University of Mumbai

No. AAMS_UGS/ICC/2024-25/ 102

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Board of Studies in Statistics** at its meeting held on 05th July, 2024 and subsequently passed by the Board of Deans at its meeting held on 10th July, 2024 **vide** item No. 6.3 (N) have been accepted by the Academic Council at its meeting held on 12th July, 2024 **vide** item No. 6.3 (N) and that in accordance therewith **syllabus** for the **M.Sc (Statistics) (Sem. III & IV)** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The circular is available on the University's website www.mu.ac.in).

Baliram

MUMBAI – 400 032
22nd August, 2024

(Prof.(Dr) Baliram Gaikwad)
I/c Registrar

To

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Department.

A.C/6.3(N)/12/07/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science & Technology,
3) The Chairman, **Board of Studies in Statistics**,
4) The Director, Board of Examinations and Evaluation,
5) The Director, Board of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari.
8) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentre@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

1	The Chairman, Board of Deans
2	The Dean, Faculty of Humanities,
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology,
7	The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari, director@idol.mu.ac.in

AC – 12/07/2024

Item No. – 6.3 (N)

As Per NEP 2020

University of Mumbai

Title of the program

M.Sc. (Statistics)

Syllabus for

Semester – Sem.- III & IV
Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25)

University of Mumbai

(As per NEP 2020)

Sr.No.	Heading	Particulars
1	**Title of program** **O:_____ B**	**M.Sc. (Statistics)**
2	**Scheme of Examination** **R: _____**	**NEP** **50% Internal** **50% External,** **Semester End Examination** **Individual Passing in Internal and External Examination**
3	**Standards of Passing** **R: _____**	**40%**
4	**Credit Structure** **R: SP-35A** **R: SP-35B**	**Attached herewith**
5	**Semesters**	**Sem. III & iV**
6	**Program Academic Level**	**6.5**
7	**Pattern**	**Semester**
8	**Status**	**New**
9	**To be implemented from Academic Year**	**2024-25**

Sign of the BOS Chairman
Dr. Santosh Gite
Board of Studies in Statistics

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

Preamble

1) Introduction

M.Sc. Statistics is a two years (four semesters) program. The program consists of 88 credits, for each semester there are 22 credits. In semester I, "Research Methodology" is a mandatory course. In semester I, II and semester III, there are three mandatory courses each of four credits and one course can be selected from the available list of elective courses whereas in semester IV there are two mandatory courses each of four credits and one course can be selected from the available list of elective courses. An elective course consists of a theory course of two credits and practical course of two credits. In addition there is one practical course of two credits in each semester**.**

2) Aims and Objectives

The program accentuates both the core and modern applications of statistics. The program is structured so that students will have in depth knowledge of Statistics for pursuing their higher studies and also necessary skills in statistics for the employability in corporate. The program has the unique features like, field projects, internships, research project, and adequate amount of courses in core as well as in applied Statistics.

3) Learning Outcomes

On completion of this program learners will have,

a) Knowledge of ethical values to become a responsible researcher in Statistics.

b) Fair knowledge of core statistics such as probability theory, distribution theory, statistical modeling, multivariate techniques etc.

c) Fluency in statistical computing using R- language, Python,SQL etc.

d) Knowledge of reframing real situation information into statistical language, analyzing the data and to draw valid inferences based on it.

4) Any other point (if any)

_____

5) Baskets of Electives

For semester III:

- Elements of Data Science-I and Statistics Practical – VI,
- Statistical Process Control-II and Statistics Practical – VI,
- Financial Mathematics-I and Statistics Practical – VI
- Statistics in Insurance-I and statistical practical-VI

For semester IV:

- Elements of Data Science-II and Statistics Practical – VIII,
- Financial Mathematics-II and Statistics Practical –VIII,
- Statistics in Insurance-I and Statistics Practical – VIII,
- Statistical Decision Theory and Statistics Practical – VIII

6) Credit Structure of the Program (Table as per (Parishishth 1) with sign of HOD and Dean):

R: SP-35A

Year (2 Yr PG)	Level	Sem. (2 Yr)	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory*	**Electives Any one**					
I	**6.0**	**Sem I**	502: Probability Theory (04) 503: Linear Models (04) 504: Statistical Inference -I (04) 505: Statistics Practical I (02)	E1 506 (A): Sampling Techniques (02) E1 506 (B): Statistics Practical II (02) OR E2 506 (A): Optimization Techniques (02) E2 506 (B): Statistics Practical II (02) OR E3 506 (A): Basic Statistics for Data Analysis (02) E3 506 (B): Statistics Practical II (02)	501: Research Methodology in Statistics (04)			22	**PG Diploma (after 3 Year Degree)**
		Sem II	507: Multivariate Analysis – I (04) 508: General Linear Models (04) 509: Statistical Inference- II (04) 510: Statistics Practical -III (02)	E1 511 (A): Nonparametric Inference (02) E1 511 (B): Statistics Practical IV (02) OR E2 511 (A): Statistical Process Control - I (02) E2 511 (B): Statistics Practical IV (02) OR E3 511 (A): Operations Management (02) E3 511 (B): Statistics Practical IV (02) OR E4 511 (A): Elementary Statistics for Data Analysis (02) E4 511 (B): Statistics Practical IV (02)		04		22	
Cum. Cr. For PG Diploma			**28**	**8**	**4**	**4**	**-**	**44**	

R: SP-35B

Exit option: PG Diploma (44 Credits) after Three Year UG Degree

II	**6.5**	**Sem III**	601: Multivariate Analysis II (04) 602: Design of Experiments (04) 603: Stochastic Processes (04) 604: Statistics Practical V (02)	E1 605 (A): Elements of Data Science – I (02) E1 605 (B): Statistics Practical VI (02) OR E2 605 (A): Statistical Process Control - II (02) E2 605 (B): Statistics Practical VI (02) OR E3 605 (A): Financial Mathematics – I (02) E3 605 (B): Statistics Practical VI (02) OR E4 605 (A): Statistics in Insurance – I (02) E4 605 (B): Statistics Practical VI (02)			04	22	**PG Degree After 3-Yr UG**
		Sem IV	607: Time series Analysis (04) 608: Reliability and Survival Analysis (04) 609: Structural Equation Modeling (02) 610: Statistics Practical VII (02)	E1 611 (A): Elements of Data Science – II (02) E1 611 (B): Statistics Practical VIII (02) OR E2 611 (A): Financial Mathematics – II (020 E2 611 (B): Statistics Practical VIII (02) OR E3 611 (A): Statistics in Insurance- II (02) E3 611 (B): Statistics Practical VIII (02) OR E4 611 (A): Statistical Decision Theory (02) E4 611 (B): Statistics Practical VIII (02)			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

Syllabus
M.Sc. (Statistics) Part - II
(Semester III and Semester IV)
Academic year 2024-2025

STRUCTURE OF THE SYLLABUS

M.Sc. Statistics is a two years (four semesters) program. The program consists of 88 credits, for each semester there are 22 credits. In semester one "Research methods in Statistics" is a compulsory course. In semester I, II and semester III, there are three mandatory courses each of four credits and one course can be selected from the available list of elective courses whereas in semester IV there are two mandatory courses each of four credits and one course can be selected from the available list of elective courses. An elective course consists of a theory course of two credits and practical course of two credits. In addition there is one practical course of two credits in each semester.
Following is the table showing the proposed courses (mandatory and elective) to be covered in semester I and semester II of first year M.Sc. program.

SEMESTER III

MANDATORY COURSES

Mandatory courses				**Elective courses**	**RP**
Course code	Course Title	Credits	Total number of lectures		
601	Multivariate Statistics-II	04	60	Learner can select one theory course as an elective course from the following list of subjects and practical course based on the selected theory course.	04
602	Design of Experiment	04	60		
603	Stochastic Process	04	60		
604	Statistics Practical – V	02	60		

LIST OF ELECTIVES.

Elective courses			
Course code	Course Title	Credits	Total number of lectures
E1 605 (A): E1 605 (B):	Elements of Data Science – I and Statistics Practical VI	02 02	30 60
E2 605 (A): E2 605 (B):	Statistical Process Control - II and Statistics Practical - VI	02 02	30 60
E3 605 (A) E3 605 (B)	Financial Mathematics – I and Statistics Practical VI	02 02	30 60

E4 605 (A) E4 605 (B)	Statistics in Insurance – I and Statistics Practical VI	02 02	30 60

SEMESTER IV

MANDATORY COURSES

Mandatory courses				Elective courses	RP
Course code	Course Title	Credits	Total number of lectures		
607	Time series Analysis	04	60	Learner can select one theory course as an elective course from the following list of subjects and practical course based on the selected theory course.	06
608	Reliability and Survival Analysis.	04	60		
609	Structural Equation Modeling.	02	60		
610	Statistics Practical – III	02	60		

LIST OF ELECTIVES

Elective courses			
Course code	Course Title	Credits	Total number of lectures
E1 611 (A) E1 611 (B)	Elements of Data science-II and Statistics Practical – VIII	02 02	30 60
E2 611 (A) E2 611 (B)	Financial Mathematics-II and Statistics Practical – VIII	02 02	30 60
E3 611 (A) E3 611 (B)	Statistics in Insurance-II and Statistics Practical – VIII	02 02	30 60
E4 11 (A) E4 511 (B)	Statistical Decision Theory and Statistics Practical-VIII	02 02	30 60

DURATION OF THEORY COURSE

Duration of each of the theory course will be 60 hours for entire semester. Each theory course will be of four credits having four hours of classroom teaching per week. Syllabus of each theory course is divided into two modules each should be covered in 30 lectures each of one hour.

DURATION OF PRACTICAL COURSE

Duration of each of the practical course will be 60 hours for entire semester. Each practical course will be of two credits. Each practical will have four hours of practical session per week per batch of practical. Each batch of practical consists of 10 students.

PROGRAM LEARNING OUTCOMES

The program accentuates both the core and modern applications of statistics. The program is structured so that students will have in depth knowledge of Statistics for pursuing their higher studies and also necessary skills in statistics for the employability in corporate. The program has the unique features like, field projects, internships, research project, and adequate amount of courses in core as well as in applied Statistics.

On completion of this program learners will have,

PO 1) Knowledge of ethical values to become a responsible researcher in Statistics.

PO 2) Fair knowledge of core statistics such as probability theory, distribution theory, statistical modeling, multivariate techniques

PO 3) Fluency in statistical computing using R- language, Python.

PO 4) Knowledge of reframing real situation information into statistical language, analyzing the data and to draw valid inferences based on it.

DETAILED SYLLABUS

Semester III

Mandatory courses

501: Multivariate Statistics-II

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	601: **Multivariate Statistics-II**	
Total Credits:	04	**Total Marks:**	100	
University assessment:	50	**College assessment:**	50	
Pre requisite: Matrix theory: eigenvalue and eigenvectors, symmetric matrices,				
Course outcomes: After completion of the course learners will, CO 1) Understand data reduction techniques. CO 2) understands to extract important factors using exploratory factor analysis. CO 3) able to understand how to find correlation between two set of variables. CO 4) able to know how to make clusters using cluster analysis methods.				
MODULE I:			**(2 CREDITS)**	
Unit 1:	Principal Component Analysis: population and sample principal components, principal components for special structure of dispersion matrix: diagonal matrix, correlation matrix, sample variation, interpretation of sample principal components, graphing the principal components, large sample inference, large sample confidence interval for eigenvalues, test for equal correlation structure.			15
Unit 2:	Factor Analysis: introduction, methods of estimation: principal components method, maximum likelihood method. Factor rotation, factor scores.			15
MODULE II: **(2 CREDITS)**				
Unit 3:	Canonical Correlation and Variates: introduction, interpretation, sample canonical correlation and covariates, large sample inference.			15
Unit 4:	Cluster Analysis: similarity measures, hierarchical clustering methods and non hierarchical methods. Multidimensional scaling..			15
References:				

- Anderson, T. W. (2003): An Introduction to Multivariate Statistical Analysis. John Wiley. 3rd edition.
- Giri, N. C. (2003): Multivariate Statistical Analysis. CRC Press. 2nd edition.
- Hardle, W. K. and Hlavka, Z. (2015): Multivariate Statistics: Exercise and solutions. Springer.
- Johnson, R. A. and Wichern, D. W. (2015): Applied Multivariate Statistical Analysis. 6th Edition. PHI Learning Private Limited.
- Kshirsagar, A. M. (1979): Multivariate Analysis, Marcel Dekker Inc. New York.
- Mukhopadhyay, P. (2008): Multivariate Statistical Analysis. World Scientific.
- Srivastava, M. S. (2002): Methods of Multivariate Statistics. John Wiley.

Muralidhar, K. Ghosh, A. and Singhvi, A. K. (2019): Ethics in science education. Research and Governance, Indian national science academy, New Delhi

502: Design of Experiments.

Programe Name:	M.Sc. Statistics	**Course Code and Name:**	502: Design of Experiments.	Lectures alloted
Total Credits:	04	**Total Marks:**	100	
University assessment:	50	**College assessment:**	50	
Pre requisite				
Course outcomes: After completion of the course learners will have, CO 1) knowledge in basic principles of design, general block design (GBD). CO 2) knowledge in balanced incomplete block design (BIBD), optimality of block design. CO 3) Knowledge in factorial designs such as 2^2 , 2^3 and 2^k. CO 4) Knowledge in blocking and confounding. CO 5) Knowledge to find behavior of sequence of random variables for large n.				**15**
MODULE I:				**(2 CREDITS)**
Unit 1:	Brief History of Statistical Design. Basic principles of design. Contrast, orthogonal contrast and mutual orthogonally of contrasts. General block design (GBD) - an example. C-Matrix and its properties. Properties of design – Connectedness, Balance and orthogonal. Statistical analysis of GBD. Randomized Block Design as a particular case of GBD			15
Unit 2:	Balanced incomplete block design (BIBD). C-matrix, properties, statistical analysis of BIBD. Optimality of block design. : A,D,E – optimality.			15
MODULE II:				**(2 CREDITS)**
Unit 3:	Factorial design – an example. Basic definitions and principles .The advantage of factorial designs. The 2^2 factorial design. The general 2^k factorial design with r replications. . A single replicate of 2^k design. NPP method, half NPP method, hidden replication method. The addition of center points to the design. Basic introduction of 3^2 and 3^3 factorial design.			15
Unit 4:	Blocking and confounding of a replicated 2^k factorial design. Das method, contrast method and sign method to obtain principal block. Total and partial confounding. Two level fractional factorial			15

	designs . The one half fractions and one quarter fraction of the 2^k design. General $2^{(k-p)}$ fractional factorial design, Das method. Alias structure. Complete defining relation. Resolution – III designs. Resolution -IV and Resolution - V designs. Statistical analysis of all these designs. Fitting response curves and response surfaces.	

References:

- Chakraborti, M. C. (1962): Mathematics of Design and analysis of Experiments. Asia Publishing House.
- Cochran, W. G. and cox, G. M. (1959): Experimental Design. 2nd Edition, Asia Publishing House
- Davies, O. L. (1954): The Design and analysis of Industrial Experiments. Oliver and Boyd.
- Das, M. N. and Giri, N. C. (2015): Design and analysis of Experiments. 2nd edition. New Age International Publishers.
- Fisher, R. A. (1935): The Design of Experiments. Oliver and Boyd.
- Montgomery, D. C. (2016): Design and analysis of Experiments. 8th edition, Wiley.

603: Stochastic Process

<table>
<tr><td>Programme Name:</td><td>M.Sc. Statistics</td><td>Course Code and Name:</td><td>603: Stochastic Processes</td><td></td></tr>
<tr><td>Total Credits:</td><td>04</td><td>Total Marks:</td><td>100</td><td></td></tr>
<tr><td>University assessment:</td><td>50</td><td>College assessment:</td><td>50</td><td></td></tr>
<tr><td colspan="4">Pre requisite:502: Probability theory.</td><td></td></tr>
<tr><td colspan="4">Course outcomes: After completion of the course learners will,
<table>
<tr><td>CO 01)</td><td>Have a good understanding of the key concepts of stochastic processes.</td></tr>
<tr><td>CO 02)</td><td>Have basic theory of Markov chain, Branching process, Renewal process, Birth and Death process, Wiener process.</td></tr>
<tr><td>CO 03)</td><td>Able to classify states of Markov chain.</td></tr>
<tr><td>CO 04)</td><td>Able to obtain higher step transition probability matrix, stationary distribution of Markov chain.</td></tr>
<tr><td>CO 05)</td><td>Able to concepts and theory behind Poisson process, Birth and Death process.</td></tr>
<tr><td>CO 06)</td><td>Able to find extinction probability of branching process.</td></tr>
</table></td><td></td></tr>
<tr><td colspan="4">MODULE I: (2 CREDITS)</td><td></td></tr>
<tr><td>Unit 1:</td><td colspan="3">Introduction to stochastic processes, real life applications of stochastic processes, introduction to different types of stochastic processes.
Markov chain, real life examples of Markov chain, order of a Markov chain, transition probabilities, Chapman-Kolmogorov equations, classification of states, periodicity, closed class, minimal closed class, stationary distribution of a Markov chain. Gamblers ruin problem, random walk. Concept of absorption probabilities, Statistical inference for Markov chains.</td><td>15</td></tr>
<tr><td>Unit 2:</td><td colspan="3">Continuous time Processes: Poisson process, Generalizations of Poisson process, birth and Death process. Brownian Motion, Wiener process, Kolmogorov equations.</td><td>15</td></tr>
<tr><td colspan="4">MODULE II: (2 CREDITS)</td><td></td></tr>
<tr><td>Unit 3:</td><td colspan="3">Renewal Process: Renewal process in continuous time, renewal</td><td>15</td></tr>
</table>

	equation, stopping time, renewal theorem. Real life applications.	
Unit 4:	Branching Process: Introduction to branching process, probability generating function of branching process, moments, classification of states, identification of criticality parameter, extinction probability, relationship between criticality parameter and extinction probability of the process, Expression for mean and variance of the process. Extinction probability, Some applications.	15
References: • Bhat, B.R. (2000). Stochastic Models: Analysis and Applications, New Age International. • Bhat, U. N. and Miller, G. K. (2002): Elements of Applied Stochastic Processes. 3rd Edition. Wiley • Basu, S (2012): Applied Stochastic Processes. New Central book agency. • Durrett, R. (1999): Essentials of Stochastic Process. • Hoel, P. G., Port, S. C. and Stone, C. J. (1972): Introduction to Stochastic Processes, Houghton Mifflin • Karlin, S. and Taylor, H. M. (1975): First Course in Stochastic Processes second edition. • Kulkarni, V. G. (2011): Modeling and Analysis of Stochastic Systems, Chapman and Hall, London. • Medhi, J. (1994): Stochastic Processes Second edition, Wiley Eastern. • Ross, S. M. (2004): Introduction to Probability Models, Wiley Eastern.		

604: Statistics Practical - V

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	604: Statistics Practical V
Total Credits:	02	**Total Marks:**	50
University assessment:	50	**College assessment:**	---

Pre requisite: Courses :601,602,603

Course outcomes: After completion of the course learners will,

CO 1) Able to understand how to reduce variable from large number of variables by principal component analysis and how to identify latent variables by exploratory factor analysis.

CO3) understand the how

CO 2) Have introduction to R language.

CO 3) Able to solve numerical problems based on one-way and two-way analysis of variance.

MODULE I: **(2 CREDITS)**

Unit 1: Following practicals must be completed using software's.

1. Principal component Analysis
2. Factor Analysis
3. Canonical correlation and variates.
4. Cluster Analysis.
5. General Block Design (GBD) and Randomized Block Design (RBD)
6. Balanced Incomplete Block Design (BIBD)
7. Factorial Experiments
8. 2^k factorial experiments
9. 2^k factorial experiments- Single replicate
10. Confounding in 2^k factorial design
11. 2-level fractional factorial design .

Elective Courses.

E1 605 (A) Elements of Data Science - I

<table>
<tr><td colspan="2">Programme Name:</td><td>M.Sc. Statistics</td><td>Course Code and Name:</td><td>E1 605 (A): Elements of Data Science - I</td><td>Lectures alloted</td></tr>
<tr><td colspan="2">Total Credits:</td><td>02</td><td>Total Marks:</td><td>50</td><td></td></tr>
<tr><td colspan="2">University assessment:</td><td>25</td><td>College assessment:</td><td>25</td><td></td></tr>
<tr><td colspan="5">Pre requisite: 502: Linear Models and 508: General Linear Models.</td><td></td></tr>
<tr><td colspan="5">Course outcomes: After completion of the course learners will,
CO 01) Know fundamental concepts statistical learnings.
CO 02) Know advanced methods of tree based classification method.
CO 03) Able to generate optimum decision tree to classify a new observation.
CO 04) Able to fit best neural network.</td><td></td></tr>
<tr><td colspan="5">MODULE I:
(2 CREDITS)</td><td></td></tr>
<tr><td>Unit 1:</td><td colspan="4">Concept of statistical learning, supervised, unsupervised learning. Classification problem, naïve Bayes classification, k-nearest neighbor, support vector machine, CART: pruning, optimal pruning. Bagging, boosting, AdaBoost, XGBoost, Random forests, model performance measures.</td><td>15</td></tr>
<tr><td>Unit 2:</td><td colspan="4">Training and testing data, bootstrap method, cross-validation approach for model accuracy. Feature selection and extraction. Neural Networks: single, multilayer neural network, convolutional neural network, types of activation functions, fitting of neural network. Real life examples. Statistical techniques for unsupervised learning.</td><td>15</td></tr>
<tr><td colspan="5"><u>References:</u>
• Breiman, L., Friedman, J. H., Olschen, R. A. and Stone, C.J. (1984): Classification of Regression Trees, Wadsowrth Publisher.
• Hand, D. J. , Mannila, H. and Smith, P. (2001): Principles of Data Mining, MIT Press, Cambridge.
• Hassoun, M. H. (1998): Fundamentals of Artificial Neural Networks, Prentice-Hall of India, New Delhi.</td><td></td></tr>
</table>

• Hastie, T., Tibshirani, R. and Friedman, J. H. (2001): The elements of Statistical Learning: Data Mining, Inference & Prediction, Springer Series in Statistics, Springer- Verlag. • Hastie, T., Tibshirani, R. and Wainwright, M. (2015): Statistical Learning with Sparsity: The Lasso and generalizations.	

E1 605 (B) Statistics Practical- VI

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E1 605 (B): Statistics Practical VI**	
Total Credits:	**02**	**Total Marks:**	**50**	
University assessment:	**50**	**College assessment:**	**---**	
Pre requisite: 502: Linear Models and 508: General Linear Models.				
Course outcomes: After completion of the course learners will, CO 01) Know fundamental concepts of python. CO 02) Able to solve practical problems on classification problems using R/python. CO 03) Able to handle and visualize the real life data using python. CO 04) Able to fit neural network to the real life data using R/python.				
MODULE I: **(2 CREDITS)**				
Unit 1:	Practical must be completed using R-Environment/ python language on following topics of E1(A): Elements of Data Science - I; naïve Bayes classification, k-nearest neighbor, support vector machine CART, Random forests, single, multilayer neural network.			15
Unit 2:	40 sessions should be conducted on python language; Introduction: basic data types, lists, tuples, dictionaries. Numpy arrays and array operations, Pandas, creating data frames. Reading and writing data, exporting and importing data files, control statements, defining functions, built-in functions. Data Handling and Visualization: dropping, renaming variables,			15

	sub-setting data, creating new variables, indexing, diagrammatic and graphical visualization, Box plot, scatter plot, heat map, higher-dimensional Plots. Multiple linear and logistic regressions.	

E2 605 (A): Statistical Process control-II

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	E2 506 (A) : Statistical Process Control-II	
Total Credits:	02	**Total Marks:**	50	
University assessment:	25	**College assessment:**	25	
Pre requisite:				
Course outcomes: After completion of the course learners will, CO 1) understands the engineering process control methods, robust design. CO 2) understand concept of six sigma, different phases, process maping etc. CO 3) understands improve phase methods. CO 4) understands ISO 9000.				
MODULE I: **(2 CREDITS)**				
Unit 1:	Engineering Process Control, Process Design and Improvement with Designed Experiments, Process Optimization with Designed Experiments, Robust Deign and Signal to Noise Ratios.			15
Unit 2:	Introduction to Lean and six – sigma: Definition of Lean, 5 S in Lean, 7 wastes in lean, 5 principles of lean. Definition of six – sigma and definition of Lean six – sigma. DMAIC over view, Define phase : VOC,VOB,VOP,CTQ,COPQ ,Project charter, DPU, DPMO, Yield, Brain Storming, SIPOC, Cause and Effect diagram Measure phase: Process definition, Process Mapping, Value Stream Mapping, sigma calculation using sigma calculator, Gage R and R. Improve Phase: Multi voting, Delphi Technique, Nominal group technique, Kaizen. ISO 9000.			15

References:

- Duncan, A. J. (1986): Quality Control and Industrial Statistics. Irwin. 5th Edition.
- Grant, E. L. and Leavenworth, R. (2017): Statistical Quality Control. McGraw Hill. 7th Edition.
- Johnson, N. L. (1977): Statistics and Experimental Design in Engineering and Physical Science. John Wiley.
- Montgomery, D. C. (2004): Introduction to Statistical Quality

Control. John Wiley. 4th Edition.

- Muralidharan, K. (2015): Six sigma for organizational Excellence: A statistical approach. Springer.
- Phadke, M. S. (1989): Quality Engineering Using Robust Design. Pearson.
- Taguchi, G. (1986): Introduction to Quality Engineering: Designing quality into products and processes. Quality resources.

E2 605 (B): Statistics Practical VI

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E2 605 (B): Statistics Practical VI**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**
Pre requisite: ---			
Course outcomes: After completion of the course learners will, CO 01) Know fundamental concepts of python. CO 02) Able to solve practical problems on statistical process control. CO 03) Able to handle and visualize the real life data using python. CO 04) Able to fit neural network to the real life data using R/python			
MODULE I: **(2 CREDITS)**			
Unit 1:	3 to 4 Practicals must be completed on topics covered in E3 605 (A): Statistical Process Control-II		
Unit 2:	40 sessions should be conducted on python language; Introduction: basic data types, lists, tuples, dictionaries. Numpy arrays and array operations, Pandas, creating data frames. Reading and writing data, exporting and importing data files, control statements, defining functions, built-in functions. Data Handling and Visualization: dropping, renaming variables, sub-setting data, creating new variables, indexing, diagrammatic and graphical visualization, Box plot, scatter plot, heat map, higher-dimensional Plots. Multiple linear and logistic regression.		

E3 605 (A): Financial Mathematics – I

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E3 605 (A): Financial Mathematics - I**	**Lectures alloted**
Total Credits:	**02**	**Total Marks:**	**50**	
University assessment:	**25**	**College assessment:**	**25**	
Pre requisite: ---				
Course outcomes: After completion of the course learners will, CO 01) Know fundamental concepts of markets, types of trading. CO 02) Able to determine forward and future price. CO 03) Know different types of interest rates. CO 04) Able to model behavior of stock prices.				
MODULE I: **(2 CREDITS)**				
Unit 1:	Introduction, future markets, determination of forward and future prices, hedging markets, interest rates, Binomial trees			15
Unit 2:	Binomial trees , model of the behavior of stock prices, Markov property, Wiener processes, Ito's lemma, The Black-Scholes-Merton model			15

References:

- David, R. (2004): Statistics and Finance: An Introduction. Springer.
- Hull, J. C. (2006): Options, Futures and Other Derivatives, 6th Edition.
- Lindstorm, E., Madsen, H. and Nielsen, J. N. (2015). *Statistics for Finance*, CRC Press
- Ross, S. M. (2011): An Elementary Introduction to Mathematical Finance. Cambridge University Press. 3rd Edition.
- Ruppert, D. (2015). *Statistics and Data Analysis for Financial Engineering: with R examples,* 2nd Ed.*,* Springer

E3 605 (B): Statistics Practical VI

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E3 605 (B): Statistics Practical VI**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**
Pre requisite: ---			

Course outcomes: After completion of the course learners will,

CO 01) Know fundamental concepts of python.

CO 02) Able to solve practical problems on Financial Mathematics.

CO 03) Able to handle and visualize the real life data using python.

CO 04) Able to fit neural network to the real life data using R/python

MODULE I:	**(2 CREDITS)**
Unit 1:	3 to 4 Practicals must be completed on topics covered in E3 605 (A): Financial Mathematics – I
Unit 2:	40 sessions should be conducted on python language; Introduction: basic data types, lists, tuples, dictionaries. Numpy arrays and array operations, Pandas, creating data frames. Reading and writing data, exporting and importing data files, control statements, defining functions, built-in functions. Data Handling and Visualization: dropping, renaming variables, sub-setting data, creating new variables, indexing, diagrammatic and graphical visualization, Box plot, scatter plot, heat map, higher-dimensional Plots. Multiple linear and logistic regression.

E4 605 (A) Statistics in Insurance - I

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E4 605 (A): Statistics in Insurance - I**	
Total Credits:	**02**	**Total Marks:**	**50**	
University assessment:	**25**	**College assessment/Department:**	**25**	
Pre requisite: ---				
Course outcomes: After completion of the course learners will, CO 01) Know need of insurance and applications of Statistics in insurance. CO 02) Know different types of insurance. CO 03) Know role of an Actuary.				
MODULE I: (2 CREDITS)				
Unit 1:	Principles of Insurance. Need of Insurance. (Utility Theory). Difference between Banks and Insurance Companies. Brief history of Insurance.			15
Unit 2:	Types of Insurance & Insurance products a. Life insurance - Term Assurance, Endowment Assurance, Annuities etc. b. Non-life insurance c. Health insurance Role of an Actuary. Actuarial Principles of Life and Health insurance including time value of money.			15
References: • Black, K. and Skipper, H. D. (2015): Life insurance. Lucretian • Bowers, N. L. Gerber, H. U., Hickman, J. C., Jones, D. A. and Nesbitt, C. J. (1997): Actuarial Mathematics. Society of Actuaries of London. 2nd Edition.				

E4 605 (B) Statistics Practical VI

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E4 605 (B): Statistics Practical VI**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**
Pre requisite: ---			

Course outcomes: After completion of the course learners will, CO 01) Know fundamental concepts of python CO 02) Able to solve insurance based practical problems. CO 03) Able to handle and visualize the real life data using python. CO 04) Able to fit neural network to the real life data using R/python.	
MODULE I:	**(2 CREDITS)**
Unit 1:	3 to 4 Practicals must be completed on topics covered in E4 605 (A): Statistics in Insurance - I
Unit 2:	40 sessions should be conducted on python language; Introduction: basic data types, lists, tuples, dictionaries. Numpy arrays and array operations, Pandas, creating data frames. Reading and writing data, exporting and importing data files, control statements, defining functions, built-in functions. Data Handling and Visualization: dropping, renaming variables, sub-setting data, creating new variables, indexing, diagrammatic and graphical visualization, Box plot, scatter plot, heat map, higher-dimensional Plots. Multiple linear and logistic regression.

605: Research Project-I

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**605: Research Project-I**
Total Credits:	**04**	**Total Marks:**	**100**
University assessment:	**50**	**College assessment/Department:**	**50**

Pre requisite:501: Research Methodology in statistics.

Course outcomes: After completion of the course learners will,

CO1) Understand how to collect literature on chosen research problem.

CO2) Understand how to collect real life data, coding , analyze the data using advanced statistical methods and interpretation of results.

CO3) understand how to make project presentations using advanced software like Beamer and how to write reports in Latex software.

Evaluation Pattern

	Total Marks	**Project**	**Project**	**Viva**

		Report	**presentation**	
External	**50**	**20**	**20**	**10**
Internal	**50**	**Internal evaluation will be done by allotted supervisor.**		

EXAMINATION PATTERN FOR THEORY COURSES

Each course will be evaluated in two components,

Component A] Continuous Internal Evaluation (CIE) and

Component B] Semester End Examination (SEE)

CIE will be of 50 marks which will include,

- one test of 30 marks of one and half hour duration and
- other 20 marks are composed of any one or combinations of group discussion, presentation, viva-voce, open notebook test, surprise test, assignments, data analysis etc. to be conducted by respective teacher.

SEE will be a theory examination of 50 marks of two hours duration based on entire syllabus. The question paper will consist of six questions of 10 marks each. Student should answer any five questions out of six questions.

EXAMINATION PATTERN FOR PRACTICAL COURSES

At the end of semester there will be a practical examination of 50 marks and of two hours duration for each of the practical course. The distribution of total of 50 marks is as given below,

Practical Examination	Viva	Journal	Total
40 marks	10 marks	Compulsory	50 marks

M.Sc. (Statistics) Part II
Semester IV
Mandatory courses

607 : Time series Analysis.

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**607: Time Series Analysis**	
Total Credits:	**04**	**Total Marks:**	**100**	
University assessment:	**50**	**College assessment:**	**50**	
Pre requisite: ---				
Course outcomes: After completion of the course learners will, CO 01) Know the essential knowledge and concepts of time series. CO 02) Know a comprehensive set of tools and techniques for analyzing time series. CO 03) Know concepts of trend, periodic, irregular fluctuations, stationarity. CO 04) Know ARMA, ARIMA, SARIMA, ARCH, GARCH processes. CO 05) Able to carry out exploratory analysis of a time series. CO 06) Able to identify different components of a time series. CO 07) Able to analyze different time series processes. CO 08) Able to determine best fitted time series process to the real life data.				
MODULE I: **(2 CREDITS)**				
Unit 1:	Real life examples of time series, types of variation in time series, exploratory time series analysis, auto-covariance and auto-correlation functions, properties of auto-correlation function of a stationary process. Estimation of mean, auto covariance and autocorrelation functions of stationary process. Tests of randomness, tests for trend, seasonality, Portmanteau tests for noise sequences, Gaussian process. Moving average smoothing. Exponential and Holt -Winters smoothing, adaptive smoothing. Forecasting based on smoothing.			15

Unit 2:	General linear process, Auto regressive (AR), Moving average (MA) and Autoregressive moving average (ARMA) processes, autocorrelation and partial autocorrelation functions, stationary and invertibility conditions of ARMA process. Computations of π weights, ψ weights.	15
MODULE II: **(2 CREDITS)**		
Unit 3:	Preliminary estimates: Yule-Walker estimation, Durbin-Levinson algorithm, innovations algorithm. Maximum likelihood estimators, least square estimators of ARMA process parameters. Forecasting of ARMA process.	15
Unit 4:	Model building: identification techniques, order selection, residual analysis and diagnostic checking. Nonstationary and seasonal time series models: Auto regressive integrated moving average (ARIMA) models, Seasonal ARIMA (SARIMA) models, estimation and forecasting. Introduction to ARCH and GARCH models, introduction to count time series.	15
References: • Brockwell, P. J. and Davis, R. A. (2003): Introduction to Time Series Analysis, Springer • Chatfield, C. (2001): Time Series Forecasting, Chapman &Hall. • Fuller, W. A. (1996): Introduction to Statistical Time Series, 2nd Ed. Wiley. • Box, G.E. P., Jenkins, G. M., Reinsel, G. C. and Lung, G. M. (2016): Time series analysis: Forecasting and control. 5th Ed. Wiley. • Hamilton, N. Y. (1994): Time Series Analysis, Princeton University press. • Kendall, M. and Ord, J. K. (1990): Time Series, 3rd Ed. Edward Arnold. • Lutkepohl, H. (2005): New Introduction to Multiple Time Series Analysis, Springer • Montgomery, D. C., Jennings, C. L. and Kulahci, M. (2015): Introduction to time series analysis and forecasting. 2nd Ed. Wiley. • Shumway, R. H. and Stoffer, D. S. (2010): Time Series Analysis &		

Its Applications, Springer. • Tsay, R. S. (2010): Analysis of Financial Time Series, Wiley.	

608: Reliability and Survival Analysis

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	608:Reliability and Survival Analysis.	Lectures alloted
Total Credits:	04	**Total Marks:**	100	
University assessment:	50	**College assessment:**	50	
Pre requisite: Course 503				
Course outcomes: After completion of the course learners will, CO 1) Able to understand concept of survival analysis and reliability of products. CO 2) Able to uses of different distribution in life time data. CO 3) Able to understand parametric and nonparametric estimation of time to event data. CO4) Able to understand concept of frailty models and their uses in real life situation.				
MODULE I: **(2 CREDITS)**				
Unit 1:	Introduction to Survival Analysis: need of survival analysis, Survival function, Hazard function, cumulative hazard function, reversed hazard function, nature of hazard function, bath-tub shape hazard function, class of increasing failure rate distributions, decreasing failure rate distributions, theorems. Relations between survival function, probability function, hazard function, cumulative hazard function, and reversed hazard function. Lifetime distributions: exponential, Weibull, gamma, extreme value distributions, log-normal distribution.			15
Unit 2:	Censoring: left censoring, right censoring, interval censoring, random censoring, times censoring, order censoring, hybrid censoring. Kaplan-Meier estimator of survival function, properties of Kaplan-Meier estimator, Nelson-Aalen estimator of cumulative hazards function. Linear and log-transformed confidence interval			15

	for survival function and cumulative hazard function. Q-Q plot, hazards plot for lifetime distributions. Competing risk models.	
MODULE II: **(2 CREDITS)**		
Unit 3:	Regression models in Survival analysis: proportional hazards model, Accelerated failure time model, Cox proportional hazards model, residual analysis of proportional hazards models. Frailty models: Univariate frailty, multivariate frailty models, shared frailty, correlated frailty, additive frailty models. Using Weibull as baseline and gamma as frailty distribution.	15
Unit 4:	Reliability of the system: structure function, standard systems: series system, parallel system, k-out-of-n system, coherent system, path sets and path vectors, minimal path sets, cut sets and cut vector, minimal cut sets, reliability of coherent system, reliability bounds.	15

References:

- Barlow, R. E. and Proschan, F. (1965): Mathematical theory of reliability
- Barlow, R. E. and Proschan, F. (1975): Statistical theory of reliability and life testing. Holt, Reinhart and Winston.
- Deshpande, J. V. and Purohit, S. G. (2005). Life Time Data: Statistical Models and Methods, World Scientific.
- Hanagal, D. D. (2011). Modeling Survival Data Using Frailty Models. CRC Press.
- Hosmer, D. and Lemeshow, S. (1999). Applied Survival Analysis: Regression Modeling of Time to Event Data, Wiley, New York.
- Kalbfleisch, J. D. and Prentice, R.L. (1986): The Statistical Analysis of Failure Time Data, John Wiley.
- Kleinbaum, D. G. and Klein, M. (2012). Survival Analysis: A Self-Learning Text, 3rd Ed, Springer, New York.
- Lawless, J.F.(1982): Statistical models and methods for life time data. John Wiley.
- Lee, E. T. and Wang, J. W. (2003). Statistical Methods for Survival Data Analysis, 3rd Edition. John Wiley.
- Liu, X. (2012). Survival Analysis: Models and Applications, Wiley, New York.

- Ross S. M. (2014): Introduction to Probability Models. Elsevier. 11th Edition.
- Smith, P.J. (2002): Analysis of Failure and Survival data. CRC.
- Wienke, A. (2011). Frailty Models in Survival Analysis, CRC.

609: Structural Equation Modeling.

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	608:Structural Equation Modeling	
Total Credits:	02	**Total Marks:**	50	
University assessment:	25	**College assessment:**	25	
Pre requisite: Course 508, 601				
Course outcomes: After completion of the course learners will, CO 1) Understand the concept of Structural equation model and real life application. CO 2) Understand how to build-up model using software. CO 3) understand the how to modify model if not fit well.				
MODULE I: **(2 CREDITS)**				
Unit 1:	Introduction to SEM, Measurement scale, Measurement variable and latent variable , Measurement model and structural model. Developing SEM Model: Model Specification, Model identification, Model estimation. Confirmatory factor analysis (CFA), Exploratary factor analysis vs Confirmatory factor analysis (CFA), Regression model. Path model			15
Unit 2:	Model fit indices: Goodness of fit index(GFI), Adjusted goodness of fit index(AGFI),Root mean square residual (RMR), Standardized (RMR) is SRMR , Root mean square of approximation (RMSEA) Model comparison: Tucker-Lewis index(TLI), Normed fit index (NFI), Model Parsimony: Parsimony fit index (PNFI) Comparative fit index(CFI), Non normed fit index(NNFI), Akaike			15

	information criterion(AIC). Modification Indices.	
References: • Randall E. Schumacker, A beginner's guide to Structural Equation Modelling, Third Edition, Routledge, Taylor and Francies publication. •		

610: Statistics Practical - VII

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	610: Statistics Practical VII
Total Credits:	02	**Total Marks:**	50
University assessment:	50	**College assessment:**	---
Pre requisite: Courses 607, 608, 609			
Course outcomes: After completion of the course learners will, CO 1) be able to solve time series models using softwares. CO 2) understand how to apply time series models to real life situation CO 3) understand how to estimate survival function , hazard function using parametric as well as non-parametric methods. CO4) be able to create path models using software's in structural equation modeling and their real life application.			
	List of Practicals		
	1. Survival Analysis. 2. Non-parametric function of Survival Function 3. Data Plotting 4. Structural Equation Modelling 5. Smoothing 6. Elementary Time Series 7. Fitting of Time series.		

Elective Courses

E1 611 (A) Elements of Data Science - II

<table>
<tr><td>Programme Name:</td><td>M.Sc. Statistics</td><td>Course Code and Name:</td><td>E1 611 (A): Elements of data science - II</td><td>Lectures alloted</td></tr>
<tr><td>Total Credits:</td><td>02</td><td>Total Marks:</td><td>50</td><td></td></tr>
<tr><td>University assessment:</td><td>25</td><td>College assessment:</td><td>25</td><td></td></tr>
<tr><td colspan="4">Pre requisite: 503: Linear Models, 508: General Linear Models.</td><td></td></tr>
<tr><td colspan="4">Course outcomes: After completion of the course learners will,
CO 01) Know basic concepts of advanced regression methods.
CO 02) Know penalized regression, dimension reduction regression methods.
CO 03) Know different nonlinear regression methods.
CO 04) Know the fundamental concepts of nonparametric regression methos.</td><td></td></tr>
<tr><td colspan="4">MODULE I:
(2 CREDITS)</td><td></td></tr>
<tr><td>Unit 1:</td><td colspan="3">Penalized regression: ridge, generalized ridge, lasso regression, selection of tuning parameter, principle component, partial least squares regression. Introduction to high-dimension data problem.</td><td>15</td></tr>
<tr><td>Unit 2:</td><td colspan="3">Introduction to Nonlinear regression, polynomial regression, regression, smoothing splines, generalized additive models, introduction to Nonparametric regression, kernel methods.</td><td>15</td></tr>
<tr><td colspan="4"><u>References:</u>
• Hardle, W.(1990): Applied Nonparametric Regression, Cambridge University Press.
• Hastie, T. and Tibshirani, R.(1990): Generalized Additive Models, Chapman and Hall, London.
• Hastie, T., Tibshirani, R. and Friedman, J. H. (2001): The elements of Statistical Learning: Data Mining, Inference & Prediction, Springer Series in Statistics, Springer- Verlag.
• Hastie, T., Tibshirani, R. and Wainwright, M. (2015): Statistical Learning with Sparsity: The Lasso and generalizations.
• Seber, G. A. F. and Wild, C. J. (1989): Nonlinear Regression, John Wiley.</td><td></td></tr>
</table>

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E1 611 (B): Statistics Practical VIII**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**

Pre requisite: ---

Course outcomes: After completion of the course learners will,

CO 01) Know fundamental concepts of SQL language.

CO 02) Able to solve practical problems on advanced regression problems using R-Environment/python language.

CO 03) Able to handle and visualize the real life data using SQL language.

CO 04) Able to fit neural network to the real life data using SQL language.

MODULE I: (2 CREDITS)

Unit 1:	Practicals must be completed using R-Environment/ python language on following topics; Penalized regression, principle component and partial least squares regression, nonlinear regression.
Unit 2:	40 sessions should be conducted on SQL language; Database management system, introduction to SQL, creating database, data editing: count, update, delete, unique, drop. Logical operators, where, group by, having order by, querying using database office, statistical data visualization, summary statistics.

E3 611 (A) Financial Mathematics – II

<table>
<tr><td colspan="2">Programme Name:</td><td>M.Sc. Statistics</td><td>Course Code and Name:</td><td>E3 611 (A): Financial Mathematics- II</td><td></td></tr>
<tr><td colspan="2">Total Credits:</td><td>02</td><td>Total Marks:</td><td>50</td><td></td></tr>
<tr><td colspan="2">University assessment:</td><td>25</td><td>College assessment:</td><td>25</td><td></td></tr>
<tr><td colspan="5">Pre requisite: ---</td><td></td></tr>
<tr><td colspan="5">Course outcomes: After completion of the course learners will,
CO 01) Know volatility smiles.
CO 02) Know the concept of VaR measure.
CO 03) Able to model VaR measure.
CO 04) Able to estimate current and future levels of volatilities and correlations using EWMA, ARCH, GARCH models.</td><td></td></tr>
<tr><td colspan="5">MODULE I:
(2 CREDITS)</td><td></td></tr>
<tr><td>Unit 1:</td><td colspan="4">Volatility, value at Risk: VaR measure, linear, quadratic model building approach.</td><td>15</td></tr>
<tr><td>Unit 2:</td><td colspan="4">Estimating volatilities and correlations: exponentially weighted moving average, ARCH, GARCH models, stochastic volatility models.</td><td>15</td></tr>
<tr><td colspan="5"><u>References:</u>
• David, R. (2004): Statistics and Finance: An Introduction. Springer.
• Hull, J. C. (2006): Options, Futures and Other Derivatives, 6th Edition.
• Lindstorm, E., Madsen, H. and Nielsen, J. N. (2015). Statistics for Finance, CRC Press
• Ross, S. M. (2011): An Elementary Introduction to Mathematical Finance. Cambridge University Press. 3rd Edition.
• Ruppert, D. (2015). Statistics and Data Analysis for Financial Engineering: with R examples, 2nd Ed., Springer</td><td></td></tr>
</table>

E3 611 (B) Statistics Practical VIII

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E3 611 (B): Statistics Practical VIII**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**

Pre requisite: ---

Course outcomes: After completion of the course learners will,

CO 01)	Know fundamental concepts of SQL language.
CO 02)	Able to solve practical problems on financial mathematics.
CO 03)	Able to handle and visualize the real life data SQL language.
CO 04)	Able to fit neural network to the real life data using SQL language.

MODULE I: (2 CREDITS)

Unit 1:	Practicals must be completed on topics covered in E3 611 (A): Financial Mathematics - II;
Unit 2:	40 sessions should be conducted on SQL language; Database management system, introduction to SQL, creating database, data editing: count, update, delete, unique, drop. Logical operators, where, group by, having order by, querying using database office, statistical data visualization, summary statistics.

E4 611 (A) Statistics in Insurance - II

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E4 611 (A): Statistical in Insurance – II**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**25**	**College assessment:**	**25**

Pre requisite: ---

Course outcomes: After completion of the course learners will,

CO 01) Able to calculate risk premiums.

CO 02) Able to determine pension plans.

CO 03) know different risks and managing it

MODULE I: (2 CREDITS)

Unit 1:	Gross Premium and Net Premium calculation. Life Insurance Reserves. Risk Premium calculation. Statistical distributions useful in General Insurance.
Unit 2:	Credibility Theory and Bayes' Theorem. Pension plans and Wealth Management.

	Risks - Types of Risk and Risk Management including Underwriting.

References:

- Black, K. and Skipper, H. D. (2015): Life insurance. Lucretian
- Bowers, N. L. Gerber, H. U., Hickman, J. C., Jones, D. A. and Nesbitt, C. J. (1997): Actuarial Mathematics. Society of Actuaries of London. 2nd Edition.

E4 611 (B) Statistics Practical VIII

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E4 611 (B): Statistics Practical VIII**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**

Pre requisite: ---

Course outcomes: After completion of the course learners will,

CO 01) Know fundamental concepts of SQL Language.

CO 02) Able to solve practical problems on insurance.

CO 03) Able to handle and visualize the real life data using SQL Language.

CO 04) Able to fit neural network to the real life data using SQL Language.

MODULE I: (2 CREDITS)

Unit 1:	Practicals must be completed on topics covered in E4 611 (A): Statistics in Insurance.
Unit 2:	40 sessions should be conducted on SQL language; Database management system, introduction to SQL, creating database, data editing: count, update, delete, unique, drop. Logical operators, where, group by, having order by, querying using database office, statistical data visualization, summary statistics.

E4 611 (A): Statistical Decision Theory

Programme Name:	M.Sc. Statistics	**Course Code and Name:**	E4 611 (A): Statistical Decision Theory
Total Credits:	02	**Total Marks:**	50
University assessment:	25	**College assessment:**	25
Pre requisite: ---			
Course outcomes: After completion of the course learners will, CO 1) Understand concept of decision problem and real life application. CO 2) Able to understand how to find loss function ,risk function. CO 3) Understand concepts of optimum decision rules, minimax rule.			
MODULE I:			**(2 CREDITS)**
Unit 1:	Formulation of decision problems, randomized and nonrandomized decision rules, illustrative examples, loss function, risk function, prior distributions, conjugate priors, posterior distributions.		
Unit 2:	Optimum decision rules, Bayes' rule, minimax rule, admissibility of rules, sufficiency and Rao-Blackwellization.		

References:

- Gross, D. and Harris, C. M. (2002): Fundamentals of queueing theory. John Wiley.
- Kambo, N. S. (2008): Mathematical Programming Techniques. Affiliated East West Press Pvt.
- Taha, H. A. (2010): Operations Research: An introduction. Pearson. 9th Edition.
- Winston, W. L. (2003): Operations Research: Applications and Algorithms. Cengage Learning. 4th Edition.
- Swarup, K., Gupta, P. K. and Mohan, M. (1992): Operations Research. Sultan Chand and Sons.

E4 611 (B) Statistics Practical VIII

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**E4 611 (B): Statistics Practical VIII**
Total Credits:	**02**	**Total Marks:**	**50**
University assessment:	**50**	**College assessment:**	**---**
Pre requisite: ---			
Course outcomes: After completion of the course learners will,			

CO 01)	Know fundamental concepts of SQL Language.
CO 02)	Able to solve practical problems on insurance.
CO 03)	Able to handle and visualize the real life data using SQL Language.
CO 04)	Able to fit neural network to the real life data using SQL Language.

MODULE I:	**(2 CREDITS)**
Unit 1:	Practical must be completed on topics covered in E4 611 (A): Statistical decision theory.
Unit 2:	40 sessions should be conducted on SQL language; Database management system, introduction to SQL, creating database, data editing: count, update, delete, unique, drop. Logical operators, where, group by, having order by, querying using database office, statistical data visualization, summary statistics.

605: Research Project-II

Programme Name:	**M.Sc. Statistics**	**Course Code and Name:**	**605: Research Project-II**
Total Credits:	**06**	**Total Marks:**	**150**
University assessment:	**75**	**College assessment/Department:**	**75**

Pre requisite:501: Research Methodology in statistics.

Course outcomes: After completion of the course learners will,

CO1) Understand how to formulate research problem and their objectives.

CO2) Understand how to collect literature on given research problem.

CO3) Understand how to collect real life data, coding , analyze the data using advanced statistical methods and interpretation of results.

CO4) understand how to write research paper and publish paper in journal or one presentation in state/national/ International conferences.

Note: Student must publish paper in peer-reviewed journal or one presentation in state/national/International conferences.

Evaluation Pattern

	Total Marks	**Project Report**	**Paper publication/ Presentations in conferences**	**Project presentation**	**Viva**
External	**75**	**20**	**20**	**20**	**15**

Internal	**75**	**Internal evaluation will be done by allotted supervisor.**

EXAMINATION PATTERN FOR THEORY COURSES

Each course will be evaluated in two components,

Component A] Continuous Internal Evaluation (CIE) and

Component B] Semester End Examination (SEE)

CIE will be of 50 marks which will include,

- one test of 30 marks of one and half hour duration and
- other 20 marks are composed of any one or combinations of group discussion, presentation, viva-voce, open notebook test, surprise test, assignments, data analysis etc. to be conducted by respective teacher.

SEE will be a theory examination of 50 marks of two hours duration based on entire syllabus. The question paper will consist of six questions of 10 marks each. Student should answer any five questions out of six questions.

EXAMINATION PATTERN FOR PRACTICAL COURSES

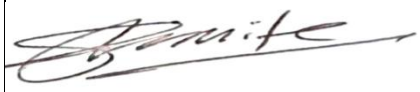
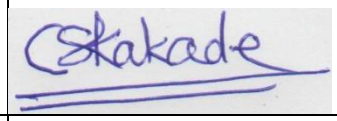
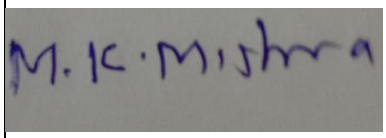
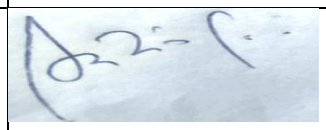
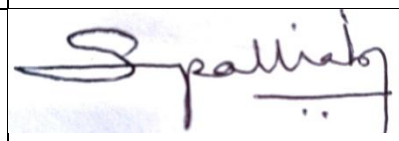
At the end of semester there will be a practical examination of 50 marks and of two hours duration for each of the practical course. The distribution of total of 50 marks is as given below,

Practical Examination	Viva	Journal	Total
40 marks	10 marks	Compulsory	50 marks

LETTER GRADES AND GRADE POINTS

Semester GPA / Program CGPA Semester / Program	**Percentage of Marks**	**Alpha-sign / Letter Grade Result**
09.00 – < 10.00	90.00 – 100	O (Outstanding)
08.00 – < 09.00	80.00 - < 90.00	A+ (Excellent)
07.00 – < 08.00	70.00 - < 80.00	A (Very Good)
06.00 – < 07.00	60.00 - < 70.00	B+(Good)
05.50 – < 06.00	55.00 - < 60.00	B (Above Average)
05.00 - < 05.50	50.00 - < 55.00	C (Average)
04.00 – < 05.00	40.00 - < 50.00	P (Pass)
Below 04.00	Below 40.00	F (Fail)
Absent	---	Absent

List of B.O.S, Members in Statistics.

Sr.No	Name	Signature
1.	Dr. Santosh P. Gite	
2.	Dr. C.S. Kakde	
3.	Dr. Manoj Mishra	
4.	Dr. Alok Dabade	
5.	Dr. Sujata Suvarnapatki	

Appendix-B

Justification for M.Sc. (Statistics)

1.	Necessity for starting the course:	Now days Statistics is required to analyze data in every field. This program accentuates both the core and modern applications of Statistics. The program is structured so that students will have in depth knowledge of Statistics for pursuing their higher studies and also necessary skills in statistics for the employability in corporate.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether the course have commenced from the academic year 2022-23.	The course has already commenced from the academic year 1948 and in academic year 2022-23, it is restructured under NEP, 2020.
4.	The course started by the university is self-financed, whether adequate number of eligible permanent faculties is available?	This course is not self-financed. Currently three permanent faculty members are working in the department out of ten sanctioned faculty positions.
5.	To give details regarding the duration of the course and is it possible to compress the course?	Duration of the program is two years (four semesters). It is not possible to compress the course. Under NEP, 2020 students have option of exit at the end of first year with PG Diploma in Statistics.
6.	The intake capacity of each course and number of admissions given in the current academic year;	The intake capacity of program is 60. Number of admissions for the academic year 2022-23 is 60.
7.	Opportunity of Employability / Employment available after undertaking these courses:	There is a good opportunity for employment. Students have employability in education and research. Also they can get employment in corporate, multinational companies as a statistician, like finance, banks sector, pharmaceutical sector, IT sector etc.

Sign of the BOS Chairman
Dr. Santosh Gite
Board of Studies in Statistics

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology