications in R*. Springer.
4. Larose, D. T. and Larose, C. D. (2014). *Discovering Knowledge In Data: An Introduction to Data Mining*, Wiley Interscience, N.J., USA.
5. Matter, U. (2024). *Big Data Analytics: A Guide to Data Science Practitioners Making the Transition to Big Data*. CRC Press is an imprint of Taylor & Francis Gro.
6. Goodfelllow, I., Benjio, Y., Courville, A. (2017). *Deep Learning*. The MIT Press.

References:

1. Shalev-Shwartz, S. and Ben-David, S. (2014). *Understanding Machine Learning: From Theory to Algorithms*. Cambridge University press.
2. Bertrand Clarke · Ernest Fokou´e Hao Helen Zhang (2009). *Principles and Theory for Data Mining and Machine Learning*, Springer Science+Business Media, LLC, Dordrecht Heidelberg, Germany.
3. Hastie, T., Tibshirani, R. and Friedman, J. (2008). *The Elements of Statistical Learning: Data mining, Inference and Prediction*, Springer Series in Statistics.
4. Patricia B. Cerrito (2006*). Introduction to Data Mining Using SAS ® Enterprise Miner,* SAS Institute Inc., Cary, NC, USA.
5. Ripley, B. D. (2002*). Statistical Data Mining*, Springer-Verlag, New York.
6. Sumathi, S. and Sivanandam, S.N. (2006). *Introduction to Data Mining and its Applications*, Springer-Verlag, Berlin, Heidelberg.

M.Stat. 506: Advanced Bioinformatics

Course Code	**:** M.Stat. 506
Course Title	**:** Advanced Bioinformatics
Course Type	**:** Optional
Level/Term and Section	**:** M.Sc. Final
Academic Session	**:** 2023 - 2024
Course Instructor	**:**
Pre-requisite (If any**)**	**:**
Credit Value	**:** 3
Total Marks	**:** 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course gives a solid methodological background in bioinformatics which combined statistical, biological and computer sciences. It is designed to provide advanced knowledge on genomics and bioinformatics. Student gathers knowledge to apply advanced statistical algorithms for BIG molecular OMICS data analysis using computer programming and online/offline computer software. Topics will include statistical genomics, Transcriptomics, metagenomics and their online databases.

COURSE OBJECTIVES:

Student will able to

1. learn statistical modeling on genomics and its application;
2. apply statistical modeling on transcriptomics and its application;
3. employ statistical modeling on proteomics and its application;
4. develop statistical modeling on meta-genomics and its application;
5. evaluate statistical modeling on molecular docking for exploring genome-guided drugs.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	to analyze genomics data to detect biomarker genes and their function
CLO2	to analyze transcriptomics data to detect biomarker genes and their function
CLO3	to analyze proteomics data to develop PTM and PPI prediction models
CLO4	to analyze metagenomics data to detect diseases-causing microbial genes and their function
CLO5	to perform molecular docking for exploring genome-guided drugs

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	2	2	3	3	2	2	1	1
CLO2	2	2	3	3	3	3	1	1
CLO3	2	2	3	3	3	3	1	1
CLO4	2	2	3	3	3	3	1	1
CLO5	2	2	3	3	2	3	1	1

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**DNA/RNA/Protein Sequence Analysis**: Introduction to DNA/RNA/protein sequences. Multiple sequence alignment (MSA) and phylogenetic tree analysis. Sequence encoding approaches. Sequence based protein-protein interaction (PPI) and post-translational modification (PTM) analysis.	Lecturing with multi-media tools, Interactive brainstorming and Q/A **session**	Assignments, Class tests, Final examination	12
CLO2	**RNA-Seq Data Analysis:** Introduction to different types of RNA-Seq data including scRNA-Seq. Preprocessing approaches (Transformation, Normalization, and filtering). Identification of differential expressed genes (DEGs) in two or more groups. Identification of Key/Hub genes. Gene-set enrichment analysis. Gene regulatory networks (GRN) analysis. Clustering and Classification with RNA-Seq Data.			6
CLO3	**Genome-wide Association Studies (GWAS):** Introduction to SNP-data. Identification of important SNPs by using contingency table, ANOVA, linear mixed and fixed effect models, and meta-analysis approaches. Regional multi-locus association models. Linkage disequilibrium and tagging.			9

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO4	**Metagenomic Analysis**: Introduction to microbiome, Microbial sequence assembling, shotgun and amplicon sequencing, high-through sequencing, sequence filtering, diversity analysis, met transcriptomics.			9
CLO5	**Genome-Guided Drug/Vaccine Discovery**: Introduction to drug/vaccine targets/receptors and agents/ligands. Describe ADME for drug discovery. Identification of drug targets from genome. Explore candidate drugs based on molecular docking analysis between targets and ligands by using AutoDock-vina and/or other computer aided programs.			9

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Ben Hui Liu and Leming M Shi. (2013). *Statistical Genomics and Bioinformatics*, Chapman and Hall/CRC press, New York.
2. David W. Mount. (2004). *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press.

Recommended Books:

1. Xu, S. (2013). *Principles of statistical genomics*. Springer.
2. Liu, B. H. (1997). *Statistical genomics: linkage, mapping, and QTL analysis*. CRC press.
3. Eija Korpelainen, Finland Jarno, Panu Somervuo, Mikael Huss, Garry Wong (2015). *RNA-Seq Data Analysis: A Practical Approach.* CHAPMAN & HALL/CRC
4. Gondro, C., Van der Werf, J., & Hayes, B. J. (Eds.). (2013). *Genome-wide Association Studies and Genomic Prediction*. Humana Press.
5. Walter Filgueira de Azevedo Jr. (2019). *Docking Screens for Drug Discovery*. Methods in Molecular Biology ISBN 978-1-4939-9751-0 ISBN 978-1-4939-9752-7. Springer.

M.Stat. 507: Advanced Demography

Course Code	:	M.Stat. 507
Course Title	:	Advanced Demography
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	
Credit Point (CP)	:	3
Total Marks	:	75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

Firstly, observed the values of the demographic parameters using indirect techniques and secondly, take necessary future plan of action on the basis of the findings for the nation of country.

COURSE OBJECTIVES:

This course will develop the students' ability to

1. understand the concepts of single, double and multiple decrement life tables;
2. observed eliminating effect of specific disease on expectation of life;
3. estimate different parameters of vital events using indirect techniques in absence of direct information;
4. understand the concept of population growth models and their graduation;
5. understand the application of projection matrix for fertility and mortality;
6. understand the concept of fecundability, its distribution and effect the use of contraceptives.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	describe include public health;
CLO2	apply reproductive health;
CLO3	employ population policy, such as fertility, mortality, migration etc.;
CLO4	develop population policy using different projection methods.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	2	1	1	2	2	1	2
CLO2	2	3	3	2	1	1	2	2
CLO3	3	3	3	3	2	1	1	2
CLO4	1	2	3	2	2	2	2	1

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Life table analysis**: General idea, ordinary life table. Properties and interrelationships. Probability distributions of life table functions. Methods of construction of double and multiple decrement tables and increment decrement life tables. Joint life functions, Multi life functions. Last survivor status. General Multi life status.	Lecturing with multimedia projector, Interactive board and Q/A session	Assignment, class tests, presentation, final exam.	8
CLO2	**Demographic estimation**: Concept and applicability of the indirect techniques involve in the estimation of infant, child, adult and maternal mortality. Estimates of fertility. Estimation of migration. Dual record system. Chandra-Sekar and Deming Method. Coal's indices, Coale's nuptiality model. Davis-Blake framework of intermediate variables. Proximate determinants of fertility.			10
CLO2	**Stable population theory and models**: Concept of stationary, stable and quasi-stable population. Natural growth rate and intrinsic growth rate, Lotka's Intregal Equation, Net maternity function. Graduation of NMF by Normal, Wicksell and Hadwiger curve. Effects of change of birth and death rates on stable population. Study of some growth models - Exponential, Malthusian, Logistic and Quasi-stable models.			12
CLO3	**Population projection**: Development of Leslie projection matrix. Properties of Leslie matrix. Forward and backward operation of population projection. Stable vector, dominant root. Frejka's component method for population projection. Projection of fertility and mortality.			10
CLO4	**Fecundability**: Concepts of reproductivity, fecundity, fecundability and sterility. Effective fecundability. Residual fecundability. Estimation of fecundability. Pearl index. Effectiveness and efficiency of FP methods.			5

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Pollard, J.H. (1980). *Mathematical models for the growth of human populations*.
2. Keyfitz, N. (1977). *Applied Mathematical Demography*, Wiley & Sons.

References:

1. Biswas, S. (1988). *Stochastic Processes in Demography and Applications*. Wiley Eastern Ltd., India
2. Johnson RCE & Johnson (1980). *Survival Models and Data Analysis*, Wiley NL & Sons, NY.
3. Islam, N. (1996). *Levels and Correlates of Marriage and Fertility in Bangladesh*. Unpublished Ph.D desperation, R.U.
4. Shryock, H. J. S. Siegel and Associates (1976). *The Methods and Materials of Demography*; New York, Academic Press.
5. UNFPA (1993). *Population Research Methodology*, Vols. 1-8. Chicago, Illinois, and other UNFPA publications.
6. UNO (1983). *Indirect Technique Demographic Estimation*, Population Studies No. 81.

M.Stat. 508: Environmental Statistics

Course Code	:	M.Stat. 508
Course Title	:	Environmental Statistics
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	
Credit Point (CP)	:	3
Total Marks	:	75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

The aim of this course is a broad discipline stretching from how and what to sample, through to modeling impacts on human and ecosystem health and ultimately to providing predictions of what changes might occur in the future. Addressing the problems often involves quantitative aspects; in particular, the acquisition and analysis of environmental data. Treating these quantitative problems effectively involves the use of statistics. The course is about how to extract information from data and how informative data are generated in the first place.

COURSE OBJECTIVES:

This course will develop the students' ability to

1. introduce basic concepts useful for environmental data analysis;
2. become aware of a wide range of applications of statistics in environmental management & decision making;
3. develop technical skills to use statistical tools and software in environmental data analysis.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	develop an intuitive statistical sense for inferring meaning out of data collected from different environmental matrices;
CLO2	implement statistics for environmental monitoring and sampling;
CLO3	critically analyze environmental evidence;
CLO4	analyze, model and quantify uncertainty and variability in environmental data;
CLO5	extract information and draw scientific inference from large amount of data collected to solve environmental problems;
CLO6	apply statistical tools and software to analyze environmental data.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	1		2	1		2	3
CLO2	2	3		1	1	2	2	2
CLO3	3	2	1	1	1	1	2	3
CLO4	2			1	1	2	1	
CLO5		2	1	3	3	3	2	1
CLO6	3	2	1	1			1	1

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Introduction**: Environmental Variables – Discrete and continuous; Data collection – primary and secondary; Presentation of data – spatial and non-spatial data. **Design and Analysis of Environmental Data:** Conceptual Foundations Methods, Environmental data, Data Exploration, screening and adjustment, Confidence Intervals and More, Deterministic functions, Bestiary of probability distributions, Continuous probability distributions, Discrete probability distributions, Statistical Models-putting it all together, Frameworks for statistical Inference, Bayesian Inference, Hypothesis testing concepts, Nonparametric Inference: Ordinary least squares and more, Maximum Likelihood inference.	Lecturing with multimedia projector, Interactive board and Q/A session	Assignment, class tests, presentation, final exam.	14
CLO2 & CLO3	**Hazard in the environment:** Concept of risk, vulnerability, hazard, and disaster; Types of Natural Hazards and their Global and National perspectives, Role of Global climatic changes and Global warming. Causes and consequences of Global Warming, Sea level rise in climate. **Study of Agro-meteorological Features:** Fundamentals Concept of Meteorology and Climatology. Desertification, Drought and Flood management and Modeling Analysis:			14

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	Flood hazard and its management: Definition, Causes, nature, frequency of flooding and its impacts. Desertification and Drought – Causes of desertification; Evaluation of desertification hazard – potential and zoning: Drought – causes, types, distribution and management.			
CLO4 & CLO5	**Food Security and Environmental Impact on Health and Agriculture:** Pollution and Soil degradation, Deforestation, Land use pattern and regional pattern of productivity. Case Study of Environmental Data Analysis: 1.Applications of probability distributions and Markov chain model, 2.Drought Identification and Characterization at Local, National and Global level, 3.Drought indices by Standardized Precipitation Index (SPI), 4.Drought Prediction Using Markov chains modeling, 5. Applications of non-linear and non-stochastic Time series analysis, Wavelets analysis, Spectral analysis			12
CLO6	**Geographical Information System (GIS):** Basic principles, Raster and vector data, Map Projection, Overlay analysis, Data structure and Digital cartography. Global Positioning System (GPS): Basic principles, Applications to environmental studies.			5

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Ott, W. R. (2018). *Environmental statistics and data analysis*. Routledge.
2. Shamsuddin, S. D., Ahmed, R., & Jahan, R. (2015). *Climate Variability: Issues and perspectives for Bangladesh*. Sahitya Prokash, Dhaka, Bangladesh.

References

1. Al-Karkhi, A. F., & Alqaraghuli, W. A. (2019). *Applied statistics for environmental science with R*. Elsevier.

2. Islam, T., Srivastava, P. K., Gupta, M., Zhu, X., & Mukherjee, S. (2014). *Computational intelligence techniques in earth and environmental sciences*. Springer Netherlands.
3. Barnett, V. (2005). *Environmental statistics: methods and applications*. John Wiley & Sons.
4. Isaacson, D. L., & Madsen, R. W. (1985). *Markov chains- theory and applications*. Robert E. Krieger Publishing Company, INC., Malabar, FL(USA), 1985, 270.
5. Wikle, C. K. (2006). *Environmental Statistics: Methods and Applications*.
6. Sericola, B. (2013). *Markov chains: theory and applications*. John Wiley & Sons.
7. Byers, H. R. (1944). *General meteorology*. McGraw-Hill
8. Willett, H. C., & Sanders, F. (2013). *Descriptive meteorology*. Elsevier.
9. Patil, G. P. (1991). *Encountered data, statistical ecology, environmental statistics, and weighted distribution methods*. Environmetrics, 2(4), 377-423.
10. Manly, B. F. (2008). *Statistics for environmental science and management*. Chapman and Hall/CRC.
11. Stocker, T. (2011*). Introduction to climate modelling*. Springer Science & Business Media.
12. Botterill, L. C., & Cockfield, G. (2013). *Drought, Risk Management, and Policy: Decision-Making Under Uncertainty*. CRC Press.
13. Grover, V. I. (2012). *Impact of climate change on water and health*. CRC Press.
14. Ott, W. R. (1978). *Environmental indices: theory and practice*.

M.Stat. 509: Advanced Actuarial Statistics

Course Code : M.Stat. 509
Course Title : Advanced Actuarial Statistics
Course Type : Optional
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any**)** :
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

A general term for the data used by actuaries in evaluating the risks of morbidity and mortality in particular groups, and projecting future financial liabilities of insurance policies and pensions. The strength of Actuarial Statistics is the emphasis on understanding statistical concepts and methods, and their practical application to actuarial problems. In designing such new course will enhance Actuarial Science for the students through development of transferable skills and enhanced employability. The aim of Actuarial Statistics is to provide grounding in mathematical and statistical methods that are of relevance for actuarial work. This course includes both theory and application of the ideas about stochastic process, death process, survival models etc. using different software.

COURSE OBJECTIVES:

1. The core aim of Actuarial Statistics is to provide grounding in mathematical and statistical methods that are of relevance for actuarial work
2. The learners in such course may efficiently apply mathematical and statistical methods to assess risk in insurance, finance and other industries and professions
3. Actuaries apply rigorous mathematics to model matters of uncertainty
4. Actuarial Statistics is the profession concerned with the application of mathematical, statistical, probabilistic, and financial theories to solve real business problems. These problems involve analyzing future financial events, especially where future payments involved have certain or uncertain timing.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	describe and use statistical distribution for modeling;
CLO2	describe and apply the main concepts underlying the analysis of time series models;
CLO3	understand and apply Markov chains and processes;
CLO4	know and apply techniques of survival analysis;
CLO5	assess the suitability of actuarial, financial and economic models in solving actuarial problems.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
CLO1	3	2	2	1	1	1	2	2
CLO2	2	3	3	2	1	1	1	1
CLO3	3	3	3	2	2	1	2	2
CLO4	1	2	3	3	2	2	2	1
CLO5	3	2	1	2	3	2	2	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Insurance:** Nature and functions of insurance; Benefits and costs of insurance system to the society; Economic theories of insurance; The mathematical basis for insurance; Insurable interest; Principle of indemnity; Doctrine of subrogation; Warranties; Proximate causes; assignment of transfer of interest; Return to premium.	Lectures will be delivered with multi-media accessories, Interactive brainstorming and Q/A session	Assignments, Class tests, Tutorial, Final examination	6
CLO2	**Life Insurance:** Essential features of life insurance contract; Risk selection for life insurance; Sources of risk information; Classification on annuities.			5
CLO3	**Health Insurance:** Types of health insurance coverage; Exclusion in health insurance policies; Payment of claim; Fire insurance, Marine insurance and other insurance: Concepts, features, policies and coverage; Payment of claim.			5
CLO3	**Risk Management:** Loss, peril, hazard and risk; Types of risk; Development and implementation of risk management programs; Methods of dealing with risk; Personal risk management; The economics of insurance, utility theory; Application of probability to problems of life and death, the determination of single premiums for insurances and annuities in both the discrete and continuous case; Theory and practice of pension			14

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	funding, assumptions; Basic actuarial functions and population theory applied to private pensions. Survival distributions and life tables; Life insurance, life annuities; Net premium, premium series, multiple life functions, multiple decrement models; Valuation theory for pension plans, the expense function and dividends.			
CLO4	**Measurement of Risk and Mortality Table:** Mortality tables and its classifications; Construction of mortality tables; Premium calculation of various life policies.			5
CLO5	**Exposure formulas:** assumed and using implications, techniques of calculating exposures from individual records including consideration involving selection of studies, various observation periods and various methods of tabulating deaths; Techniques of calculating exposures from various schedules including the general concepts of fiscal year; The use of interim schedules and variations in observation period or method of grouping deaths and practical aspects of construction of actuarial tables.			10

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Dorfman, M. S. (1998). *Introduction to risk management and insurance*. Prentice Hall.
2. Mishra, M. N., & Mishra, S. B. (2011). *Insurance Principles and Practice*. S. Chand Publishing.

References:

1. Hafeman, M. (2009). *The Role of the Actuary in Insurance. Primer series on insurance*, (4).
2. Gupta, P. K. (2011). *Insurance and risk management*. Himalayan Books.
3. Finney, H. A. (1920). *Introduction to actuarial science*.
4. Outreville, J. F. (1998). *Theory and practice of insurance*. Springer Science & Business Media.
5. Gray, R. J., & Pitts, S. M. (2012). *Risk modelling in general insurance: From principles to practice*. Cambridge University Press.
6. Ohlsson, E., & Johansson, B. (2010). *Non-life insurance pricing with generalized linear models*. Berlin: Springer.
7. Asmussen, S., & Steffensen, M. (2020). *Risk and insurance*. Springer International Publishing.
8. Rejda, G. E. (2011). *Principles of risk management and insurance*. Pearson Education India.
9. Vaughan, E. J., & Vaughan, T. (2007). *Fundamentals of risk and insurance*. John Wiley & Sons.
10. Glen, N. (2016). *Actuarial science*. J. Smith & son.
11. Charpentier, A. (Ed.). (2014). *Computational actuarial science with R*. CRC press.

M.Stat. 510: Biomedical Informatics

Course Code : M.Stat. 510
Course Title : Biomedical Informatics
Course Type : Optional
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any**)** : B. Stat. 410
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

The course describes the necessary knowledge and skills to critique, design and conduct human population based research, including observational studies and randomized controlled trials. More specifically, this course provides advanced knowledge of statistical analysis for epidemiological data, study design and protocol development.

COURSE OBJECTIVES:

Students will be able to

1. understand the epidemiology and public health
2. to list the functions of public health
3. outline the process of population-based health management
4. demonstrate different public health programs
5. develop the study design, sample size determination, sampling procedure, and data analysis for health science and epidemiology.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	define health and epidemiology and its related terms
CLO2	explains population based perspective to examine disease and health-related events
CLO3	compare different types of mathematical models to apply health and epidemiology data
CLO4	analyze health and epidemiology data
CLO5	evaluate the design, analysis and interpretation of health science and epidemiological studies

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
CLO1	2	2		3		3	3	2
CLO2	1	2		2		2	2	2
CLO3	2	1		3		2	1	2
CLO4	3	2		2		2	2	2
CLO5	2	3	2	2		3	2	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	Introduction to bioinformatics, Cell Structure and Function, Cell components. Chromosome, Chromosome structure and organization. DNA, RNA, Gene and Central dogma and bioinformatics. Introduction to Bioinformatics. Importance/scope/ Applications of Bioinformatics. DNA sequencing, Shotgun sequencing, Long repeats, r-scane.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Presentation, and Final examination	8
CLO2	Protein Sequencing and Amino Acids, Amino acids and Amino Acids structure and functions. Codons. Metabolic and Biochemical pathway analysis e.g. E.coli. pathways. Sequence alignment, Overview of methods of sequence alignment. Dynamic programming algorithm for sequence alignment, Multiple Sequence alignments, statistical methods for aiding alignment.			8
CLO3	Overview of the use and maintenance of different databases in common use in biology. Databases: GenBank, DDBJ, EMBL NCBI, EBI, UniGene, UniProt, KEGG, Swiss-Prot, and PDB. BLAST and FASTA analysis. Phylogenetics, Methods of Phylogenetic Analysis. Protein Classification, Structure and Prediction, Protein Structure Prediction, Methods for predicting the secondary and tertiary structure of proteins. Techniques: neural networks, SVMs, genetic algorithms and stochastic global optimization.			8
CLO4	Drug Discovery Informatics, Metabolome and Metabolomics. Systems biology, Approaches to drug and vaccine design using bioinformatics tools, Molecular docking using Autodock and/or other computer aided programs.			8
CLO4	Introduction to Biomedical Informatics, Perspectives and goals of Medical Informatics, History, Taxonomy and standards of Medical Informatics, Organization			7

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	of Medicine and Health Information, Paper-based Medical Report and Electronic Medical Report (EMR), PHR, Probability Assessment, Sensitivity, Specificity, Measures of test performance, Pervasive Healthcare, Telemedicine.			
CLO5	Scope and applications of Network analysis in Biomedical informatics. Bayesian Network (BN) Analysis and application, Artificial Neural Network (ANN) Analysis and application. Other relevant network. Disease Surveillance, Disease prediction models. Survival analysis. Risk classifications. CAPRA and D'Amico risk classifications. Nomogram development for disease prediction.			6

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Shortliffe, E. H., Shortliffe, E. H., Cimino, J. J., & Cimino, J. J. (2014). *Biomedical informatics: computer applications in health care and biomedicine*. Springer.
2. Husmeier, D., Dybowski, R., & Roberts, S. (2006). *Probabilistic modeling in bioinformatics and medical informatics*. Springer Science & Business Media.

References:

1. Gentleman, R., Carey, V. J., Huber, W., Irizarry, R. A., & Dudoit, S. (2005). *Bioinformatics and computational biology solutions using R and Bioconductor*. New York: Springer.
2. Ewens, W. J., & Grant, G. R. (2005). *Statistical methods in bioinformatics: an introduction*. New York: Springer.
3. Neapolitan, R. E. (2009). *Probabilistic methods for bioinformatics: with an introduction to Bayesian networks*. Morgan Kaufmann.
4. Chiang, M. F. (2021). *Biomedical Informatics: Computer Applications in Health Care and Biomedicine*. Springer Nature.
5. Pevsner, J. (2015). *Bioinformatics and functional genomics*. John Wiley & Sons.

M.Stat. 511: Health and Epidemiology

Course Code : M.Stat. 511
Course Title : Health and Epidemiology
Course Type : Optional
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any) **:** B. Stat.-401, B. Stat.-402, B. Stat.-403 and B. Stat.-407
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

The course describes the necessary knowledge and skills to critique, design and conduct human population based research, including observational studies and randomized controlled trials. More specifically, this course provides advanced knowledge of statistical analysis for epidemiological data, study design and protocol development.

COURSE OBJECTIVES:

Students will be able to

1. understand the epidemiology and public health;
2. list the functions of public health;
3. outline the process of population-based health management;
4. demonstrate different public health programs;
5. develop the study design, sample size determination, sampling procedure, and data analysis for health science and epidemiology.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	evaluate the design, analysis and interpretation of health science and epidemiological studies;
CLO2	describe and discuss the role and contribution of epidemiology to health;
CLO3	select, devise and develop appropriate study designs for health science and epidemiological research;
CLO4	Conduct appropriate statistical analyses for health and epidemiological data.

Mapping CLOs with PLOs

CLOs	**Program Learning Outcomes (PLOs)**							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	2	2	1	1	1	2	1
CLO2	2	3	3	2	1	2	2	2
CLO3	1	3	3	2	1	3	2	1
CLO4	3	2	2	2	1	1	1	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Introduction:** Some examples of health study; Selection of health problem for research; Framing different type of study design: prospective study, retrospective study, longitudinal study, experimental study, observational study, intervention study, single blind study, double blind study; Selection of study population and cases for the study; causal variables, confounder variables; Ethical issue related to health study.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Final examination	10
CLO2	**Measuring Health and Disease:** Sources of health statistics. Meaning and Concept. Biological variations. Health indicators classification. Morbidity concepts and measures. Illness, diseases and their classifications. Multiple causation of diseases The conquest and resurgence of infectious diseases. The biomedical basis of chronic diseases. Measuring diseases frequency and errors in measurement. Mortality. Nutrition in Bangladesh; special emphasis on infant and child nutrition.			09
CLO2	**Statistics in Epidemiology:** Categorical response data in epidemiology and diagnosis-prognosis; OR, RR, NNT, PPR, NPR, sensitivity, specificity, true positive rate, true negative rate; ROC analysis; power, precision, sample size calculation.			06
CLO3	**Statistical Models in Epidemiology:** Data Analysis and interpretation using statistical models. Linear regression model; log linear models, building and applying log linear models, log linear and logit models for ordinal variables; multinomial response models. Models for mixed health hazards; multilevel sources of variation. Analysis of repeated epidemiological outcomes. Parametric and semiparametric models for complete and incomplete data in epidemiology, Cox proportional hazards model.			10
CLO4	**Mathematical Models in Epidemiology:** Basic Concepts, SI Model Formulation, Solution and Interpretation, SIS Model with Constant Coefficient Formulation, Solution and Interpretation, SIS Model with Constant			10

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	Coefficient is a function of time t, SIS Model with Constant Number of Carriers Formulation, SIS Model When the Carrier is a Function of Time t, General Deterministic Model with Removal (SIR Model) Formulation, Solution of Model Equation Interpretation, Epidemic Model with Vaccination Solution of Model Equation			

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Bonita R, Beaglehohe R and Kjellstrom T (2006): *Basic Epidemiology*.
2. Bonita, R., Beaglehole, R., & Kjellström, T. (2006). *Basic epidemiology*. World Health Organization.

References:

1. Armitage, P (1971). *Statistical Methods in Medical Research*. Blackwell, NY.
2. Klien JP and Moeschberger, ML (2003): *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.
3. Josepn L. Fleiss (1973): *Statistical Methods for Rates and Proportions*. Wiley, NY.
4. Lawless, JF (1982). *Statistical Models and Methods for Lifetime Data*. Wiley.
5. Schoenbach VJ and Rosamond WD (2000): *Understanding the Fundamentals of Epidemiology*, an evolving text.
6. Singh,B and Agarwal, N(2005), *Bio-Mathematics*, First Edition, Krishna Prokashan Media (p) Ltd., Meerat, India.
7. Spiegelman, M. (1968): *Introduction to Demography*, North Holland.

M.Stat. 512: Statistical Methods in Industrial Management

Course Code : M.Stat. 512
Course Title : Statistical Methods in Industrial Management
Course Type : Optional
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any**)** :
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course prepares students to take on management responsibility in the middle management in private industry, the service sector or public administration. It provides a background in the principles, objectives, decision making, and method of reducing accidents, industrial psychology, quality control, inspection, supply chain management and network analysis.

COURSE OBJECTIVES:

1. To know the develop a strong training business management experts, engineering, and providing theoretical instruction with an extensively;
2. To understands the management, quality, job analysis, job evaluation and factors effecting productivity;
3. To develop concept the quality certification, Deming philosophy, project management and project life cycle.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	management functions, drive the industrial organization chart and factors of production;
CLO2	preventive maintenance and repairable system;
CLO3	perform the reliability centered maintenance and inventory;
CLO4	derive the network techniques, planning, scheduling with Gantt charts.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
CLO1	3	2	1	1	1	2	2	1
CLO2	2	3	3	2	1	2	1	2
CLO3	3	2	3	2	2	1	1	2
CLO4	3	1	1	2	2	2	1	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLO	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Industrial management:** Meaning, Principles, Characteristics and importance. Management by objectives. Advantages and disadvantages of management by objectives. Industrial organization chart. Decision making techniques. Industrial accidents and safety. Causes of accidents. Methods of reducing accidents. Job analysis and evaluation. Methods of job analysis and evaluation. Production and productivity. Factors of production. Tools of productivity. Factors affecting productivity.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Final examination	12
CLO2	**Industrial Psychology:** Quality, Scope and Aims of industrial psychology, Problem of industrial psychology, Pattern of human behavior, Human needs, Difficulties and suggestion for improvement of human and social relationships.			5
CLO3	**Quality control and inspection:** Objectives of quality control. Quality conformance. Quality principles. Advantages of quality control. Quality certification, Objectives of inspection. Various kinds of inspection. Advantages and disadvantages of inspection. Quality philosophies. Deming philosophy. Tools and techniques. Total quality management (TQM). Implementation of TQM, Philosophies of TQM. Pareto analysis, Cause-and-effect-diagrams. Failure modes and effect analysis (FMEA).			10
CLO3	**Corrective maintenance (CM) and preventive maintenance (PM):** Preventive maintenance models for complex systems. Maintenance of repairable systems. Models for complex repairable systems. Parameter estimation. Model selection. Preventive maintenance scheduling. Reliability centered maintenance (RCM). Steps of the RCM process. Inventory. Managing and controlling inventory. Forecasting for inventory management of service parts. Supply-chain management. Case studies in industrial management and maintenance.			10

CLO	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO4	**Network Analysis:** Network Techniques. Project Management, Key decisions in project management, Project life cycles, planning and scheduling with Gantt Charts, PERT and CPM strategies, Steps in PERT and CPM project Plan. Deterministic time estimate, Probabilistic time estimate.			8

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Mukhi, H. R. (2001). *Industrial Management*, Satya Prakashan, New Delhi.
2. William J. Stevenson (2005*). Operation Management*, McGraw Hill Company, N.Y.

Books Recommended:

1. Davis Aquilano and Chase (2004). *Fundamentals of operation Management*, McGraw Hill Company, N.Y.
2. Küpper, A. (2005). *Location-based services: fundamentals and operation*. John Wiley & Sons.
3. Hill, T. (2000). *Operations Management: Strategic, Context and Managerial Analysis*, University of Oxford.
4. Anderson, D. R., Sweeney, D. J., Williams, T. A., Camm, J. D., & Cochran, J. J. (2018). *An introduction to management science: quantitative approach*. Cengage learning.
5. Hiller and Hiller (2005). *Introduction to Management Science*, McGraw Hill Company, N.Y.
6. Kelly A. and Harris, M.J. (1978). *Management of Industrial Maintenance*, Butterworth Heinemann Ltd.
7. Kobbacy, K.A.H and Murthy, D.N.P. (2008). *Complex System Maintenance Handbook*, Springer-Verlag.
8. Zipkin (2005). *Fundamental of inventory Management*, McGraw Hill Company, N.Y.

M.Stat. 513: Statistical Methods for Reliability Data

Course Code	:	M.Stat. 513
Course Title	:	Statistical Methods for Reliability Data
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	
Credit Point (CP)	:	3
Total Marks	:	75 (Examination 60, Tutorial 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

The aim of this course is to provide an analytical introduction to the core concepts of reliability and maintenance with emphasis on more advanced topics in statistical methods for reliability data and analysis of field reliability data, accelerated failure time data, degradation data, prediction reliability and software reliability modeling.

COURSE OBJECTIVES:

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

1. understand a general and advanced strategies that can be used for data analysis, modeling, and inference from reliability data;
2. critically analyze field-failure data, repairable system and recurrence data;
3. develop the capacity of modelling accelerating life tests data, degradation data;
4. comprehend maintenance and software reliability;
5. analyze field reliability data.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	describe basic terminology of reliability, reasons for collecting reliability data;
CLO2	explain system reliability modeling, the distribution of system failure time as a function of individual component failure-time distributions;
CLO3	describe typical data from repairable systems and analyze recurrence data using parametric and nonparametric graphical methods jointly;
CLO4	differentiate field reliability data and apply suitable method for analysis;
CLO5	present accelerated life test data by nonparametric and graphical methods;
CLO6	judge reliability data of different sources and go insight of the reliability data;
CLO7	formulate software reliability data.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	2	2	3	2	3	2	3
CLO2	2	2	2	1	1	3	1	2
CLO3	3	3	3	2	2	1	1	2
CLO4	3	3	3	3	2	2	2	2
CLO5	3	3	3	3	2	2	1	2
CLO6	3	2	2	2	3	1	1	2
CLO7	3	2	2	2	3	2	2	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Reliability concepts:** Basic concept of reliability. Examples and features of reliability data. Strategy for collection, modeling, and analysis of reliability data. Models for continuous failure-time processes. Models for discrete data from a continuous process.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignment, class tests, presentation, final exam.	3
CLO2	**Component and system reliability concepts and methods:** Location-scale-based distributions - concept and applications in reliability. Probability plots. Reliability block diagram, component reliability, system reliability, reliability of series and parallel systems. Failure mode. Competing risk model. Mixture model.			4
CLO3	**Analysis of repairable system and recurrence data:** Intensity function, mean cumulative function, tests for recurrence rate trend. Models for perfect repair, minimal repair and imperfect repair – derivation and estimation.			4

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO4	**Accelerated failure time models:** Accelerating variables, life-stress relationships and acceleration models. Guideline for the use of accelerating models. Non-parametric and graphical methods for presenting and analyzing accelerated life test (ALT) data. Likelihood methods for analyzing censored data from an ALT. Suggestions for drawing conclusions from ALT data. Potential pitfalls of accelerated life testing.			4
CLO4	**Degradation data, models, and data analysis:** Degradation data. Models for degradation data. Estimation of model parameters. Comparison with traditional failure-time analysis. Approximate degradation analysis.			5
CLO4	**Failure time regression models:** Models fitting and applications in reliability.			5
CLO5	**Software reliability modeling:** Concept of software reliability. Software reliability modeling and estimation. Software testing procedures. Prediction and management of software reliability.			6
CLO6	**Prediction of reliability:** Motivation and prediction problems. Naive method for computing a prediction interval. Prediction of future failures from a single group of units and from multiple groups of units with staggered entry into the field.			6
CLO6	**Maintenance:** Maintenance, preventive and corrective maintenance, optimum preventive maintenance – concept and applications.			4
CLO7	**Case studies:** Analysis of field reliability data.			4

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Karim, M. R. and Islam, A. (2019). *Reliability and Survival Analysis*, Springer, Singapore.
2. Meeker, W. Q., Escobar, L. A., & Pascual, F. G. (2022). *Statistical methods for reliability data*. John Wiley & Sons.

References:

1. Nelson, W. B. (2009). *Accelerated testing: statistical models, test plans, and data analysis*. John Wiley & Sons.

2. Balakrishnan, N. and Rao, C. R. (2001). *Handbook of Statistics*. Advances in Reliability, Elsevier, The Netherlands.
3. Blischke, W. R., Karim, M. R., & Murthy, D. P. (2011). *Warranty data collection and analysis*. London: Springer.
4. Blischke, W. R. and Murthy, D. N. P. (2000). *Reliability*. Wiley, New York.
5. Hamada, M. S., Alyson G. Wilson, C. Shane Reese and Harry F. Martz (2008). *Bayesian Reliability*, Springer-Verlag.
6. Lawless, J. F. (2011). *Statistical models and methods for lifetime data*. John Wiley & Sons.
7. Deshpande, J. V., & Purohit, S. G. (2015). *Lifetime Data: Statistical Models and Methods*. World Scientific Publishing Company.
8. Kececioglu, D. (2002). *Reliability and life testing handbook*. DEStech Publications, Inc.
9. Bain, L. J., & Engelhardt, M. (2017). *Statistical analysis of reliability and life-testing models: theory and methods*. Routledge.
10. Sinha, S. K. (1986). *Reliability and Life Testing*, Wiley Eastern Ltd., India.
11. Pham, H. (2003). *Handbook of reliability engineering*. H. Pham (Ed.). London: Springer.
12. Tobias, P. A., & Trindade, D. (2011). *Applied reliability*. CRC Press.

M.Stat. 514: Physical Health and Human Growth Modeling

Course Code	:	M.Stat. 514
Course Title	:	Physical Health and Human Growth Modeling
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	B. Stat.-103, 202 & 303
Credit Point (CP)	:	3
Total Marks	:	75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course is designed to cover out the in depth knowledge on human growth process, body composition, body shape and size, different types of growth maturations, analysis of growth events, lung capacity, lung related other variables, pre-caution of growth failure, heart failure and its causes, finding risk factor of heart failure, different parametric and non-parametric growth model and higher dimensional growth model to understand and predict biological variables and adult stature.

COURSE OBJECTIVES:

Students would be able to

1. understand all the features of human growth, and morphometric;
2. apply longitudinal data to fit human growth model in two or higher dimensions; and
3. understand the diseases and disorder of growth process.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	Describe Morphometry and its measurement, the status of child growth.
CLO2	Explain the growth failure, growth maturations, status of Lung and Heart, different growth indices.
CLO3	Calculate physical strength, Lung capacity, Risk of Heart Failure, Biological parameters and growth charts for the medical Practitioners, etc.
CLO4	Analyze Morphometric Data, Different non-linear Growth models, Higher Dimensional growth model, Growth and Maturation of the Children.
CLO5	Evaluate Lung Status, Sign and Symptom of Heart failure, Growth failure, Growth model.
CLO6	Develop standard Biological Parameters for the Nation, create non-linear models for assessing physical Health and Human Growth.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
CLO1	3					3	3	
CLO2	3					3	3	3
CLO3	3	3				3	3	3
CLO4		3			3	3	3	3
CLO5		3			3	3	3	3
CLO6			3	3	3	3	3	3

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Morphometry:** Basic concepts, stature, weight, BMI, vital capacity, strength, sitting-height, chest circumference, Bouchard's index. Livi's weight-height index. Body Mass Index (BMI), Rohrer's body build index, index of morphological equilibrium. Grid method and auxogram. Manouverier's indexes of body build. Cormic index. Pirguet's index of body build, Demeny's vital index, Speh's index, Bruugsch's chest-stature index, Pignet's coefficient of robusticity, **Craniometry and Osteometry**: Planes of orientation, cranial landmarks, craniometric indices and cranial capacity. Osteometry, index of the body, foramen and Baudoin's sexual index vertebral index and Cunningham's index. Measurement of sacrum and long bones. Elliptical Fourier Analysis.	Lecturing with multimedia projector, Interactive board and Q/A session	Assignment, class tests, presentation, final exam.	12
CLO2 & CLO3	**Growth and Maturation**: Basic concepts, stages in child growth, early childhood, mid-childhood, late childhood, adolescence, prenatal and postnatal growth, Skeletal maturation, sexual maturation, age at menarche, body composition and nutritional status, sequence of adolescent events.			10
CLO4 & COL5	**Lung Capacity:** Introduction, Vital Capacity and its measurement, Tidal Volume, Inspiratory Vital Capacity, Expiratory Vital Capacity, Total Lung Capacity, Forced Expiratory Vital Capacity, Forced Expiratory Volume, and their relationship			12

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	Growth Failure: Introduction, synonyms and keywords, Symptoms, Causes, Exam and test, Treatment. **Heart Failure:** Concept, Relation between Heart Rate and Age, Classes of Heart Failure, Warning sign of Heart Failure, Risk of Heart Failure, Symptom & Diagnosis, Prevention & Treatment, Advanced Heart Failure,			
CLO6	**Growth Model**: Biological variables and its secular trends, Algometry Model, the Gompertz and logistic growth models, Jenss model, Count model, double logistic model, PB models, ICP model, Reed models, SSC model, JPPS model, JPA-1 and JPA-2 models, modified ICP model, BTT model and Kernel's (non-parametric) model, Wavelet model, polynomial model, growth variations due to genetics and nutrition. Twin growth, heritability of growth. **Higher Dimensional Growth Model**: Extension of BTT model, Extension of other growth models.			11

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Roche, A. F. (1992). *Growth, maturation, and body composition: the Fels Longitudinal Study* 1929-1991. Cambridge University Press.
2. Bock, R. D. (2003). *AUXAL: Auxological analysis of longitudinal measurements of human stature*. Scientific Software International.

References:

1. Abu Shahin Md, Md, A. A., & Shawkat Ali, A. B. M. (2013). *An Extension of Generalized Triphasic Logistic Human Growth Model*. J Biomet Biostat, 4(162), 2.
2. Carter, J. L., Carter, J. L., & Heath, B. H. (1990). *Somatotyping: development and applications*. Cambridge university press.
3. Bogin, B. (2020). *Patterns of human growth*. Cambridge University Press.
4. Falkner, F. and Tanner J.M. (1978). *Human Growth*, Neurobiology and Nutrition, Plenum Press, New York.
5. Johnston, F. E. (Ed.). (2013). *Human physical growth and Maturation: Methodologies and factors*. Springer Science & Business Media.

M.Stat. 515: Advanced Stochastic Modeling

Course Code : M.Stat. 515
Course Title : Advanced Stochastic Modeling
Course Type : Optional
Level/Term and Section: M.Sc. Final
Academic Session : 2023 - 2024
Course Instructor :
Pre-requisite (If any) : B. Stat.-305
Credit Value : 3
Total Marks : 75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

The course is designed on advanced probability to cater to the needs of students and to the non-specialists. It would be suitable for research level courses in statistics. Uncertainties arises in several ways in different aspects of growth processes and also due to the involvement of unpredictable human behavior, a brief description of stochastic processes and stochastic differential equation in terms of which different models have been incorporated.

COURSE OBJECTIVES:

Students will able to

1. understand the self-contained modules of concepts and notations;
2. differentiate the deterministic and non-deterministic models;
3. understand all features of stochastic epidemic processes and queue processes;
4. develop maturity on stationary processes and time series.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	know when it is appropriate to use the properties of generating functions in different processes
CLO2	know how the renewal theory and arguments have often been advanced in a variety of situations, such as demography, manpower studies, reliability, replacement and maintenance
CLO3	create interest in the application of probability theory, concerned with objects or individuals that can generate objects of similar kinds, such as human beings, animals, genes, bacteria, and also neutrons which yield new neutrons under a nuclear chain.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	3	2	1	2	2	1	1
CLO2	3	2	2	2	1	1	1	2
CLO3	3	3	3	2	1	2	2	2

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Review of Stochastic Process and Markov Models**: Definition, state space and parameters of stochastic process. Markov process, Markov Chain, Poisson Process, Birth and death process, Illness-Death Process, Branching process, Renewal Process and Queuing Process, Application of Markov Model and MCMC. **Stochastic Epidemic Process**: The random variable technique and its application. Simple epidemic model, General epidemic model, Carrier borne epidemic model. Kermack and McKendrick's model, Daley and Kendall's Model. Stochastic Process of Clinical Drug Trials. Two armed bandit model, the Winner sampling model, the Optimum allocation model.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Final examination	18
CLO1	**Models for Social and Occupational Mobility:** Introduction, Models for social mobility, Models for occupational mobility. **Markov Models for Educational and Manpower Systems:** A model for system with given Input. A model for an expanding system with given size.			5
CLO2	**Continuous Time Models for Stratified Social Systems:** Some basic theory of Markov Processes. A manpower system with given Input. A Manpower system with given growth rate. Systems with given Input and loss rate depending on length of service. Hierarchical systems with given input and promotion rates depending on seniority. Fix and Neyman Model. **Stochastic Models of Reproductive Process**: Dandekar's Modified binomial and Poisson model, Brass model, Singh's modified model, Model of waiting times of conception Sheps and Perrin model of reproductive process.			10
CLO2	**Stochastic Process in Genetics**: Introduction, Physical basis of heredity. Genotypes under random mating, Herdy Weinberg law, Mating under various types of selection. Autosomal inheritance, Sex-linked inheritance, Change of			6

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	gene frequencies, Homozygosity under random mating.			
CLO3	**Stochastic Process in Queueing and Reliability**: General concept, steady state and transient behavior of M/M/I models, Birth and death process, Multichannel models, Network of Markovian queueing system, GI/M/I and M/G (a,b)/I Models.			6

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Diekmann, A., & Mitter, P. (2014). *Stochastic modelling of social processes*. Academic Press.
2. Biswas, S. (2004). *Applied Stochastic Process*, New Central Book Agency Ltd., Kolkata, India.

References:

1. Medhi, J. (1994). *Stochastic Process*, Wiley Eastern Ltd., New Delhi, India.
2. Bhat, U. N., & Miller, G. K. (2002). *Elements of applied stochastic processes*. Wiley-Interscience.
3. Anderson, T. W. (2011). *The statistical analysis of time series*. John Wiley & Sons.
4. Elandt-Johnson, R. C. (1971). *Probability models and statistical methods in genetics*. New York, London, Sydney, Toronto: John Wiley & Sons, Inc..
5. Lefebvre, M. (2007). *Applied stochastic processes*. Springer Science & Business Media.
6. Tan Wai-Yuan(1991: *Stochastic Process of Carcionogenesis*, Marcel Dekker,

M.Stat. 516: Advanced Biostatistics

Course Code	:	M.Stat. 516
Course Title	:	Advanced Biostatistics
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite(If any)	:	B. Stat.-403
Credit Value	:	3
Total Marks	:	75 (Examination 60, In-Course/Tutorial/Terminal 11.25 and Attendance 3.75)

COURSE DESCRIPTION:

This course deals with survival analysis, clinical trials and accelerated life testing (ALT) model. Estimations, tests and confidence intervals for survival probability, median survival time and hazard ratio are included in the survival analysis. Clinical trial includes the topics related to the invention of a new drugs/treatment. ALT model deals with ALT data to estimate the lifetime distribution under used stress (Temperature, Voltage, Cycle, Load etc.) level.

COURSE OBJECTIVES:

Students will be able to

1. estimate survival times for a group of patients and compare survival time of patients between two or more groups;
2. assess the relationship of covariates to survival time;
3. compare two or more hazard functions through calculating hazard ratio;
4. determine whether new drugs or treatments are both safe and effective by analyzing data obtained from clinical trials;
5. know the quality of high reliable products based on the analysis of accelerated life testing industrial data;
6. estimate the multivariate life distribution.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	define the basic concept of different lifetime distributions;
CLO2	estimate the survival probability and assess the relationship between the covariates and survival times;
CLO3	compute hazard ratio to compare two or more hazard functions;
CLO4	analyze clinical trial data for the invention of a new drugs which is safe and effective;
CLO5	justify about the improvement of the quality of their products by analyzing industrial data ;
CLO6	rearrange the collected data that has to be analyzed to improve health services and public health.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	2						
CLO2			3			2		
CLO3				2	2	3		
CLO4						3		3
CLO5						3		2
CLO6					2	3		

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Basic Concept:** Survival data. Different distribution of survival data and their characteristics. Survival function, hazard function and their interrelationships. Parametric and nonparametric estimation of survival function.	Lecturing with multi-media tools, Interactive brainstorming and Q/A session	Assignments, Class tests, Final examination	7
CLO2	**Parametric Regression Models:** Introduction. Inclusion of strata. Specifying a Distributions. Residuals. Residual analysis and other model checks. Predicted values. Fitting the Model. Exponential, Weibull, Normal, Lognormal and Gamma regression models. Interval estimation of the parameters and quantiles. Applications of parametric regression models.			8
CLO2 & CLO3	**Proportional Hazards (PH) Models:** Introduction. Hypothesis test. Stratified and Penalized Cox models. Residual analysis. Partial likelihood. Applications of proportional hazards model. Estimation of hazard ratio. Comparison of two or more survival functions.			6
CLO3	**Extension of the Cox PH Model:** Definition and examples of time-dependent variables, extended Cox model for time-dependent variables, hazard ratio for extended cox model, assessing time-dependent variables that do not satisfy PH assumption, extended cox likelihood. Application of the extended Cox model.			6
CLO4	**Clinical Trials:** Basic concepts of clinical trials. Controlled and uncontrolled clinical trials, historical controls, protocol, placebo, randomization, blind and double blind trials, ethical issues, protocol deviations, volunteer bias. Simple comparative trials, Cross-over trials, size			6

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
	of trials, meta analysis, interim analysis, multi-centre trials, combining trials.			
CLO5	**Accelerated life testing models:** Accelerating variables, different types of life-stress relationships. Constant-stress and step-stress accelerated test models. Different methods for representing and analyzing accelerated life test (ALT) data based on different sampling schemes. Application of accelerated life testing models.			6
CLO6	**Multivariate lifetime models:** Multivariate lifetime distributions and their characteristics, parametric and nonparametric estimation of multivariate lifetime distribution, models with multiple failure modes.			6

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Kleinbum, D.G and Klein, M (2012). *Survival Analysis; A self-learning Text*, Springer .
2. Fleiss, J. L., Levin, B., & Paik, M. C. (2013). *Statistical methods for rates and proportions*. John Wiley & Sons.

References:

1. Bain, L. J., & Engelhardt, M. (2017). *Statistical analysis of reliability and life-testing models: theory and methods*. Routledge.
2. Lawless, J.F.(2003). *Statistical Models and Methods for Lifetime Data*, John Wiley and Sons, N.Y.
3. Bland, M. (2015). *An introduction to medical statistics*. Oxford University Press.
4. Kirkwood, B. R., & Sterne, J. A. (2010). *Essential medical statistics*. John Wiley & Sons.
5. Balakrishnan, N. (1995). *Recent advances in life-testing and reliability*.
6. Daly, L., & Bourke, G. J. (2008). *Interpretation and uses of medical statistics*. John Wiley & Sons.
7. Nelson, W. B. (2009). *Accelerated testing: statistical models, test plans, and data analysis*. John Wiley & Sons.
8. Elandt-Johnson, R. C., & Johnson, N. L. (1980). *Survival models and data analysis*. John Wiley & Sons.
9. Johnson RCE & Johnson (1980). *Survival Models and Data Analysis*, Wiley NL & Sons, NY.

M.Stat. 517: Planning, Monitoring and Evaluation of Research

Course Code	:	M.Stat. 517
Course Title	:	Planning, Monitoring and Evaluation of Research
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	
Credit Point (CP)	:	3
Total Marks	:	75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course gives the fundamental concepts of research methods, research proposal, research report and related materials. Student will gather concepts of research performance monitoring and evaluation system. Student will also earn necessary expertise to conduct a project planning, monitoring, evaluation and reporting. There is a particular focus on the contribution of statistical methods in both the design and analysis of such studies.

COURSE OBJECTIVES:

Students would be able to:

1. develop research plan and capable to conduct a scientific research;
2. elaborate a methodology to monitor the development of the research;
3. clearly state what are the milestones of the research and what are the final outputs.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	define research terminology and identify the elements and steps of an M&E plan;
CLO2	identify M&E roles and responsibilities;
CLO3	create an analysis plan and reporting templates.

Mapping CLOs with PLOs

CLOs	Program Learning Outcomes (PLOs)							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	2	1	1	2	2	1	1
CLO2	2	3	3	2	2	1	2	2
CLO3	3	3	3	2	1	1	2	1

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Introduction**: Designs for program evaluation and principle. Research, data analysis techniques and reporting, Developing a M & E system, Developing a terms of reference and responding to proposals. Data sources and research methods, Performance monitoring, Theoretical framework, Statistical methods used in the analysis of data devised from such designs, in particular for the estimation and test of hypothesis.	Lecturing with multimedia projector, Interactive board and Q/A session	Assignment, class tests, presentation, final exam.	12
CLO2	**Monitoring and Evaluation**: Basic concept, Opportunities and Barriers, Purpose and benefits of planning, monitoring and evaluation. **Introduction to the Logical Framework Approach (LFA), Steps of the LFA**: Stakeholder analysis, Problem analysis, Objectives analysis, Alternatives analysis, Identification of indicators and means of verification, Identification of assumptions and risks, Setting baselines and targets, Theory of Change, How to produce a plan of action. Key concepts and approaches in evaluations (including effectiveness, efficiency, impact, relevance and sustainability). Development practitioners, project leaders and decision makers responsible for designing, implementing, monitoring or evaluating development projects. Collecting, Analyzing, and Using Monitoring Data, Key Elements of M & E Work Plan, Comprehensive Monitoring and Evaluation Framework.			18
CLO3	**Evaluation of Research Question**: Outcome, Impact, Output, Input, Study Designs, Types and Objectives of Monitoring and Evaluation, Steps in Developing a Monitoring Plan, Country Monitoring and Evaluation Matrix. Planning, Monitoring and Evaluation for Development Projects.			15

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. ESSENCE on Health Research. (2016). *Planning, Monitoring and Evaluation Framework for Research Capacity Strengthening*.
2. Tengan, C., Aigbavboa, C., & Thwala, W. D. (2021). *Construction Project Monitoring and Evaluation: An Integrated Approach*. Routledge.

References

1. Mayne, R., Hamilton, J., & Hobson, K. (2013). *Step by Step Guide to Monitoring and Evaluation.* Resource.
2. World Health Organization. (2016). *Planning, Monitoring, and Evaluation: Framework for Research Capacity Strengthening*. ESSENCE.
3. Patton, M.Q. (2017). *Managing for Sustainable Development Goals- An Integrated approach to planning, Monitoring and Evaluation*, Priciples-Focussed Evaluation: The Guide.
4. Rossi, P. H., Lipsey, M. W., & Henry, G. T. (2018). *Evaluation: A systematic approach*. Sage publications.
5. UNDP, (2002). *Handbook on Monitoring and Evaluating for Results, Evaluation Office*.
6. Epstein, I., & Tripodi, T. (1977). *Research techniques for program planning, monitoring, and evaluation*. New York: Columbia University Press.

M.Stat. 518: Data Science and Big Data Analytics

Course Code	:	M.Stat. 518
Course Title	:	Data Science and Big Data Analytics
Course Type	:	Optional
Level/Term and Section	:	M.Sc. Final
Academic Session	:	2023 - 2024
Course Instructor	:	
Pre-requisite (If any)	:	
Credit Point (CP)	:	3
Total Marks	:	75 (Examination 60, Tutorial/Terminal 11.25, and Attendance 3.75)

COURSE DESCRIPTION:

This course aims to teach students about data science principles, tools, and techniques required to analyze and derive insights from big data. The focus will be on applying data analytics methodologies in a big data environment using various tools, platforms, methods, models, and algorithms.

COURSE OBJECTIVES:

Students would be able:

1. To gain knowledge about data science.
2. To teach how statistical models can be brought to bear in computer systems to analyze high-dimensional big data sets.
3. To apply computer programming algorithms to solve the problems related to process and analyzing vast amounts of information rather than the traditional statistical methods.
4. To acquire basic knowledge about artificial intelligence.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO1	Gain knowledge about data science.
CLO2	Gain knowledge of big data analytics and toolkits.
CLO3	Apply computer programming algorithms to analyze vast amounts of information rather than the traditional statistical methods.
CLO4	Gain basic knowledge of artificial intelligence.

Mapping CLOs with PLOs

CLOs	**Program Learning Outcomes (PLOs)**							
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**
CLO1	3	2	1	1	2	2	1	1
CLO2	2	3	3	2	2	1	2	2
CLO3	3	3	3	2	1	1	2	1
CLO4	2	2	3	3	2	2	1	1

Note: 3 - High, 2 - Medium, 1 – Low

COURSE CONTENT, TEACHING AND ASSESSMENT STRATEGY:

CLOs	Topics to be covered	Teaching-Learning Strategies	Assessment Techniques	No. of lectures
CLO1	**Data Science:** Introduction, Datafication, and Data Quantification; Data, Information, Knowledge, Intelligence and Wisdom; Definitions of data science. Data science structure and system.	Lecturing with multimedia projector, Interactive board and Q/A session	Assignment, class tests, presentation, final exam.	6
CLO1	**Data Science Techniques**: Problem of analytics and learning, Conceptual map of data science techniques, Data-to-insight-to-decision analytics and learning, Descriptive-to-Predictive-to-Prescriptive analytics, Data science applications, Prospects and opportunities in data science. Widely used techniques in data science applications.			7
CLO2	**Big Data:** Definition, types, sources, and analytics of big data. The 4Vs of big data, Big data mining, and Technical elements of the big data platform.			5
CLO2	**Analytics Toolkit:** Components of the analytics toolkit, System recommendations, installing software for the analytics toolkit. Python for Data Science: Pandas, NumPy, Scikit-learn. R for Data Science: Data manipulation, Visualization, Big data tools. Distributed data processing.			7
CLO3	**Big Data with Hadoop:** Fundamentals of Hadoop, Core modules of Hadoop, Hadoop distributed file system (HDFS), Data storage process in HDFS, MapReduce, YARN, and Hive, Hadoop MapReduce programs. Learning data analytics with R and Hadoop. Big data analysis with machine learning.			8
CLO3	**Big Data Mining:** Big data mining techniques including high-performance mining, web mining, stream mining, graph mining, text mining, etc. Data science in the cloud platforms: AWS, Google Cloud, Microsoft Azure.			7
CLO4	**Artificial Intelligence:** Overview of basic concepts and techniques of Artificial Intelligence (AI), including its history and applications, and statistical machine learning.			5

Assessment Strategy Evaluation Policy (Grading System) and make-up procedures: According to the ordinance.

Main Books:

1. Cao, L. (2018). *Data Science Thinking: The Next Scientific, Technological and Economic Revolution*. Springer.
2. Favero, L.P., Belfiore, P., Souza, R.D.F. (2023). *Data Science, Analytics and Machine Learning with R*, Elsevier Inc.
3. Qamar, U. and Raza, M.S. (2023). *Data Science Concepts and Techniques with Applications*, Springer.

References:

1. Kotu, V. and Deshpande, B. (2019). *Data Science Concepts and Practice*. Elsevier Inc. All.
2. Russell, S. and Norvig, P. (2020). *Artificial Intelligence: A Modern Approach*, 4th edition. Pearson Education.

COURSE: M.Stat. 519

Viva-voce

Full Marks: 100

General Group

COURSE: M.Stat. 520

Practical Examination

Full Marks: 150

(Practical examination 105 marks, spread over 8 Sessions and continuous assessment 45 marks)

Session-I: Advanced Statistical Inference

1. Box plots and their various interpretations and outlier detection.
2. cdf estimation and quantile estimation, Density estimation.
3. Robust estimation of univariate location and scale parameters.
4. Huber's M-estimation of location and Scale parameter
5. Variance estimation by Jackknife, bootstrap, and influence function.
6. Robust estimation of multivariate location and scatter matrix.
7. Estimation of SE of r and b_1 by non-parametric and parametric bootstrap and jackknifing
8. Different bootstrap CI of r and b_1
9. MPT, UMPT, SRT, MPSRT, UMPSRT, Asymptotic efficiency of the above tests
10. Sequential test, OC and ASN function, Construction of decoction regions, Tests of 2x2 contingency table.
11. ARE of Mann- Whitney test and sign test, Kruskal-Wallis test, Square rank test for variances, Friedman test
12. Fitting regression models by bootstrapping. Different density estimators of univariate data.

Session-II: Advanced Experimental Design and Sampling Techniques

1. Analysis of data using two-way and three-way classification with equal and unequal number of observations per cell.
2. Analysis of data using the non-orthogonal model.
3. Arrange the data in BIBD, PBIBD, and Youden design. Also, analyze the data using such designs.
4. Estimate and test the data using intra-block and inter-block BIBD models.
5. Analyze the data using Split plot and Split-split plot design.
6. Analyze factorial experiments of levels 2, 3, and 5 with different factors. Construct plans of $2^{\frac{1}{n}}$ and $3^{\frac{1}{n}}$ replicate of such experiments and analyze the data using RBD and LSD model. Also study confounding, defining contrast and aliases.
7. Analyze lattice design/Balanced lattice design/Partially balanced lattice design with different replications.
8. Sampling with Varying Probabilities: Unequal probability sampling with and without replacement, Methods of selecting a PPS sample, Des Raj’s ordered, Murthy’s unordered and Horvitz-Thompson estimation methods.
9. Two-Stage and Multistage Cluster Sampling: Two-stage with equal and unequal cluster sizes, three-stage and multistage sampling, and Optimal allocation of sample size.
10. Double Sampling and Multiphase Sampling: Double sampling, Ratio, Difference, Regression, Optimum allocation, Multiphase sampling.
11. Non-Sampling Errors: Effect of non-response, Hansen and Hurwitz technique, Politz-Semons techniques, Randomized response technique.

Session-III: Advanced Multivariate Analysis

1. Fit the multivariate straight-line regression model and test the goodness of fit.
2. Apply CA and MCA for categorical data analysis.
3. Apply CA and MCA for mixed tables of metric and categorical data analysis.
4. Fit the multivariate normal and t mixture models by estimating the parameters using the EM algorithm.
5. Find the clusters from a given dataset.
6. Compute Bayesian prediction using the multivariate regression model.
7. Perform factor analysis of multivariate data using the Bayesian approach. Recover source signals (original signals) from the mixed signals using the Bayesian approach. The mixture of artificial signals, natural images, and audio signals with Gaussian noise can be considered as the mixture dataset.

Session–IV: Time Series Analysis and Forecasting

1. **Single time series:** Checking Time series properties, Tests for order of integration. Spectral representation, Fitting an appropriate ARIMA, SARIMA, model. Diagnostic and Stability, Checking and Forecasting.
2. **Multivariate time series:** Tests for cointegration and spurious correlation. Fitting different VAR and VEC models. Tests for Granger causality, Estimation of impulse response functions. Decomposition of forecast error variance.
3. **Stylized facts of time series:** Test for ARCH effect, Modeling, and forecasting volatility. Detection of structural breaks.

Session–V: Data Mining and Machine Learning

1. Exploratory data analysis to uncover anomalous fields exploring variables and multivariate relationships.
2. Applications of tools for data visualization, data preparation, missing value identification, outlier detection, and finding statistics.
3. Applications and comparison of different classification methods.
4. Real-world case studies of deep learning in areas such as healthcare, autonomous vehicles, natural language processing, etc.
5. Applications of various supervised and unsupervised machine learning algorithms to big data and data mining-related real-world problems for identifying their business applications.

Session–VI: Group 1

Advanced Bioinformatics (Related to M.Stat. 506)

1. DNA sequence data Analysis using BLAST / PYTHON, Phylogenetic Analysis of DNA sequence data using R/BLAST /PYTHON, QTL data analysis using R, Gene-expression data analysis using R.
2. GWAS/SNPs data analysis using R., Microbial sequence analysis using online/offline software.

Advanced Demography (Related to M.Stat. 507)

1. Construction of multiple decrement life tables, estimation of fertility and mortality by indirect techniques
2. Estimation of completeness of registration and survey data by Chandra-Sekar and Deming method, estimation of nuptiality parameters of nuptiality model, Estimation of Cole's indices
3. Graduation of net maternity function by Normal, Wicksell and Hadwiger curve
4. Problems related to population projection, Problems related to fecundability
5. Estimation of proximate determinants of fertility and inhibiting effects of marriage and divorce

Environmental Statistics (Related to M.Stat. 508)

Experiments based on Statistical methods and computer applications

1. Use of computer programs R, Matlab for analysis of environmental data.
2. Regression analysis, trend analysis, error analysis and application of statistical tests in environmental problems.
3. Fitting of polynomials to environmental data, Use of Chi-square, F-test and t- test.
4. Principle component analysis of environmental variable, Determine drought index and SPI by using Markov chain model using R.
5. Study of non-linear and non-stochastic time series analysis of environment data by using Matlab, wavelets analysis and Spectral analysis of environment data by using Matlab.
6. Study of geo-statistical modeling analysis, spatio-temporal modeling, Extreme value modeling by using GIS.

Advanced Actuarial Statistics (Related to M.Stat. 509)

1. Survival distributions and life tables, Life annuities, Net premium, Premium series.
2. Multiple life functions, Multiple decrement models, Pension plans, the expense function and dividends, measurement of risk and Mortality Table: Construction of mortality tables.
3. Premium calculation of various life policies, techniques of calculating exposures form individual records including consideration involving selection of studies, various observation periods and various methods of tabulating deaths.
4. Techniques of calculating exposures from variation schedules, including the general concepts of the fiscal year, the use of interim schedules and variations in observation period or method of grouping deaths, and construction of actuarial tables.

Session – VII: Group 2

Biomedical Informatics (Related to M.Stat. 510)

1. Protein sequencing analysis using BLAST / PYTHON / PERL.
2. Protein classification using supervised and unsupervised statistical algorithms, Phylogenetic Analysis of Protein Sequencing using R, and Metabolomics data analysis using R/MATLAB.
3. Bayesian network (BN) analysis, Nomogram construction, and disease prediction.

Health and Epidemiology (Related to M.Stat. 511)

1. To find the growth over time by using algometric growth and other suitable models.
2. To detect the factors that directly and indirectly influence health by using statistical tools, Estimation of relative risk and odds ratio, To solve the care management problem using linear programming methods (graphical and simplex)
3. Statistical models to control extraneous factors: Linear regression, Log-linear regression, Logistic regression, Poisson regression and Negative Binomial regression
4. Calculation of OR, RR, NNT, PPR, NPR, sensitivity, specificity, true positive rate, true negative rate, ROC with 95% CI using raw data and their interpretation
5. Calculation of sample size with respect to various problems (regarding power and precision)
6. Fitting and interpretation of the linear model, logistic model, and multinomial model.
7. Analysis of repeated measures and parametric and Cox proportional hazards models.

Statistical Methods in Industrial Management (Related to M.Stat. 512)

1. Economic order quantity, order Cycle, order size, optimal quantity, Optimal order quantity, total annual cost, Quantity discounts, constructing Networks
2. Draw a precedence diagram using AOA and critical path and determine an optimum crushing plan.
3. Deterministic time estimates, Probabilistic time estimates, Compute slack times, Gantt chart

Statistical Methods for Reliability Data (Related to M.Stat. 513)

1. Distribution ID plot and overview plot. Parametric and nonparametric distribution analysis. Life data event plots, probability plots, and parametric ML fit.
2. Selection of a suitable model from a set of competitive models for reliability data.
3. Multiple failure mode data analysis: individual and combined modes, accelerated life test models analysis, parametric regression model fit with censored product reliability data.
4. Recurrence (point process) data analysis, warranty claims data and warranty cost modeling, Degradation data modeling, and analysis, and case studies with real product reliability data.

Session–VIII: Group 3

Physical Health and Human Growth Modeling (Related to M.Stat. 514)

1. Morphological indices, Differential indices of body building, Craniometric indices, detection of Cranial landmarks.
2. Extraction of growth parameters, Fitting of growth models: Models described in M.Stat. 514.

Advanced Stochastic Modeling (Related to M.Stat. 515)

1. Study of simple epidemic models, analysis of Kermack and McKendrick's epidemic model.
2. Study of Daley and Kendall's epidemic model.
3. Study of Optimum allocation model in clinical drug trials.
4. Study of Robbins model, Study of Hardy Weinberg law of heredity
5. Analysis of M/M/1 Queuing models, Analysis of multi-channel Queuing models
6. Study of Network models, Study of models of waiting times of conceptions-Sheps and Perrion model of reproductive process.

Advanced Biostatistics (Related to M.Stat. 516)

1. Non-parametric estimation of survival and hazard functions with standard errors and confidence intervals.
2. Fitting of parametric survival distributions under different types of censored data.
3. Comparison of two and/or more than two survival curves.
4. Check of proportional hazard assumptions. Cox proportional hazard model analysis.
5. Fitting of parametric regression models and tests of fit.

Planning, Monitoring and Evaluation of Research (Related to M.Stat. 517)

1. Sample size determination for finite and infinite population. Estimation of population mean and standard errors using SRS, Stratified, Systematic and Cluster sampling.
2. Make a simple questionnaire and collect data using a suitable sampling scheme.
3. Write a sample executive summary, general introduction, objectives, literature review, research gap and conclusion of a research proposal, Framework for research, monitoring and evaluation
4. Outcome Mapping, Case studies, Monitoring, Evaluation, and Learning Consultancy Services, Approaches to evaluation capacity development
5. Write down a sample research proposal and research project.

Data Science and Big Data Analytics (Related to M.Stat. 518)

1. Applications of widely used techniques in data science applications.
2. Analysis of big data with Hadoop.
3. Applications of statistical models and methods using cloud computing techniques.
4. Case Studies and Industry Applications: Big data analytics in healthcare, Financial fraud detection, Retail and customer behavior analysis, Social media and sentiment analysis, etc.

COURSE: M.Stat. 521

Excursion and Fieldwork & Research project

Full Marks: 50

Thesis Group

COURSE: M.Stat. 17

(a) Thesis Written	100
(b) Thesis Defense	50
Thesis (a + b)	150

COURSE: M.Stat. 523

Excursion and In-plant Training

Full Marks: 50

To complete in-plant training, students must submit a report on a specific topic designed by the examination committee.

Mapping between Program Educational Objectives (PEOs) and Course Learning Outcomes (CLOs)

Course	Course Learning Outcomes (CLOs)	Program Educational Objectives (PEOs)				
		PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
M.Stat. 501	CLO-1	3	2	1	2	3
	CLO-2	2	1	2	2	3
	CLO-3	3	3	2	1	1
M.Stat. 502	CLO-1	3	2	2	1	1
	CLO-2	2	3	2	1	1
	CLO-3	3	2	1	3	2
	CLO-4	3	2	1	2	3
	CLO-5	3	2	1	1	1
M.Stat. 503	CLO-1	2	3	1	1	2
	CLO-2	3	3	2	2	1
	CLO-3	3	2	1	2	2
M.Stat. 504	CLO-1	3	3	2	2	2
	CLO-2	3	2	1	1	1
	CLO-3	3	3	2	1	2
	CLO-4	3	2	3	3	2
	CLO-5	2	3	2	1	1
M.Stat. 505	CLO-1	3	2	3	1	1
	CLO-2	2	3	1	1	2
	CLO-3	1	2	3	2	1
	CLO-4	2	2	1	2	3
	CLO-5	1	2	3	2	2
	CLO-6	2	2	3	2	3
Group 1						
M.Stat. 506	CLO-1	2	3	2	1	1
	CLO-2	3	3	2	2	1
	CLO-3	2	3	2	2	1
	CLO-4	3	2	1	1	1
	CLO-5	3	2	2	1	2
M.Stat. 507	CLO-1	2	3	2	1	2

Course	Course Learning Outcomes (CLOs)	Program Educational Objectives (PEOs)				
		PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
	CLO-2	3	2	1	2	2
	CLO-3	2	3	2	1	2
	CLO-4	3	2	1	1	1
M.Stat. 508	CLO-1	3	1	2	2	1
	CLO-2	3	2	3	3	2
	CLO-3	3	2	1	2	1
	CLO-4	2	3	3	2	1
	CLO-5	2	3	1	1	2
	CLO-6	3	2	1	2	1
M.Stat. 509	CLO-1	3	1	2	2	1
	CLO-2	3	2	1	3	2
	CLO-3	2	3	1	2	3
	CLO-4	1	3	2	1	1
	CLO-5	2	2	3	1	2
Group 2						
M.Stat. 510	CLO-1	1	2	1	3	2
	CLO-2	3	3	2	1	1
	CLO-3	3	2	1	1	1
	CLO-4	1	2	2	1	1
	CLO-5	2	3	2	3	2
M.Stat. 511	CLO-1	2	1	1	2	2
	CLO-2	3	3	1	2	2
	CLO-3	2	3	2	1	1
	CLO-4	1	2	1	3	2
M.Stat. 512	CLO-1	3	2	1	2	3
	CLO-2	3	2	1	1	1
	CLO-3	3	3	1	2	2
	CLO-4	2	3	1	2	2
M.Stat. 513	CLO-1	3	2	1	2	2
	CLO-2	2	3	2	1	1
	CLO-3	3	2	1	1	1

Course	Course Learning Outcomes (CLOs)	Program Educational Objectives (PEOs)				
		PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
	CLO-4	2	3	2	3	2
	CLO-5	2	3	1	1	2
	CLO-6	2	3	2	1	1
	CLO-7	3	2	2	1	1
Group 3						
M.Stat. 514	CLO-1	2	3	1	3	2
	CLO-2	2	3	2	2	2
	CLO-3	3	2	1	2	2
	CLO-4	2	3	2	1	1
	CLO-5	3	1	1	1	2
	CLO-6	3	2	2	2	1
M.Stat. 515	CLO-1	2	3	1	2	2
	CLO-2	3	1	2	1	1
	CLO-3	3	3	2	2	1
M.Stat. 516	CLO-1	2	2	3	2	1
	CLO-2	1	2	2	1	2
	CLO-3	2	1	2	1	3
	CLO-4	2	3	1	2	2
	CLO-5	2	2	1	1	2
	CLO-6	2	3	2	1	1
M.Stat. 517	CLO-1	2	2	3	1	2
	CLO-2	1	3	1	2	2
	CLO-3	3	2	1	1	2
M.Stat. 518	CLO-1	2	1	1	2	2
	CLO-2	3	3	1	2	2
	CLO-3	2	3	2	1	1
	CLO-4	1	2	3	2	2