MAR ATHANASIUS COLLEGE (AUTONOMOUS)

KOTHAMANGALAM, KERALA-686666

NAAC Accredited 'A+ ' Grade Institution

Email: mac@macollege.in
www.macollege.in

SCHEME AND SYLLABUS

FOR

POSTGRADUATE PROGRAMME

UNDER CREDIT SEMESTER SYSTEM

MAC-PG-CSS 2020

IN

STATISTICS

EFFECTIVE FROM THE ACADEMIC YEAR 2020-21

BOARD OF STUDIES IN STATISTICS (PG)

ACADEMIC COUNCIL

COMPOSITION – With Effect From 01-06-2020

Chairperson : **Dr. Shanti A. Avirah**
Principal
Mar Athanasius College (Autonomous), Kothamangalam

Experts/Academicians from outside the college representing such areas as Industry,Commerce, Law, Education, Medicine, Engineering, Sciences etc.

1. **Dr. Winny Varghese**
Secretary
Mar Athanasius College Association
Kothamangalam

2. **Prof. Dr. V.N. Rajasekharan Pillai**
Former Vice-Chairman
University Grants Commission,
New Delhi.

3. **Dr. R.K. Chauhan**
Former Vice-Chancellor, Lingaya's University,
Faridabad, Haryana -121002

4. **Dr. Sheela Ramachandran**
Pro-Chancellor,
Atmiya University
Rajkot.

5. **Prof. Kuruvilla Joseph**
Senior Professor and Dean,
Indian Institute of Space Science and Technology (IIST),
Department of Space, Govt. of India, Valiyamala, Thiruvananthapuarm

6. **Dr. M.C. Dileep Kumar**
Former Vice Chancellor
Sree Sankaracharya Sanskrit University
Kalady, Kerala, India

7. **Dr. Mathew. K.**
Principal
Mar Athanasius College of Engineering,
Kothamangalam, Kerala - 686 666

8. **Adv. George Jacob**
Senior Advocate
High Court of Kerala
Ernakulam

Nominees of the University not less than Professors

9. **Dr. Biju Pushpan**
SAS SNDP Yogam College
Konni

10. **Dr. Suma Mary Sacharia**
UC College
Aluva

11. **Dr. V.B. Nishi**
Associate Professor
Sree Shankara College, Kalady.

Member Secretary

12. **Dr. M.S. Vijayakumary**

Dean – Academics

Mar Athanasius College (Autonomous)

Kothamangalam

Four teachers of the college representing different categories of teaching staff by rotation on the basis ofseniority of service in the college.

13. **Dr. Bino Sebastian. V** (Controller of Examinations)

14. **Dr. Manju Kurian,** Asst. Professor, Department of Chemistry

15. **Dr. Smitha Thankachan**, Asst. Professor, Department of Physics

16. **Dr. Asha Mathai**, Asst. Professor, Department of Malayalam

Heads of the Departments

17. Dr. Mini Varghese, Head, Department of Hindi

18. Dr. Jayamma Francis, Head, Department of Chemistry

19. Dr. Igy George, Head, Department of Economics

20. Ms. Shiny John, Head, Department of Computer Science

21. Dr. Deepa. S, Head, Department of Physics

22. Sri. Dr. Rajesh.K. Thumbakara, Head, Department of Mathematics

23. Dr. Aji Abraham, Head, Department of Botany

24. Dr. Selven S., Head, Department of Zoology

25. Dr. Diana Ann Issac, Head, Department of Commerce

26. Smt. Sudha. V, Head, Department of Statistics

27. Dr. Aswathy Balachandran, Head, Department of English

28. Dr. Diana Mathews, Head, Department of Sociology

29. Dr. Jani Chungath, Head, Department of History

30. Dr. Seena John, Head, Department of Malayalam

31. Mr. Haary Benny Chettiamkudiyil, Head, Department of Physical Education

32. Ms. Shari Sadasivan, Head, Department of International Business

33. Ms. Sheeba Stephen, Head, Department of B. Com Tax Procedure and Practice

34. Dr. Julie Jacob, Head, Department of Biochemistry

35. Ms. Nivya Mariyam Paul, Head, Department of Microbiology

36. Ms. Jaya Vinny Eappen, Head, Department of Biotechnology

37. Ms. Shalini Binu, Head, Department of Actuarial Science

38. Prof. Dilmol Varghese , Head, Department of M. Sc Zoology

39. Ms. Simi. C.V, Head, Department of M.A.History

40. Ms. Bibin Paul, Head, Department of M. A. Sociology

41. Ms. Sari Thomas, Head, Department of M.Sc Statistics

BOARD OF STUDIES MEMBERS IN STATISTICS (PG)

SL. NO.	NAME	OFFICIAL ADDRESS
	CHAIRPERSON	
1	Smt. SUDHA V	Assistant Professor Department of Statistics Mar Athanasius College(Autonomous), Kothamangalam
	EXPERTS (2)	
2	Dr. RANI SEBASTIAN	Assistant Professor Department of Statistics St Thomas College, Thrissur
3	Dr. G RAJESH	Associate Professor Department of Statistics Cochin University of Science & Technology Kalamassery, Kochi.
	UNIVERSITY NOMINI	
4	Dr. JAMES KURIEN	Associate Professor and Head. Department of Statistics Maharajas College, Ernakulam
	MEMBER FROM INDUSTRY	
5	Dr. D DHANURAJ	Chairman Centre for Public Policy Research, Kochi
	MERITORIOUS ALUMNUS	
6	Dr. ABDUL SATHAR E I	Assistant Professor Department of Statistics Kerala University, Kariavattom
	MEMBER TEACHERS IN THE DEPARTMENT	
7	Dr. NIDHI P RAMESH	Assistant Professor Department of Statistics Mar Athanasius College(Autonomous), Kothamangalam
8	SARI THOMAS	Assistant Professor and Course Co-ordinator Department of Statistics Mar Athanasius College(Autonomous), Kothamangalam
9	GIGI PAULOSE	Assistant Professor Department of Statistics Mar Athanasius College(Autonomous), Kothamangalam
10	ELBY ALIAS	Assistant Professor Department of Statistics Mar Athanasius College(Autonomous), Kothamangalam

TABLE OF CONTENTS

PREFACE

Statistics is the language of the uncertainties riddled modern information age. Statistics facilitates the decision making process by quantifying the element of chance or uncertainties. It's descriptive and inferential roles not only formulate the basis of the growth of almost all the disciplines of the contemporary world, but also provide an array of non-traditional employment avenues ranging from that of sport analysts to business analysts. The thrust of the course is to prepare students to enter into a promising professional life even after graduation, as also provide to them a platform for pursuing higher studies leading to post-graduate or doctorate degrees.

The Board of Studies in Statistics proceeded with the task of restructuring the PG programme in Statistics at Mar Athanasius College (Autonomous) as per the terms of reference and guidelines given by the university in line with the proposals put forward by the University Grant Commission. The board of studies prepared a comprehensive plan of action for introducing the CSS in the PG programmes with effect from the academic year 2020-2021. The revision were effected based on the recommendations made at the workshops conducted for the purpose, besides several sittings of the board of studies. It is envisaged that students will have maximum opportunity to pursue their own interest and chosen fields of courses. The diversity available within the overall frame work helps flexible specialization. We greatfully acknowledge the assistance and guidance received from the management and the university and all those who have contributed in different ways in the venture. It is recommended that the content of the syllabi to be reviewed and adopted in the consultive process, made use of in future curriculum initiatives and also in the periodical revision of the syllabi and curriculum. I hope this restricted syllabi and curriculum would enrich and equip the students to meet future challenges.

Smt. Sudha V
Chairperson and Member
Board of Studies of Statistics
Mar Athanasius College (Autonomous),
Kothamangalam

LIST OF PG PROGRAMMES IN MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM

SL. NO.	PROGRAMME	DEGREE	FACULTY
1	ENGLISH	MA	LANGUAGE AND LITERATURE
2	ECONOMICS	MA	SOCIAL SCIENCES
3	SOCIOLOGY	MA	SOCIAL SCIENCES
4	HISTORY	MA	SOCIAL SCIENCES
5	MATHEMATICS	M.Sc	SCIENCE
6	CHEMISTRY	M.Sc	SCIENCE
7	PHYSICS	M.Sc	SCIENCE
8	BOTANY	M.Sc	SCIENCE
9	STATISTICS	M.Sc	SCIENCE
10	ZOOLOGY	M.Sc	SCIENCE
11	BIOCHEMISTRY	M.Sc	SCIENCE
12	BIOTECHNOLOGY	M.Sc	SCIENCE
13	MICROBIOLOGY	M.Sc	SCIENCE
14	ACTUARIAL SCIENCE	M.Sc	SCIENCE
15	FINANCE AND TAXATION	M.Com	COMMERCE
16	MARKETING AND INTERNATIONAL BUSINESS	M.Com	COMMERCE

REGULATIONS OF THE POSTGRADUATE PROGRAMMES UNDER CREDIT SEMESTER SYSTEM MAC-PG-CSS2020 (2020 Admission onwards)

1. SHORT TITLE

1.1 These Regulations shall be called "Mar Athanasius College (Autonomous) Regulations (2020) governing Postgraduate Programmes under the Credit Semester System (MAC-PG-CSS2020)".

1.2 These Regulations shall come into force from the Academic Year 2020-2021.

2. SCOPE

2.1 The regulations provided herein shall apply to all Regular Postgraduate (PG) Programes, M.A. /M.Sc. /M.Com. conducted by Mar Athanasius College (Autonomous) with effect from the academic year 2020-2021 admission onwards.

3. DEFINITIONS

3.1 **'Academic Committee'** means the Committee constituted by the Principal under this regulation to monitor the running of the Post-Graduate programmes under the Credit Semester System (MAC-PG-CSS2020).

3.2 **'Academic Week'** is a unit of five working days in which distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day. A sequence of 18 such academic weeks constitutes a semester.

3.3 '**Audit Course**' is a course for which no credits are awarded.

3.4 **'CE' means Continuous Evaluation (Internal Evaluation)**

3.5 **'College Co-ordinator'** means a teacher from the college nominated by the Principal to look into the matters relating to MAC-PG-CSS2020 for programmes conducted in the College.

3.6 **'Comprehensive Viva-Voce'** means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.

3.7 **'Common Course'** is a core course which is included in more than one programme with the same course code.

3.8 '**Core Course**' means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

3.9 '**Course**' means a segment of subject matter to be covered in a semester. Each Course is to be designed variously under lectures / tutorials / laboratory or fieldwork / seminar / project /practical training / assignments/evaluation etc., to meet effective teaching and learning needs.

3.10 **'Course Code'** means a unique alpha numeric code assigned to each course of a programme.

3.11 '**Course Credit**' One credit of the course is defined as a minimum of one hour lecture /minimum of 2 hours lab/field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the final examination.

3.12 **'Course Teacher'** means the teacher of the institution in charge of the course offered in the programme.

3.13 **'Credit (Cr)'** of a course is a numerical value which depicts the measure of the weekly unit of work assigned for that course in a semester.

3.14 '**Credit Point(CP)**' of a course is the value obtained by multiplying the grade point (GP) by (Cr) of the course **CP=GP x Cr**.

3.15 '**Cumulative Grade Point Average(CGPA)**' is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places. CGPA determines the overall performance of a student at the end of a programme.

(CGPA = Total CP obtained/ Total credits of the programme)

3.16 '**Department**' means any teaching Department offering a programme of study in the institution.

3.17 '**Department Council**' means the body of all teachers of a Department in a College.

3.18 **'Dissertation'** means a long document on a particular subject in connection with the project /research/ field work etc.

3.19 '**Duration of Programme**' means the period of time required for the conduct of the programme. The duration of post-graduate programme shall be 4 semesters spread over two academic years.

3.20 '**Elective Course**' means a course, which can be substituted, by equivalent course from the same subject.

3.21 **'Elective Group'** means a group consisting of elective courses for the programme.

3.22 **'ESE' means End Semester Evaluation (External Evaluation).**

3.23 **'Evaluation'** is the process by which the knowledge acquired by the student is quantified as per the criteria detailed in these regulations.

3.24 **External Examiner** is the teacher appointed from other colleges for the valuation of courses of study undergone by the student in a college. The external examiner shall be appointed by the college.

3.25 '**Faculty Advisor**' is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department.

3.26 '**Grace Grade Points**' means grade points awarded to course(s), recognition of the students' meritorious achievements in NSS/ Sports/ Arts and cultural activities etc.

3.27 '**Grade Point**' (GP) Each letter grade is assigned a Grade point (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

3.28 '**Grade Point Average (GPA)**' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade point obtained in the course by the sum of the weights of Course.**(GPA= ∑WGP / ∑W)**

3.29 '**Improvement Course**' is a course registered by a student for improving his performance in that particular course.

3.30 **'Internal Examiner'** is a teacher nominated by the department concerned to conduct internal evaluation.

3.31 '**Letter Grade**' or '**Grade**' for a course is a letter symbol (A+, A, B+, B, C+, C, D) which indicates the broad level of performance of a student for a course.

3.32 **MAC-PG-CSS2020 means Mar Athanasius College Regulations Governing Post Graduate programmes under Credit Semester System, 2020.**

3.33 '**Parent Department**' means the Department which offers a particular postgraduate programme.

3.34 '**Plagiarism**' is the unreferenced use of other authors' material in dissertations and is a serious academic offence.

3.35 '**Programme**' means the entire course of study and Examinations.

3.36 **'Project'** is a core course in a programme. It means a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department/ any appropriate research centre in order to submit a dissertation on the project work as specified. It allows students to work more autonomously to construct their own learning and culminates in realistic, student-generated products or findings.

3.37 '**Repeat Course**' is a course to complete the programme in an earlier registration.

3.38 '**Semester**' means a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days each.

3.39 '**Seminar**' means a lecture given by the student on a selected topic and expected to train the student in self-study, collection of relevant matter from various resources, editing, document writing and presentation.

3.40 '**Semester Grade Point Average(SGPA)**' is the value obtained by dividing the sum of credit points (CP) obtained by the student in the various courses taken in a semester by the total number of credits for the course in that semester. The SGPA shall be rounded off to two decimal places. SGPA

determines the overall performance of a student at the end of a semester (SGPA = Total CP obtained in the semester / Total Credits for the semester).

3.41 '**Tutorial**' means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

3.42 '**Weight**' is a numeric measure assigned to the assessment units of various components of a course of study.

3.43 **University** means Mahatma Gandhi University Kottayam to which the college is affiliated.

3.44 '**Weighted Grade Point (WGP)**' is grade points multiplied by weight. **(WGP=GPxW)**

3.45 **'Weighted Grade Point Average (WGPA)' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade points by the sum of the weights. WGPA shall be obtained for CE (Continuous Evaluation) and ESE (End Semester Evaluation) separately and then the combined WGPA shall be obtained for each course.**

4. ACADEMIC COMMITTEE

4.1. **There shall be an Academic Committee constituted by the Principal to Manage and monitor the working of MAC-PG-CSS2020.**

4.2. **The Committee consists of:**

1. Principal
2. Dean, Administration
3. Dean, Academics
4. IQAC Coordinator
5. Controller of Examinations
6. One Faculty each representing Arts, Science, Commerce, Languages, and Self Financing Programmes

5. PROGRAMME STRUCTURE

5.1 Students shall be admitted to post graduate programme under the various Faculties. The programme shall include three types of courses, Core Courses, Elective Courses and Common core courses. There shall be a project with

dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments / seminars/ practical's etc.

5.2 No regular student shall register for more than 25 credits and less than16 credits per semester unless otherwise specified. The total minimum credits, required for completing a PG programme is 80.

5.3 **Elective Courses and Groups**

5.3.1 There shall be various groups of Programme Elective courses for a Programme such as Group A, Group B etc. for the choice of students subject to the availability of facility and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.

5.3.2 The elective courses shall be either in fourth semester or distributed among third and fourth semesters. There may be various groups of Elective courses (three elective courses in each group) for a programme such as Group A, Group B etc. for the choice of students, subject to the availability of facility and infrastructure in the institution.

5.3.3 The selection of courses from different elective groups is not permitted.

5.3.4 The elective groups selected for the various Programmes shall be intimated to the Controller of Examinations within two weeks of commencement of the semester in which the elective courses are offered. The elective group selected for the students who are admitted in a particular academic year for various programmes shall not be changed.

5.4 Project Work

5.4.1 Project work shall be completed in accordance with the guidelines given in the curriculum.

5.4.2 Project work shall be carried out under the supervision of a teacher of the department concerned.

5.4.3. A candidate may, however, in certain cases be permitted to work on the project in an Industrial/Research Organization on the recommendation of the supervising teacher.

5.4.4 There shall be an internal assessment and external assessment for the project work.

5.4.5 The Project work shall be evaluated based on the presentation of the project work done by the student, the dissertation submitted and the viva-voce on the project.

5.4.6 The external evaluation of project work shall be conducted by two external examiners from different colleges and an internal examiner from the college concerned.

5.4.7 The final Grade of the project (External) shall be calculated by taking the average of the Weighted Grade Points given by the two external examiners and the internal examiner.

5.5 **Assignments:** Every student shall submit at least one assignment as an internal component for each course.

5.6 **Seminar Lecture:** Every PG student shall deliver one seminar lecture as an Internal component for every course with a weightage of two. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the various resources, editing, document writing and presentation.

5.7 **Test Papers(Internal):** Every PG student shall undergo at least two class tests as an internal component for every course with a weight one each. The best two shall be taken for awarding the grade for class tests.

5.8 **No courses shall have more than 5 credits unless otherwise specified.**

5.9 **Comprehensive Viva-Voce** -Comprehensive Viva-Voce shall be conducted at the end of fourth semester of the programme and its evaluation shall be conducted by the examiners of the project evaluation.

5.9.1 Comprehensive Viva-Voce shall cover questions from all courses in the Programme.

5.9.2 There shall be an internal assessment and an external assessment for the Comprehensive Viva-Voce.

6. ATTENDANCE

6.1 The minimum requirement of aggregate attendance during a semester for appearing at the end-semester examination shall be 75%. Condonation of shortage of attendance to a maximum of 15 days in a semester subject to a maximum of two times during the whole period of the programme may be granted by the University.

6.2 If a student represents his/her institution, University, State or Nation in Sports, NCC, or Cultural or any other officially sponsored activities such as college union/ university union etc., he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum 15 days in a Semester based on the specific recommendations of the Head of the Department or teacher concerned.

6.3 Those who could not register for the examination of a particular semester due to shortage of attendance may repeat the semester along with junior batches, without considering sanctioned strength, subject to the existing University Rules and Clause 7.2.

6.4 A Regular student who has undergone a programme of study under earlier regulation/ Scheme and could not complete the Programme due to shortage of attendance may repeat the semester along with the regular batch subject to the condition that he has to undergo all the examinations of the previous semesters as per the MAC-PG-CSS2020 regulations and conditions specified in 6.3.

6.5 A student who had sufficient attendance and could not register for fourth semester examination can appear for the end semester examination in the subsequent years with the attendance and progress report from the principal.

7. REGISTRATION/ DURATION

7.1 A student shall be permitted to register for the programme at the time of admission.

7.2 A student who registered for the Programme shall complete the Programme within a period of four years from the date of commencement of the programme.

7.3 Students are eligible to pursue studies for additional post graduate degree. They shall be eligible for award of degree only after successful completion of two years (four semesters of study) of college going.

8. ADMISSION

8.1 The admission to all PG programmes shall be done through the Centralised Allotment Process of Mar Athanasius College (Autonomous), Kothamangalam (MAC-PG CAP) as per the rules and regulations prescribed by the affiliating university and the Government of Kerala from time to time.

8.2 The eligibility criteria for admission shall be as announced by the Parent University from time to time.

9. ADMISSION REQUIREMENTS

9.1 Candidates for admission to the first semester of the PG programme through CSS shall be required to have passed an appropriate Degree Examination of Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the Academic council of Mahatma Gandhi University as eligible thereto.

9.2 Students admitted under this programme are governed by the Regulations in force.

10. PROMOTION:

10.1 A student who registers for the end semester examination shall be promoted to the next semester

10.2 A student having 75% attendance and who fails to register for examination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided application for notional registration shall be submitted within 15 days from the commencement of the next semester.

10.3 The medium of Instruction shall be English except programmes under faculty of Language and Literature.

11. EXAMINATIONS

11.1 **End-Semester Examinations**: The examinations shall be at the end of each Semester of three hour duration for each centralised and practical course.

11.2 Practical examinations shall be conducted at the end of each semester or at the end of even semesters as prescribed in the syllabus of the particular programme. The number of examiners for the practical examinations shall be prescribed by the Board of Studies of the programmes.

11.3 A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Different types of questions shall have different weightage.

12. EVALUATION AND GRADING

12.1 **Evaluation:** The evaluation scheme for each course shall contain two parts; (a) End Semester Evaluation (ESE) (External Evaluation) and (b) Continuous Evaluation (CE)(Internal Evaluation). 25% weightage shall be given to internal evaluation and the remaining 75% to external evaluation and the ratio and weightage between internal and external is 1:3. Both End Semester Evaluation (ESE) and Continuous Evaluation (CE) shall be carried out using direct grading system.

12.2 **Direct Grading: The direct grading for CE (Internal) and ESE(External Evaluation) shall be based on 6 letter grades (A+, A, B, C, D and E) with numerical values of 5, 4, 3, 2, 1 and 0 respectively.**

12.3 **Grade Point Average (GPA): Internal and External components are separately graded and the combined grade point with weightage 1 for internal and 3 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization provided in 12.16.**

12.4 **Internal Evaluation:** The internal evaluation shall be based on predetermined transparent system periodic written tests, assignments, seminars, lab skills, records, viva-voce etc.

12.5 Components of Internal (CE) and External Evaluation (ESE): Grades shall be given to the evaluation of theory / practical / project / comprehensive viva-voce and all internal evaluations are based on the Direct Grading System.

Proper guidelines shall be prepared by the BOS for evaluating the assignment, seminar, practical, project and comprehensive viva-voce within the framework of the regulation.

12.6 There shall be no separate minimum grade point for internal evaluation.

12.7 **The model of the components and its weightages for Continuous Evaluation (CE) and End Semester Evaluation (ESE) are shown in below:**

a) For Theory (CE) (Internal)

	Components	Weightage
i.	Assignment	1
ii.	Seminar	2
iii.	Best Two Test papers	2(1 each)
Total		**5**

(Average grade of the best two papers can be considered. For test paper all the Questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grades)

b) For Theory (ESE) (External)

Evaluation is based on the pattern of Question specified **in 12.15.5**

c) For Practical (CE) (Internal)

Components	Weightage
Written / Lab Test	2
Lab Involvement and Record	1
Viva	2
Total	**5**

(The components and weightage of the practical(Internal) can be modified by the concerned BOS without changing the total weightage 5)

d) For Practical (ESE) (External)

Components	Weightage
Written / Lab Test	7
Lab Involvement and Record	3
Viva	5
Total	**15**

(The components and weightage of the practical (External) can be modified by the concerned BOS without changing the total weightage 15)

e) For Project (CE) (Internal)

Components	Weightage
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
Total	**5**

(The components and the weightage of the components of the Project (Internal) can be modified by the concerned BOS without changing the total weightage 5)

f) For Project (ESE) (External)

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
Total	**15**

(The components and the weightage of the components of the Project (External) can be modified by the concerned BOS without changing the total weightage 15)

g) Comprehensive viva-voce (CE) (Internal)

Components	Weightage
Comprehensive viva-voce(all courses from first semester to fourth semester)	5
Total	**5**

(Weightage of the components of the Comprehensive viva-voce (Internal) shall not be modified.)

h) Comprehensive viva-voce (ESE) (External)

Components	Weightage
Comprehensive viva-voce(all courses from first semester to fourth semester)	15
Total	**15**

(Weightage of the components of the Comprehensive viva-voce (External) shall not be modified.)

12.8 **All grade point averages shall be rounded to two digits.**

12.9 To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination.

12.10 **There shall not be any chance for improvement for Internal Grade.**

12.11 The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course and a copy should be kept in the college for verification for at least two years after the student completes the programme.

12.12 **External Evaluation.** The external examination in theory courses is to be conducted by the College at the end of the semester. The answers may be written in English or Malayalam except those for the Faculty of Languages. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination.

12.13 Photocopies of the answer scripts of the external examination shall be made available to the students on request as per the rules prevailing in the University.

12.14 The question paper should be strictly on the basis of model question paper set and directions prescribed by the BOS.

12.15 **Pattern of Questions**

12.15.1 **Questions shall be set to assess knowledge acquired, standard, and application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightage shall be given to each module based on content/teaching hours allotted to each module.**

12.15.2 The question setter shall ensure that questions covering all skills are set.

12.15.3 A question paper shall be a judicious mix of short answer type, short essay type /problem solving type and long essay type questions.

12.15.4 The question shall be prepared in such a way that the answers can be awarded A+, A, B, C, D, E grades.

12.15.5 Weight: Different types of questions shall be given different weights to quantify their range as follows:

Sl.No.	Type of Questions	Weight	Number of questions to be answered
1	Short Answer type questions	1	8 out of 10
2	Short essay / problem solving type questions	2	6 out of 8
3	Long Essay Type questions	5	2 out of 4

12.16 **Pattern of question for practical**. The pattern of questions for external evaluation of practical shall be prescribed by the Board of Studies.

12.17 **Direct Grading System**

Direct Grading System based on a 6- point scale is used to evaluate the Internal and External examinations taken by the students for various courses of study.

Grade	Grade point(G)	Grade Range
A+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

12.18 **Performance Grading**

Students are graded based on their performance (GPA/SGPA/CGPA) at the examination on a 7-point scale as detailed below.

Range	Grade	Indicator
4.50 to 5.00	**A+**	**Outstanding**
4.00 to 4.49	**A**	**Excellent**
3.50 to 3.99	**B+**	**Very good**
3.00 to 3.49	**B**	**Good(Average)**
2.50 to 2.99	**C+**	**Fair**
2.00 to 2.49	**C**	**Marginal**
up to 1.99	**D**	**Deficient(Fail)**

12.19 No separate minimum is required for Internal Evaluation for a pass, but a minimum grade is required for a pass in an External Evaluation. However, a minimum C grade is required for pass in a Course.

12.20 A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

12.21 **Improvement of Course**- The candidate who wish to improve the grade/grade point of the external examination of the of a course/ courses he/ she has passed can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semester of the programme.

12.22 **One Time Betterment Programme**- A candidate will be permitted to improve the **CGPA** of the programme within a continuous period of four semesters immediately following the completion of the programme allowing only once for a particular semester. The **CGPA** for the betterment appearance will be computed based on the **SGPA** secured in the original or betterment appearance of each semester whichever is higher.

If a candidate opts for the betterment of **CGPA** of a programme, he/she has to appear for the external examination of the entire semester(s) excluding practical /project/comprehensive viva-voce. One time betterment programme is restricted to students who have passed in all courses of the programme at the regular (First appearance).

12.23 **Semester Grade Point Average (SGPA) and Cumulative Grade Point Average** (**CGPA) Calculations.** The SGPA is the ratio of sum of the credit point of all courses taken by a student in a semester to the total credit for that semester. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below.

Semester Grade Point Average -SGPA (S_j) = $\sum(C_i \times G_i) / \sum C_i$

(SGPA= Total credit Points awarded in a semester / Total credits of the semester)

Where 'S_j' is the j^{th} semester, 'G_i' is the grade point scored by the student in the i^{th} course 'C_i' is the credit of the i^{th} course.

12.24 **Cumulative Grade Point Average** (**CGPA)** of a programme is calculated using the formula:-

Cumulative Grade Point Average (CGPA) = $\sum(C_i \times S_i) / \sum C_i$

(CGPA= Total credit Points awarded in all semester / Total credits of the programme)

Where 'C_i' is the credit for the i^{th} semester, 'S_i' is the SGPA for the i^{th} semester. The **SGPA** and **CGPA** shall be rounded off to 2 decimal points.

For the successful completion of semester, a student shall pass all courses and score a minimum **SGPA** of 2.0. However a student is permitted to move to the next semester irrespective of her/his **SGPA**.

13. GRADE CARD

13.1 The Institution under its seal shall issue to the students, a consolidated grade card on completion of the programme, which shall contain the following information.

a) Name of the University.

b) Name of College

c) Title of the PG Programme.

d) Name of Semesters

e) Name and Register Number of students

f) Code, Title, Credits and Max GPA (Internal, External & Total) of each course (theory &practical), project, viva etc in each semester.

g) Internal, external and Total grade, Grade Point (G), Letter grade and Credit point (P) in each course opted in the semester.

h) The total credits and total credit points in each semester.

i) Semester Grade Point Average (SGPA) and corresponding Grade in each semester

j) Cumulative Grade Point Average (CGPA), Grade for the entire programme.

k) Separate Grade card will be issued.

l) Details of description of evaluation process- Grade and Grade Point as well as indicators, calculation methodology of SGPA and CGPA as well as conversion scale shall be shown on the reverse side of the grade card.

14. AWARD OF DEGREE - The successful completion of all the courses with 'C' grade within the stipulated period shall be the minimum requirement for the award of the degree.

15. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluations conducted.

16. RANK CERTIFICATE

Rank certificate shall be issued to candidates who secure positions 1st and 2nd . Candidates shall be ranked in the order of merit based on the CGPA secured by them. Grace grade points awarded to the students shall not be counted for fixing the rank. Rank certificate shall be signed by the Principal and the Controller of Examinations.

17. GRIEVANCE REDRESSAL COMMITTEE

17.1 Department level: The College shall form a Grievance Redressal Committee in each Department comprising of the course teacher and one senior teacher as members and the Head of the Department as Chairperson. The Committee shall address all grievances relating to the internal assessment grades of the students.

17.2. College level: There shall be a college level Grievance Redressal Committee comprising of faculty advisor, college co-ordinator, one senior teacher and one staff council member and the Principal as Chairperson.

18. FACTORY VISIT / FIELD WORK/VISIT TO A REPUTED RESEARCH INSTITUTE/ STUDENT INTERACTION WITH RENOWNED ACADEMICIANS may be conducted for all Programmes before the commencement of Semester III.

19. Each student may undertake **INTERNSHIP/ON THE JOB TRAINING** for a period of not less than 15 days. The time, duration and structure of

internship/on the job training can be modified by the concerned Board of Studies

20. TRANSITORYPROVISION

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three year from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

21. REPEAL

The Regulations now in force in so far as they are applicable to programmes offered by the college and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the existing regulations and these regulations relating to the Credit Semester System in their application to any course offered in a College, the latter shall prevail.

22. Credits allotted for Programmes and Courses

22.1 Total credit for each programme shall be **80**.

22.2 Semester-wise total credit can vary from 16to25

22.3 The minimum credit of a course is 2 and maximum credit is 5

23. Common Course: If a course is included as a common course in more than one programme, its credit shall be same for all programmes.

24. Course Codes: The course codes assigned for all courses (Core Courses, Elective Courses, Common Courses etc.)shall be unique.

25. Models of distribution of courses, course codes, type of the course, credits, teaching hours for a programme are given in the following table

M.Sc. Statistics Programme without practical

Total Credit 80 – Scheme of the Syllabus

Semester	Course-Code	Course Name	Type of the Course	Teaching Hours per week	Credit	Total Credits
I	PG20ST101	Probability Distributions	core	5	4	19
	PG20ST102	Measure and Probability	core	5	4	
	PG20ST103	Sampling Theory	core	5	4	
	PG20ST104	Analytical Tools for Statistics	core	5	4	
	PG20ST105	Statistical Computing - I	core	5	3	
II	PG20ST206	Multivariate Distributions	core	5	4	19
	PG20ST207	Advanced Probability Theory	core	5	4	
	PG20ST208	Statistical Inference - I	core	5	4	
	PG20ST209	Stochastic Processes	core	5	4	
	PG20ST210	Statistical Computing - II	core	5	3	
III	PG20ST311	Statistical Inference - II	core	5	4	19
	PG20ST312	Design and Analysis of Experiments	core	5	4	
	PG20ST313	Multivariate Analysis	core	5	4	
	PG20ST314	Time Series Analysis	core	5	4	
	PG20ST315	Statistical Computing - III	core	5	3	
IV	PG20ST416	Econometric Methods	core	5	4	23
	PG20ST417	Operations Research	Elective	5	3	
	PG20ST418	Statistical Quality Control	Elective	5	3	
	PG20ST419	Statistical Reliability Analysis	Elective	5	3	
	PG20ST420	Statistical Computing IV	core	5	3	
	PG20ST4P	Dissertation/Project	core		3	
	PG20ST4V	Viva-Voce	core		4	
		Total				**80**

Table of Elective Courses:

Three bunches A,B and C each having 3 programmes are given. A college can select anyone bunch. Selection of programmes between bunches is not allowed.

Bunch	Course code	Name Of The Course	Credit	Teaching Hours
A	Elective 01	Operations Research	3	5
	Elective 02	Statistical Quality control	3	5
	Elective 03	Statistical Reliability Analysis	3	5
B	Elective 01	Survival Analysis	3	5
	Elective 02	Population Dynamics	3	5
	Elective 03	Categorical Data Analysis	3	5
C	Elective 01	Actuarial Statistics	3	5
	Elective 02	Applied Regression Analysis	3	5
	Elective 03	Data Mining	3	5

Appendix

1. **Evaluation first stage – Both internal and external to be done by the teacher**

Grade	Grade Points	Range
A+	**5**	**4.50 to 5.00**
A	**4**	**4.00 to 4.49**
B	**3**	**3.00 to 3.99**
C	**2**	**2.00 to 2.99**
D	**1**	**0.01 to 1.99**
E	**0**	**0.00**

The final Grade range for Courses, SGPA and CGPA

Range	Grade	Indicator
4.50 to 5.00	**A+**	**Outstanding**
4.00 to 4.49	**A**	**Excellent**
3.50 to 3.99	**B+**	**Very good**
3.00 to 3.49	**B**	**Good**
2.50 to 2.99	**C+**	**Fair**
2.00 to 2.49	**C**	**Marginal**
Upto1.99	**D**	**Deficient(Fail)**

Theory-External-ESE

Maximum weight for external evaluation is 30. Therefore Maximum Weighted Grade Point (WGP) is 150

Type of Question	Qn. No.'s	Grade Awarded	Grade Point	Weights	Weighted Grade Point
Short Answer	1	A+	5	1	5
	2	-	-	-	-
	3	A	4	1	4
	4	C	2	1	2
	5	A	4	1	4
	6	A	4	1	4
	7	B	3	1	3
	8	A	4	1	4
	9	B	3	1	3
	10	-	-	-	
Short Essay	11	B	3	2	6
	12	A+	5	2	10
	13	A	4	2	8
	14	A+	5	2	10
	15	-	-	-	-
	16	-	-	-	-
	17	A	4	2	8
	18	B	3	2	6
Long Essay	19	A+	5	5	25
	20	-	-	-	-
	21	-	-	-	-
	22	B	3	5	15
			TOTAL	**30**	**117**
Calculation : **Overall Grade of the theory paper = Sum of Weighted Grade Points /Total Weight = 117/30 = 3.90 = Grade B**					

Theory-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Assignment	1	A	4	4	**WGP/Total Weight= 24/5 =4.8**
Seminar	2	A+	5	10	
Test Paper 1	1	A+	5	5	
Test Paper 2	1	A+	5	5	
Total	**5**			**24**	**A+**

Practical-External-ESE

Maximum weight for external evaluation is 15. Therefore Maximum Weighted Grade Point (WGP) is 75.

Components	Weight(W)	Grade Awarded	Grade Point(GP)	WGP=W*GP	Overall Grade of the Course
Written/Lab Test	7	A	4	28	**WGP/Total Weight= 58 / 15 = 3.87**
Lab involvement & record	3	A+	5	15	
Viva	5	B	3	15	
Total	**15**			**58**	**B**

Practical-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Written/ Lab Test	2	A	4	8	**WGP/Total Weight=17/5 =3.40**
Lab involvement & record	1	A+	5	5	
Viva	2	C	2	4	
Total	**5**			**17**	**B**

Project-External-ESE

Maximum weight for external evaluation is 15. Therefore Maximum Weighted Grade Point (WGP) is 75.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W*GP	Overall Grade of the Course
Relevance of the topic & Analysis	3	C	2	6	**WGP/Total Weight = 56/15= 3.73**
Project Content &Presentation	7	A+	5	35	
Project Viva- Voce	5	B	3	15	
Total	**15**			**56**	**B**

Project -Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Relevance of the topic & Analysis	2	B	3	6	**WGP/Total Weight= 21/5 = 4.2**
Project Content & Presentation	2	A+	5	10	
Project Viva-Voce	1	A+	5	5	
Total	**5**			**21**	**A**

Comprehensive viva-voce-External-ESE

Maximum weight for external evaluation is 15. Therefore Maximum Weighted Grade Point (WGP) is 75

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W*GP	Overall Grade of the Course
Comprehensive viva-voce	15	A	4	60	**WGP/Total Weight = 60 / 15 = 4**
Total	**15**			**60**	**A**

Comprehensive viva-voce-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Comprehensive viva-voce	5	A+	5	25	**WGP/Total Weight = 25/ 5 = 5**
Total	**5**			**25**	**A+**

1. **Evaluation Second stage-(to be done by the College)**

Consolidation of the Grade(GPA) of a Course PC-1

The End Semester Evaluation (ESE) (External evaluation) grade awarded for the course PC-1 is A and its Continuous Evaluation (CE) (Internal Evaluation) grade is A. The consolidated grade for the course PC-1 is as follows

Evaluation	Weight	Grade awarded	Grade Points awarded	Weighted Grade Point
External	3	A	4.20	12.60
Internal	1	A	4.40	4.40
Total	**4**			**17**
Grade of a Course.	GPA of the course =Total weighted Grade Points/Total weight= **17/4 =4.25 = Grade A**			

2. Evaluation Third stage-(to be done by the College)

Semester Grade Point Average (SGPA)

Course code	Titleof the course	Credits (C)	Grade Awarded	Grade Points(G)	Credit Points (CP=C X G)
01	**PC-1**	**5**	**A**	**4.25**	**21.25**
02	**-----**	**5**	**A**	**4.00**	**20.00**
03	**-----**	**5**	**B**	**3.80**	**19.00**
04	**-----**	**2**	**A**	**4.40**	**8.80**
05	**-----**	**3**	**A**	**4.00**	**12.00**
TOTAL		**20**			**81.05**
SGPA	**Total credit points / Total credits = 81.05/20 = 4.05= Grade- A**				

3. Evaluation Third stage-(to be done by the College)

Cumulative Grade Point Average (CGPA)

If a candidate is awarded three **A+** grades in semester 1(SGPA of semester 1), semester 2(SGPA of semester 2), semester 4(SGPA of semester 4) and **B** grades in semester 3(SGPA of semester 3). Then CGPA is calculated as follows:

Semester	Credit of the Semesters	Grade Awarded	Grade point (SGPA)	Credit points
I	20	A+	4.50	90
II	20	A+	4.60	92
III	20	B	3.00	60
IV	20	A+	4.50	90
TOTAL	**80**			**332**
CGPA= Total credit points awarded / Total credit of all semesters = 332 / 80= 4.15 (Which is in between 4.00 and 4.49 in 7-point scale) Therefore the overall Grade awarded in the programme is A				

ELIGIBILITY FOR ADMISSION

Academic eligibility should be satisfied as on the last date of submission of academic data. No candidate shall be admitted to the PG programme unless he/she possess the qualifications and minimum requirements thereof, as prescribed by Mahatma Gandhi University from time to time.

If an applicant for admission is found to have indulged in ragging in the past or if it is noticed later that he/she had indulged in ragging, admissions shall be denied or he/she will be expelled from Mar Athanasius College (Autonomous), Kothamangalam.

Candidates should have passed the corresponding Degree Examination under the 10 + 2 + 3 pattern with one core/main subject and two complementary/subsidiary subjects from any of the Universities in Kerala or of any other University recognized by Mahatma Gandhi University as equivalent thereto for admission, subject to the stipulation regarding marks.

OR

Candidates who have passed Degree examination with Double or Triple main subject and candidates who have passed the Degree Examination in Vocational or Specialized Programmes are also eligible for admission. However, they have to submit copy of the Equivalency/Eligibility Certificate from Mahatma Gandhi University, stating that, their Qualifying Examination is recognized for seeking admission to the relevant P.G. Degree Programme(s) as applicable, at the time of admission. This provision is not applicable in the case of those applicants who have passed their qualifying examination from MG University.

The minimum requirements for admission to M.Sc. Statistics Programme is

Graduates who have passed qualifying examination in CBCS (2017)/CBCSS (2013) pattern	**Graduates who have passed qualifying examination in CBCSS (2009) pattern**	**Graduates who have passed qualifying examination in other patterns.**
Graduation in Statistics/Mathematics/ Computer Application(triple main) with not less than CGPA/CCPA of 5.00 out of 10.00 in the Core Group (Core + Complementary + Open Courses)	Graduation in Statistics/Mathematics/Computer Application(triple main) with not less than CGPA of 2.00 out of 4 in the Core Group (Core + Complementary + Open Courses)	Graduation in Statistics/Mathematics/Computer Application (triple main) with not less than 50% marks in the Part III subjects (Main/Core+ subsidiaries/Complementaries).
Weightage of 10% marks, scored by the candidate in Part III Core/Main, shall be added to the total of Part III Core/Main for those candidates who have studied B Sc. Statistics (Core/Main), after standardizing the marks secured for the same to 600. Weightage of 5% marks, scored by the candidate in Part III Core/Main, shall be added to the total of Part III Core/Main for those candidates who have studied B Sc. Computer Applications (Triple Main) (Core/Main), after standardizing the marks secured for the same to 600.		

The Open course under core group is taken only for reckoning the eligibility for applying for the PG programme concerned. But a candidate cannot apply for the respective PG programme solely on the basis of the open course selected under core group.

Relaxation in Marks in the qualifying examination:

(i) **Kerala Scheduled Caste/Scheduled Tribe Category**: The minimum grade in the qualifying examination for admission to the PG Degree programme is 'C' in the seven point scale for CBCSS and a pass for pre CBCSS applicants.

(ii) **SEBC Category**: A relaxation of 3% marks in the qualifying examination from the prescribed minimum is allowed i.e. CGPA of 4.7 for CBCS (2017),CCPA of 4.7 for CBCSS (2013), CGPA of 1.88 for CBCSS (2009)applicants and 47% marks for pre-CBCSS applicants for admission to M Sc. Statistics Programme.

(iii) **OEC Category:** A relaxation of 5% marks in the qualifying examination from the prescribed minimum is allowed i.e. CGPA of 4.5 for CBCS (2017), CCPA of 4.5 for

CBCSS (2013), CGPA of 1.80 for CBCSS (2009) applicants and 45% marks for pre - CBCSS applicants for admission to M Sc. Statistics Programme.

(iv) **Persons with Disability category**: A relaxation of 5% marks in the qualifying examination from the prescribed minimum is allowed i.e. CGPA of 4.5 for CBCS (2017), CCPA of 4.5 for CBCSS (2013), CGPA of 1.80 for CBCSS (2009) applicants and 45% marks for pre – CBCSS applicants for admission to M Sc. Statistics Programme.

Scheme and Structure of M.Sc. Statistics Programme

(Under Mahatma Gandhi University Regulations PGCSS2019 from 2020 Academic year onwards)

1. Aim of the Program

Apart from teaching core Statistics subjects, the students are also taught programming languages and also exposed to various statistical software's such as R, SPSS, trained to handle real life problems through the practical classes. The course prepares the students for UPSC Examinations like UGC-CSIR NET, Indian Statistical Services (ISS), Indian Economic Services (IES) as well as Civil Services. The course is so designed that on successful completion, the students would be able to pursue higher studies in the areas of Statistics, Mathematics, Computer Science, Economics, Management and allied fields. Moreover, emerging areas like Actuarial science and official Statistics are included in the curriculum. It is a way to get sharper predictions from the data , particularly when there is not much data available and when one want to juice every last bit of information from it. During the last three decades, Actuarial Science has gone through revolutionary changes due to the implementation of high speed computers and modern theory. It applies mathematical and statistical methods to assess risk in insurance, finance and other industries. Official Statistics make information on economic and social development accessible to the public, allowing the impact of government polices to be assessed and thus improving accountability.

2. Eligibility for admissions

B.Sc. Degree in mathematics or statistics main or B.Sc.(triple main) with Mathematics Statistics and Computer science as main subject with at least 50% marks for the optional subjects taken together .**No private /distant students will be admitted for the programme.**

3. Examination

Credit and Semester System (CSS). Direct Grading system with 7 point scale

4. Medium of instruction and assessment

The medium of instruction shall be English.

5. Duration of the Programme

The duration of the program shall be 4 semesters. The duration of each semester shall be 90 working days. Student may be permitted to complete the program, in a period of 4 continuous semesters from the date of commencement of the first semester of the programs.

PROGRAMME OUTCOME

Post Graduate programmes offered by Mar Athanasius College (Autonomous) are outcome based and the outcome expected are as follows:

PO No.	Upon completion of postgraduate programme, the students will be able to:
PO-1	Create, apply and disseminate knowledge leading to innovation
PO-2	Think critically, explore possibilities and exploit opportunities positively
PO-3	Work in teams, facilitating effective interaction in work places.
PO-4	Lead a sustainable life
PO-5	Embrace lifelong learning

PROGRAMME SPECIFIC OUTCOMES (PSO)

PSO No.	Upon completion of M.Sc. Statistics Programme, the students will be able to:	PO No.
PSO-1	Recognize the significance of statistical thinking, training, and problem solving.	1, 2
PSO-2	Achieve the qualities of precision and clarity in the communication of statistical ideas.	2, 3
PSO-3	Acquire proficiency in the formulation and construction of statistical results, practice in analyzing, formulating, modeling, testing, and interpretation of the results.	1, 2, 3
PSO-4	Find careers in a broad range of government, financial, health, technical, banking, public policy and other sectors.	3, 4, 5
PSO-5	Develop skills to serve as a Statistical Consultant/ Data Analyst in the public or private sector and in research.	2, 3, 4
PSO-6	Pursue lifelong learning.	4, 5

PROGRAMME STRUCTURE

Semester	Course Code	Course Title	Credits	Teaching Hours	Total Credit
I	PG20ST101	Probability Distributions	4	5	19
	PG20ST102	Measure and Probability	4	5	
	PG20ST103	Sampling Theory	4	5	
	PG20ST104	Analytical Tools for Statistics	4	5	
	PG20ST105	Statistical Computing - I	3	5	
II	PG20ST206	Multivariate Distributions	4	5	19
	PG20ST207	Advanced Probability Theory	4	5	
	PG20ST208	Statistical Inference - I	4	5	
	PG20ST209	Stochastic Processes	4	5	
	PG20ST210	Statistical Computing - II	3	5	
III	PG20ST311	Statistical Inference - II	4	5	19
	PG20ST312	Design and Analysis of Experiments	4	5	
	PG20ST313	Multivariate Analysis	4	5	
	PG20ST314	Time Series Analysis	4	5	
	PG20ST315	Statistical Computing- III	3	5	
IV	PG20ST416	Econometric Methods	4	5	23
	PG20ST417	Elective 01 : Operations Research	3	5	
	PG20ST418	Elective 02 : Statistical Quality Control	3	5	
	PG20ST419	Elective 03 : Statistical Reliability Analysis	3	5	
	PG20ST420	Statistical Computing IV	3	5	
	PG20ST4P	Dissertation/Project	3		
	PG20ST4V	Viva-Voce	4		

Total credits for the programme-80 credits

FIRST SEMESTER

SYLLABUS OF COURSES OFFERED

PG20ST101 : PROBABILITY DISTRIBUTIONS

Objectives

- To discuss about different discrete, continuous distributions and compute the expected value, variance, and standard deviation.
- Understand the concept of a sampling distributions.
- To learn the formal definition of order statistics and to derive the distribution function and pdf of the r^{th} order statistic.

UNIT I

The basic concepts in distribution theory:- generating functions and properties, pgf, mgf, cumulant generating function and characteristic functions, factorial moments and recurrence relation, Discrete Distributions:- Power series, Binomial, Bernoulli, Poisson, Negative binomial, Geometric, Hyper geometric and Logarithmic series distributions.

(25 hours)

UNIT II

Pearson Family- Identification of the different types, Continuous Distributions:- Rectangular, Exponential, Weibull, Beta, Gamma, Pareto, Normal, Lognormal, Cauchy, Laplace, Logistic, Inverse Gaussian

(25 hours)

UNIT III

Functions of Random variables and their distributions using transformations of variables techniques. Distributions of sums, products and ratios of independent r.v.s, compound (Binomial and Poisson), truncated (Binomial, Poisson and Normal) and Mixture distributions.

(20 hours)

UNIT IV

Sampling distributions:-Chi-square, t and F distributions (Central and Non Central cases) Order statistics and their distributions:- joint and marginal distributions of sample median, range and mid – range (Exponential, Uniform, Logistic).

(20 hours)

Reference Books:

1. Rohatgi V.K and Saleh M (2015) An Introduction to Probability and Statistics, Third edn.Wiley.
2. Johnson N.L, Kotz S and Kemp A.W (2005) Univariate discrete distributions, Third edn. , John Wiley.
3. Johnson N.L, Kotz S and Balakrishnan N (1995) Continuous Univariate distributions I & II, Second edn. , John Wiley.
4. Arnold B.C, Balakrishnan N and Nagaraja H.N (2008) A first Course in Order Statistics.
5. Mukhopadhaya P (1996) Mathematical Statistics, The New Central Book Agency.
6. Dr. Bhuyan K.C.(2010) Probability, Distribution Theory and Statistical Inference, New Central Book Agency.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Define the concepts of random variables and probability distributions.	K1	1
2	Discuss the difference between how probabilities are computed for discrete and continuous random variables.	K2	2
3	Explain the distribution of order statistics.	K2	1, 2
4	Describe the practical applications of functions of random variables.	K2	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST102 :MEASURE AND PROBABILITY

Objectives

- To understand the basic concepts of probability theory and random variables.
- To familiarize the students with conditional probability, conditional expectation, joint distribution, independence and convergence.

- To introduce the concepts of measure and integral with respect to a measure, to show their basic properties and to provide the basics for further studies in analysis, probability etc.

UNIT I

Sequences and limit of sets, field and sigma field, monotone class, minimal sigma field, Borelfield of R and of Rn , measurable space, measure, measure space, finite and sigma finite measures, properties of measures. Definitions of Counting measures, Lebesgue measure. Definition of integral of a measurable function and its elementary properties. Monotone convergence theorem, Fatou's Lemma, Bounded convergence theorem and Lebesgue dominated convergence theorem.

(25 hours)

UNIT II

Probability space and elementary properties of probability measure. Monotone and continuity property of probability measures. Independence of finite number and sequence of events. Borel-Cantelli Lemma, Borel 0-1 criterion, conditional probability and Baye's theorem.

(20 hours)

UNIT III

Random variable, vector random variable, properties of random variables. Probability distribution, Distribution function and its properties. Jordan decomposition theorem, Correspondence theorem (statement only). Mathematical expectation, moments and its properties. Basic, Chebychev's, Markov, Liaponov's, Jensen, Cr, Cauchy-Swartz, Holders, Minkowski's inequalities.

(25 hours)

UNIT IV

Sequence of random variables and its stochastic convergence. Convergence almost surely, convergence in probability, convergence in distribution, convergence in r^{th} mean, properties, counter examples and their inter-relationship. Independence of finite and sequence of random variables weak and complete convergence of distribution, Kolmogorov's inequality and Helly-Bray Lemma (statement only).

(20 hours)

Reference Books :

1. Bhat B.R. (2014) Modern Probability theory (An introductory text book), Fourth edition, New Age International.
2. Rohatgi V.K. and Saleh M. (2015) An introduction to probability and statistics, Third edition, Wiley.
3. Ash R.B. (1972) Real Analysis and Probability, Academic press.
4. Ash R.B. and Doléans-Dade C.A. (2000) Probability and measure theory, Academic Press
5. Basu A.K. (2012). Measure Theory and Probability, Second Edition, PHI Learning Pvt. Ltd, New Delhi.
6. J.F.C. Kingman and S.J. Taylor (2008) Introduction to measure and probability, Cambridge University Press.
7. William Feller (2008) An introduction to probability theory and its application, Vol.1, Wiley Eastern Ltd
8. Billingsley P. (2012) Probability and Measure, Anniversary edition, Wiley Eastern ltd.
9. Laha R.G. and Rohatgi V.K. (1979) Probability theory, John Wiley.
10. Loeve M. (1977) Probability Theory, Fourth edition, Springer-Verlag.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Describe the basic concepts of measure theory.	K1	1
2	Examine the theory of a measure and integration is for the statistical studies.	K4	2
3	Explain the measureable functions.	K2	2
4	Develop probabilistic concepts like random variable, expectation, inequalities, convergence and the related theorems.	K5	3
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST103 : SAMPLING THEORY

Objectives

- To obtain an estimate of parameter from statistic.
- To making generalisation about the population/ universe from the studies based on samples drawn from it.

UNIT I

Census and sampling methods, probability sampling and non-probability sampling, principal steps in sample surveys, sampling errors and non-sampling errors, bias, variance and mean square error of an estimator, simple random sampling with and without replacement, estimation of the population mean, total and proportions, properties of the estimators, variance and standard error of the estimators, confidence intervals, determination of the sample size.

(25 hours)

UNIT II

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and srs. Systematic sampling – Linear and Circular, estimation of the mean and its variance. comparison of systematic sampling, srs and stratified random sampling for a population with a linear trend.

(20 hours)

UNIT III

Ratio method of estimation, estimation of the population ratio, mean and total, first order approximate expression for bias, mse of ratio estimates, comparison with srs estimation. Unbiased ratio type estimators- Hartly- Ross estimator, regression method of estimation, first order approximate expression for bias and mse of linear regression estimators, large sample comparison with mean per unit estimator and ratio estimators, Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two- stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.

(25 hours)

UNIT IV

Unequal probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method, estimation of the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator and its estimated S. E, Des-Raj's ordered estimator, Murthy's unordered estimator (properties of these estimators for n=2 only)

(20 hours)

Reference Books:

1. Cochran W. G. (2007) Sampling Techniques, 3rd edition, John Wiley and Sons.
2. Mukhopadyay P. (2014) Theory and Methods of Survey Sampling, 2nd edition, PHL, New Delhi.
3. Singh D. and Choudhary F. S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd.
4. Des Raj (1967) Sampling Theory, Tata McGraw Hill, New Delhi.
5. Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Describe the differences in simple random sampling(WR or WOR) and other types of sampling Schemes	K2	1
2	Distinguish between randomization and non randomization theory.	K2	2
3	Identify the bias and sampling variability.	K2	2
4	Analyze data from multi-stage surveys.	K4	3
5	Explain concept of ratio and regression methods in estimation	K2	2
6	Discuss the concept of unequal probability sampling.	K2	2
7	Explain the design and analysis of sampling methods that would be useful for research and management in many field.	K2	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST104 :ANALYTICAL TOOLS FOR STATISTICS

Objectives

- To expose the students to the basis of real analysis.
- Basic concepts of vector space and matrices.
- How to analyse and solve a simultaneous system of equations.

UNIT I

Real Sequences (definitions, basic concepts, Statements of theorems only), Infinite series (positive term series, Cauchy Root Test, DAlemberts Ratio Test, Raabies Test, Logarithmic Test, Integral Test without proof- Problems only), convergence, continuity, uniform continuity, differentiability. Functions of several variables: maxima and minima, Method of Lagrangian multipliers, Laplace transform and its applications to differential equations.

(20 hours)

UNIT II

Vector spaces, subspaces, linear independence of vectors, basis and dimension of a vector space, inner product and orthogonal vectors, Gram-Schmidt orthogonalization process, orthonormal basis, rank of a matrix, null space, partitioned matrices.

(25 hours)

UNIT III

Linear equations, rank nullity theorem, characteristic roots and vectors, Cayley-Hamilton theorem, characteristic subspaces of a matrix, nature of characteristic roots of some special types of matrices, algebraic and geometric multiplicity of a characteristic root, generalized inverse, properties of g-inverse, Moore-Penrose inverse and its computations.

(20 hours)

UNIT IV

Quadratic forms, congruent transformations, congruence of symmetric matrices, canonical reduction and orthogonal reduction of real quadratic forms, Unitary reduction of hermitianforms, nature of quadratic forms, simultaneous reduction of quadratic forms, similarity and spectral decomposition.

(25 hours)

Reference Books:

1. Apostol T.M. (1996) Mathematical Analysis, second Edition, Narosa Publishing House, New Delhi.
2. Malik S.C & Arora S (2017) Mathematical analysis, Fifth edn. , New age international.
3. H.L.Royden, Real Analysis, Macmillan (2010).
4. Shanti Narayan (1991) A text of book of matrices, S. Chand & Company, New Delhi
5. Biswas S. (1997) A text book of linear algebra, New age international.
6. Rao C.R. (2009) Linear statistical inference and its applications, Second edn., Wiley Eastern.
7. Hoffman K. and Kunze R. (2014) Linear Algebra, Second edition, Phi Learning.
8. Gilbert Strang (2014) Linear Algebra and its Applications, 15th Re-printing edn., Cengage Learning.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Explain the concepts of Real Analysis.	K2	1
2	Explain the concepts of linear algebra.	K2	1
3	Analyse the quadratic forms and spectral decomposition of matrices, which often arises in a multivariate data analysis.	K4	3
4	Apply the mathematical problems in statistical analysis.	K3	3,4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST105 : STATISTICAL COMPUTING - I

Objectives

- Students are expected to learn the basics in R programming and complete the practical's by the R software.

UNIT 1

Introduction to statistical software R, Data objects in R, Manipulating vectors, matrices, lists, importing of files, data frame, and computations of descriptive statistics measures. R Graphics-Histogram, Box-plot, Stem and leaf plot, Scatter plot, Plot options; Multiple plots in a single graphic window, frequency table, Controlling Loops- For, repeat, while, if, if else etc, lm and glm functions. Analysis of variance using lm function.

(25 hours)

UNIT 2

Distribution Theory using R(essential theory)-Implementation of numerical problems using R:Plotting of probability distributions and sampling distributions, P-P plot, Q-QPlot, Simulation of random numbers, Fitting of discrete and continuous distributions. Chi Square goodness of fit. Test for correlation and regression coefficients.

(20 hours)

UNIT 3

Analytical tools for Statistics using R(essential theory)-Implementation of numerical problems using R: Writing user defined functions for statistical methods studied. Use of the apply group of functions. Vectorized functions. Use of matrix methods in statistical analysis-spectral decomposition, inverse, g inverse, Moore Penrose g inverse. Use of Rin linear algebra and numerical analysis.

(20 hours)

UNIT 4

Sampling theory using R(essential theory)-Implementation of numerical problems using R : Use of statistical packages in survey sampling. Computations using the survey package. Use of other related packages in sampling theory. Writing user defined functions for various computations in sampling theory.

(25 hours)

References.

1. Introductory Statistics with R by Peter Dalgaard, Springer, 2nd edition, 2008.
2. The R Book by Michael J.Crawley, John Wiley and Sons, Ltd., 2007.
3. An Introduction to R by W. N. Venables, D. M. Smith and the R Core Team
4. The Art of R Programming by Norman Matloff, no starch press, San Francisco
5. Complex Surveys, A Guide to Analysis Using R. Thomas Lumley. John Wiley & Sons.

Evaluation: 6 numerical questions each with weightage 10 (marks per questions 50) are to be asked. The student is expected to answer any 3 full questions. Use of the package R is allowed for answering the questions in this paper. Examination of 3 hours duration must be conducted in the computer lab under the supervision of an examiner appointed by the college.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Sharpen statistical intuition and abstract reasoning as well as their reasoning from numerical data through examples and exercise by using excel and statistical software R	K5	4,5
2	Testing the ability of students in solving the practical problems based on Probability Distributions, Sampling Theory and Analytical Tools for Statistics .	K6	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

SECOND SEMESTER

SYLLABUS OF COURSES OFFERED

PG20ST206 : MULTIVARIATE DISTRIBUTIONS

Objectives

- To impact necessary knowledge about theoretical foundation of multivariate distributions.

UNIT I

Bivariate normal distribution- marginal and conditional distributions, characteristic function. Bivariate exponential distribution- Gumbel (Type I, Type II and Type III), Marshall and Olkin, Important properties. Multinomial distribution.

(20 hours)

UNIT II

Multivariate distributions-Multivariate normal distribution (both singular and non- singular)-marginal and conditional distributions, properties and characterizations, estimation of mean and dispersion matrix. Independence of sample mean and sample dispersion matrix.

(20 hours)

UNIT III

Jacobians of matrix transformations Y= AXB, Y=AXA', X= TT'. Matrix variate gamma and beta distributions, Wishart distribution, properties, distribution of generalized variance, U-Statistic.

(25 hours)

UNIT IV

Quadratic forms of normal variables and vectors - Distribution of quadratic forms in normal variables (both scalar and vector quadratic forms), Cochran's theorem, Independence of quadratic forms. Simple, partial, and multiple correlation coefficients and their inter-relationships, tests, null and non-null distribution of simple and partial cases, null distribution of multiple correlation.

(25 hours)

Reference Books:

1. Anderson T.W.(2004) An introduction to multivariate statistical analysis, Third edn, John Wiley.
2. Seber G.A.F. (1983) Multivariate Observations, John Wiley.
3. Rao.C.R (2009) Linear statistical inference and its applications (2^{nd} Ed) Wiley Eastern ltd.
4. Kotz.S, Balakrishnan N and Johnson N (2000) Continuous Multivariate Distributions, Vol.1, Models and Applications, 2^{nd}edn. John Wiley.
5. Mathai A.M (1996) Jacobians of Matrix Transformation and Functions of World Scientific Publishing Company Pvt.Ltd.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Explain the bivariate distributions such as normal and exponential distributions.	K2	2
2	Describe the properties and estimators of multivariate distributions such as multivariate normal, Wishart distribution etc.	K1	1
3	Discuss the concepts of simple, partial and multiple correlations, their properties and distributions are thoroughly investigated.	K2	4,5
4	Construct tests and estimators, and derive their properties.	K5	5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST207 : ADVANCED PROBABILITY THEORY

Objectives

- On the completion of the course, the students shall have knowledge of signed measure and their decomposition theorems, characteristic functions and concepts of law of large numbers.

UNIT I

Signed measure, Hahn and Jordan Decomposition theorems. Statement and applications of Radon – Nikodym Theorem (without proof), Lebesgue decomposition theorem (without proof), Fubini's theorem (without proof), Probability space induced by a random variable, by a random vector, conditional expectation of a random variable, martingales, submartingales, super martingales, simple Properties of Martingales.

(25 hours)

UNIT II

Characteristic function of a random variable, properties, uniform continuity and non-negative definiteness, statement of Bochner's Theorem, continuity and inversion theorems of characteristic functions, convex combinations of characteristic functions and distribution functions, characteristic function of a vector random variable.

(25 hours)

UNITIII

Law of Large numbers, Weak Law of Large numbers of Bernoulli, Chebychev, Poisson and Khinchine, Kolmogrov inequality (without proof), Strong law of large numbers -Kolmogrov strong law of large numbers for independent random variables- for i.i.d random variables, Borel strong law of large numbers, necessary and sufficient condition for weak law of large numbers.

(20 hours)

UNIT IV

Central limit theorem, Demoivre-Laplace CLT, Lindberg -Levy and LiaponovCLT, Lindberg- Feller CLT (Without proof), domain of attraction and stable distributions.

(20 hours)

Reference Books:

1. Bhat B.R (2014) Modern Probability theory, Fourth edn., Wiley Eastern Ltd, New Delhi.
2. Rohatgi V.K and Saleh M (2015). An Introduction to Probability and Statistics, Third edn.Wiley
3. Billingsley P (1995) Probability and Measure, Third edn., Wiley Eastern Ltd.
4. Laha R.G and Rohatgi V.K (1979) Probability theory, Van Nostrand.
5. Parthasarathy K.R (1973) Introduction to Probability and Measure, Mac Millian.
6. William Feller (2008) An introduction to probability theory and its application, Vol.1, Wiley Eastern Ltd.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Explain different types of convergences of distributions, probability measures and Characteristic functions	K2	3
2	Describe theory for conditional distributions and expectation from a measure- theoretic Perspective.	K1	2
3	Discuss the central limit theorem and its variants.	K2	4
4	Explain different types of martingales and its use in practical situations.	K2	4

Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.

PG20ST208 : STATISTICAL INFERENCE I

Objectives

- To describe many of the important estimation methods and to show how they are interrelated and use Classical and Bayesian approaches to formulate and solve problems for parameter estimation.

UNIT I

Criteria for estimators - unbiasedness, consistency and efficiency, minimum variance, Fisher information, Cramer – Rao inequality, Bhattacharyya's bounds, Pitman estimator.

(25 hours)

UNIT II

Sufficiency, completeness, bounded completeness, Fisher-Neymann factorization theorem, minimal sufficiency, exponential families, UMVUE, Rao- Black well theorem,
Lehmann – Scheffe theorem, ancillary statistics, Basu's theorem.

(20 hours)

UNIT III

Methods of estimation: method of moments, method of maximum likelihood & their properties, Fisher's scoring method, method of minimum chi-square and method of modified minimum chi-square, confidence intervals, shortest confidence intervals.

(25 hours)

UNIT IV

Basic elements of decision theory, statistical decision problem, loss and risk functions, decision rule, estimation and testing as particular cases, prior and posterior distributions, Bayes estimator, admissible decision rules, non-randomized and randomized decision rules.

(20 hours)

Reference Books:

1. Lehmann E.L. (2005) Theory of point estimation – Wiley, New York.
2. Rohatgi V.K and Saleh M (2015). An Introduction to Probability and Statistics, Third edn.Wiley
3. Hogg R. V. and Craig A. T. (1989) Introduction to Mathematical Statistics, Macmillan Publishing Company.
4. Kale B. K. (1999) A First Course on Parametric Inference, Narosa Publishing House.
5. Lindgren B.W (1976) Statistical Decision Theory (3rd Edition), Collier Macmillian, New York.
6. Rao C.R (2009) Linear Statistical Inference and its Applications, Second edn., John Wiley, New York.

7. Manojkumar Srivastava, Abdul Hamid Khan and Namita Srivastava (2014) Statistical Inference, Theory of Estimation.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Outline basic estimation methods.	K1	1
2	Explain basic estimator properties such as bias, efficiency and sufficiency.	K2	3
3	Describe Classical and Bayesian estimation approaches and their differences.	K2	4,5
4	Apply methods of estimation in inferential problems.	K3	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST209 : STOCHASTIC PROCESSES

Objective

- To provide a foundation in the theory and applications of stochastic processes and an understanding of the mathematical relating to random process in the areas of estimation and communication.
- Analysis of queuing model and applications of the theory to real world problem.

UNIT I

Introduction to stochastic processes:- classification of stochastic processes according to state space and time space, wide sense and strict sense stationary processes, processes with stationary independent increments, Markov process, Markov chains-transition probability matrices, Chapman-Kolmogorov equation, first passage probabilities, generating functions, classification of states, criteria for recurrent and transient states, mean recurrence time, mean ergodic theorem, the basic limit theorem of Markov chains (statement only), reducible and irreducible Markov chains, stationary distributions, limiting probabilities and absorption probabilities.

(30 hours)

UNIT II

Continuous time Markov chains, Poisson processes, pure birth processes and the Yule processes, birth and death processes, Kolmogorov forward and backward differential equations, linear growth process with immigration, steady-state solutions of Markovian queuing models--M/M/1, M/M/1 with limited waiting space, M/M/s, M/M/s with limited waiting space and M/G/1.

(30 hours)

UNIT III

Renewal processes– concepts, examples, Poisson process viewed as a renewal process, renewal equation, elementary renewal theorem, asymptotic expansion of renewal function, central limit theorem for renewals, key renewal theorem (statement only), delayed renewal processes.

(15 hours)

UNIT IV

Random walk, gambler's ruin problem; Galton-Watson branching process, generating function relations, mean and variance functions, extinction probabilities, criteria for extinction.

(15 hours)

Reference Books:

1. Ross S.M. (2007) Introduction to Probability Models, Ninth edition, Academic Press.
2. Bhat B.R. (2002) Stochastic Processes, second edition, New Age Publication.
3. Karlin S. and Taylor H.M. (2011) A First Course in Stochastic Processes, Second edition, Academic Press, New-York.
4. Medhi J. (2009) Stochastic Processes. Third Editions, Wiley Eastern, New-Delhi.
5. Basu A.K. (2003) Introduction to Stochastic Processes, Narosa, New-Delhi.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.

1	Know the basic knowledge about stochastic processes in the time domain.	K1	1
2	Construction of Markov Chains.	K5	3, 5
3	Explain the concepts of stationary processes and a appreciate their significance.	K2	2
4	Explain the basic concepts of queueing models.	K2	4, 5
5	Create steady state equations for various queueing models	K5	5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST210 : STATISTICAL COMPUTING - II

Objectives

- To make the student capable to do practical problems in more advanced area of Statistics using R software.

Applications of topics covered in

1. PG20ST206 : Multivariate Distributions
2. PG20ST208 : Statistical Inference I
3. PG20ST209 : Stochastic Processes.

Evaluation: 6 numerical questions each with weightage 10 (marks per questionis 50) are to be asked. The student is expected to answer 3 full questions. Atleast one question from each of the section must be answered. Use of the package R is allowed for answering the questions in this paper. Examination of 3 hours duration must be conducted in the computer lab under the supervision of an examiner appointed by the college.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Sharpen statistical intuition and abstract reasoning as well as their reasoning from numerical data through examples and exercise by using excel and statistical software R	K5	4,5
2	Testing the ability of students in solving the practical problems based on Statistical Inference I, Multivariate Distributions and Stochastic Processes.	K6	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

THIRD SEMESTER

SYLLABUS OF COURSES OFFERED

PG20ST311 : STATISTICAL INFERENCE - II

Objectives

- To familiar with fundamental concepts as hypothesis testing, confidence intervals, Neymann-Pearson lemma, SPRT and the likelihood ratio test.
- To study non parametric tests.
- To prepare for further study in both theoretical and practical statistics.

UNIT I

Basic concepts in testing of hypothesis, randomized tests, Neymann- Pearson lemma and most powerful tests, monotone likelihood ratio (MLR) property, uniformly most powerful (UMP) tests, construction of uniformly most accurate (UMA) confidence intervals using UMP tests, uniformly most powerful unbiased (UMPU) tests, construction of uniformly most accurate unbiased (UMAU) confidence intervals using UMPU tests, Locally most powerful (LMP) and locally most powerful unbiased (LMPU) tests.

(30 hours)

UNIT II

Similar regions tests, Neymann structure tests, likelihood ratio (LR) tests and their properties, LR tests for testing equality of mean and variance of two normal populations.

(15 hours)

UNIT III

Sequential probability ratio tests (SPRT), Properties of SPRT, Construction of sequential probability ratio tests, Wald's fundamental identity, Operating characteristic (OC) function and Average sample number (ASN) functions for Normal, Binomial, Bernoull's, Poisson and Exponential distributions.

(15 hours)

UNIT IV

Non-parametric tests-- sign test, signed rank test, Chi-square tests, Kolmogorov-Smirnov one sample and two samples tests, median test, Mann- Whiteny U-test, Wilcoxon test, test for randomness, Run test, Run up and down test, Wald–Wolfowitz run test for equality of distributions, Kruskall–Wallis one-way analysis of variance, Friedman's two-way analysis of variance. (30 hour)

References Books:

1. Rohatgi V.K. (1976) An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, New York.
2. Manojkumar Srivastava and Namita Srivstava(2009) Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.
3. Gibbons J.K. (1971) Non-Parametric Statistical Inference, McGraw Hill.
4. Casella G. and Berger R.L. (2006) Statistical Inference, Second Edition Duxbury, Australia.
5. Lehman E.L. (1998) Testing of Statistical Hypothesis. John Wiley, New York.
6. Wald A. (2013) Sequential Analysis, Wiley, Doves, New York.
7. Siegel S. and Castellan Jr. N. J. (1988) Non-parametric Statistics for the Behavioral Sciences, McGraw Hill, New York.
8. Rao C.R. (2009) Linear Statistical Inference and its Applications, Second edn., Wiley.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Describe the problem of statistical inference, problem of testing of hypothesis etc.	K1	3
2	Explain critical regions, test functions, two kinds of errors, size function, power function and apply them in real life data sets.	K2	4
3	Explain Sequential testing and Sequential probability ratio test.	K2	4
4	Construct SPRT in case of Binomial, Poisson and Normal Distribution.	K5	3

5	Explain Likelihood ratio test., Wald test, Pearson's chi-square test for goodness of fit and Bartlett's test for homogeneity of variances	K2	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST312 : DESIGN AND ANALYSIS OF EXPERIMENTS

Objectives

- To provide the students with the basics of experimental design and the analysis relating of resulting data by various methods.

UNIT I

Linear estimation: standard Gauss Markoff set up, estimability of parameters, method of least squares, best linear unbiased Estimators, Gauss – Mark off Theorem, tests of linear hypotheses.

(20 hours)

UNIT II

Planning of experiments, Basic principles of experimental design, uniformity trails, analysis of variance, one-way, two-way and three-way classification models, completely randomized design (CRD), randomized block design (RBD) latin square design (LSD) and Graeco-latin square designs, Analysis of covariance (ANCOVA), ANCOVA with one concomitant variable in CRD.

(30 hours)

UNIT III

Incomplete block design, balanced incomplete block design (BIBD), incidence Matrix, parametric relation of BIBD, construction of BIBD, intrablock analysis of BIBD. Basic ideas of partially balanced incomplete block design (PBIBD), Parametric relations of PBIBD.

(15 hours)

UNIT IV

Factorial experiments, 2^n and 3^n factorial experiments, analysis of 2^2, 2^3 and 3^2 factorial experiments, Yates procedure, confounding in factorial experiments, basic ideas of response surface designs.

(25 hours)

Reference Books:

1. Aloke Dey (1986) Theory of Block Designs, Wiley Eastern, New Delhi.
2. DAS M.N. and GIRI N.C. (2003) Design and analysis of experiments, Wiley Eastern Ltd.
3. Agarwal B.L (2010) Theory and Analysis of Experimental Design (CBS)
4. Joshi D.D. (1987) Linear estimation and Design of Experiments, Wiley Eastern.
5. Montgomery C.D. (2017) Design and Analysis of Experiments, 9thedn., John Wiley.
6. Chakrabarti M.C. (1962) Mathematics of Design and Analysis of Experiments, Asia publishing House, Bombay.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Interpret the important role of experimentation in new product design, manufacturing process development, and process improvement.	K3	4
2	Describe factorial experiment for agriculture data.	K1	4,5
3	Describe the concept of confounding in experimental designs.	K1	2,4
4	Compare the yields obtained from different field experiments	K4	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST313 : MULTIVARIATE ANALYSIS

Objectives

- To provide the students with knowledge of the statistical concepts of multivariate data analysis and their basic methodology.

UNIT I

Hotelling's T^2 (one and two samples), Mahalanobi's D^2 statistic, Fisher-Behren problem, MANOVA (one way and two-way), profile analysis.

(30 hours)

UNIT II

Dimension reduction methods, principal components, canonical correlation and variates, factor analysis.

(20 hours)

UNIT III

Classification problem, discriminant analysis, Bayes' procedures, Fishers approach, more than two groups, selection of variables. testing independence of sets of variates, tests for equality of dispersion matrices, sphericity test, Union Intersection Principle.

(20 hours)

UNIT IV

Cluster analysis, proximity data, hierarchical clustering, non-hierarchical clustering methods, K mean method, Multi dimensional scaling.

(20 hours)

Reference Books:

1. Anderson T. W. (2010) An Introduction to Multivariate Statistical Analysis (3^{rd} ed.) John Wiley.
2. Johnson R.A. and Wichern D.W. (2008) Applied Multivariate Statistical Analysis. (6^{th}edn) Pearson education.
3. Rencher,A. C. (2012) Methods of Multivariate Analysis(3^{rd}edn). John Wiley.
4. Seber G. F. (2004) Multivariate Observations, John Wiley.

5. Rao C. R. (2009) Linear Statistical Inference and Its Applications(2nd Ed.), Wiley Eastern Ltd.
6. Srivastava M.S. and Khatri C.G. (1979) Introduction to Multivariate Analysis, Elsevier.
7. Jiawei Han (2000) Data Mining –Concepts and Techniques, Third edn.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Analyze multivariate data.	K4	5
2	Compare multivariate techniques and corresponding univariate techniques.	K4	4
3	Apply factor analysis effectively for exploratory and confirmatory data analysis.	K3	3, 4
4	Describe the basic concepts of data mining techniques.	K1	5
5	Analyses data and reducing the dimensions of the data by using different dimension reduction techniques like PCA, Factor analysis etc.	K4	4
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST314 : TIME SERIES ANALYSIS

Objective

- This course aims at familiarizing the students with trend, seasonal variations, time series models, forecasting, residual analysis and diagnostic checking.

UNIT I

Time series, components of time series, additive and multiplicative models, determination of trend, analysis of seasonal fluctuations, test for trend and seasonality, exponential and moving average smoothing, holt-winter smoothing, forecasting based on smoothing.

(20 hours)

UNIT II

Time series as a discrete parameter stochastic process, auto covariance and auto correlation functions and their properties, stationary processes, test for stationarity, unit root test, stationary processes in the frequency domain, spectral analysis of time series.

(20 hours)

UNIT III

Detailed study of the stationary processes: moving average (MA), autoregressive (AR), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.

(25 hours)

UNIT IV

Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares, Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.

(25 hours)

Reference Books:

1. Chatfield C. (2004) The Analysis of Time Series - An Introduction (Sixth edition), Chapman and Hall.
2. Abraham B. and Ledolter J.C. (1983) Statistical Methods for Forecasting, Wiley.
3. Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting (Second edition), Springer-Verlag.
4. Box G.E.P and Jenkins G.M. (1970) Time Series Analysis, Forecasting and Control, Holden-Day.
5. Kendall M.G. (1978) Time Series, Charler Graffin.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Describe of the concepts of time series and their application to health, climate, finance and other areas.	K1	4,5

2	Analyze auto regressive, moving average, ARMA, ARIMA models and able to compute auto-covariance and autocorrelation of stationary time series models.	K4	5
3	Explain the concepts of spectral analysis of times series, Seasonal ARIMA, ARCH and GARCH models.	K2	4
4	Develop ability to analyze real life time series data sets.	K5	5, 6
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST315 : STATISTICAL COMPUTING - III

Objectives

- To make the students able to handle practical problems in Statistical Inference II, Design and Analysis of Experiments and also the Multivariate Analysis. They can use software R. It will enable them to handle practical situations.

Applications of topics covered in

1. PG20ST311:Statistical Inference II
2. PG20ST312 : Design and Analysis of Experiments
3. PG20ST313 : Multivariate Analysis

Evaluation: 6 numerical questions each with weightage 10 (marks per question is 50) are to be asked. The student is expected to answer 3 full questions. At least one question from each of the section must be answered. Use of the package R is allowed for answering the questions in this paper. Examination of 3 hours duration must be conducted in the computer lab under the supervision of an examiner appointed by the college

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Sharpen statistical intuition and abstract reasoning as well as their reasoning from numerical data through examples and exercise by using excel and statistical software R.	K5	4, 5
2	Testing the ability of students in solving the practical problems based on Statistical Inference II, Design and Analysis of Experiments, Multivariate Analysis and Econometric Methods.	K6	4, 5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

FOURTH SEMESTER

SYLLABUS OF COURSES OFFERED

PG20ST416: ECONOMETRIC METHODS

Objectives

- To provide students with a general background in theory and applications of various statistical and econometric analysis techniques. It is important to note that the methods presented can be used in a wide variety of data-analysis.

UNIT I

Demand and supply functions, elasticity of demand, equilibrium of market, production functions- homogeneous functions, elasticity of production, input- output analysis, Leontief's open and closed models.

(30 hours)

UNIT II

Simple linear regression models, Multiple linear regression models, estimation of the model parameters, tests concerning the parameters, confidence intervals, prediction, heteroscedasticity, tests, consequences, Multicollinearity- consequences, Farrar-Glauber test, remedial measures. Residual Analysis.

(20 hours)

UNIT III

Aitken's generalized least square method, tests for auto correlation, consequences, and estimation procedures, stochastic regressors, errors in variables, use of Dummy variables in regression, polynomial regression models in one variable, basic ideas of logistic regression and step-wise regression.

(20 hours)

UNIT IV

Simultaneous equation models, Identification problems, rank and order condition, methods of estimation- indirect least squares, least variance ratio(LVR)or LIML and two-stage least squares, FIML- methods.

(20 hours)

References Books:

1. Johnston J. (1984) Econometric Methods (Third edition), McGraw Hill, New York.
2. Montgomery D.C., Peck E.A. and Vining G.G. (2007) Introduction to Linear Regression Analysis, John Wiley, India.
3. Gujarati D (2009) Basic Econometrics, Fifth edn., McGraw Hill.
4. Apte P.G. (1990) Text book of Econometrics, Tata Me Graw Hill.
5. Theil H. (1982) Introduction to the Theory and Practice of Econometrics, John Wiley.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Apply the challenges of empirical modelling in economics and business.	K3	5
2	Analyze economic data by using regression analysis .	K4	4,5
3	Explain theoretical background for the standard methods used in empirical analyses, like properties of least squares estimators and the statistical testing of hypothesis.	K2	4,5
4	Describe the concept of structural econometric models and their applications in econometric modelling.	K1	5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

PG20ST420 :STATISTICAL COMPUTING - IV

Objectives

- To impart the practical skills in the students in the theories of Econometrics and other elective papers. To make them familiar with the software packages.

Applications of topics covered in

1. PG20ST416 : Econometric Methods
2. PG20ST417 : Elective 01
3. PG20ST418 : Elective 02

Evaluation: 6 numerical questions each with weightage 10 (marks per question is 50) are to be asked. The student is expected to answer 3 full questions. At least one question from each of the section must be answered. Use of the package R is allowed for answering the questions in this paper. Examination of 3 hours duration must be conducted in the computer lab under the supervision of an examiner appointed by the college.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Sharpen statistical intuition and abstract reasoning as well as their reasoning from numerical data through examples and exercise by using excel and statistical software R.	K5	4, 5
2	Testing the ability of students in solving the practical problems based on Statistical Quality Control, Time Series Analysis and Operations Research.	K6	4,5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

ELECTIVES

Bunch A

ELECTIVE 01- OPERATIONS RESEARCH

Objectives

- This course aims at familiarizing the students with various optimization techniques, which are frequently applied to business, decision making and to provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.

UNIT I

Linear programming:- convex sets and associated theorems, introduction to linear programming problems (LPP), graphical solution, feasible, basic feasible and optimal basic feasible solutions to an LPP, theoretical development of simplex method, big-M method, two-phase simplex method, dual of linear programming, theorems of duality, dual-simplex method, Transportation problems, assignment problems, sequencing problem.

(15 hours)

UNIT II

Inventory models, deterministic inventory models, EOQ models with and without shortages, multi-item deterministic models with one linear constraint, EOQ problem with price breaks, probabilistic inventory models single period stochastic models without set up cost, general single period models.

(30 hours)

UNIT III

Characteristics of dynamic programming and developing optimal decision policy using Bellman's principle of optimality, dynamic programming under certainty, single additive constraint-additives separable returns, single multiplicative constraint-additives separable return, single additive constraint multiplicatively separable return, dynamic programming approach for solving LPP, NLPP, QPP, Wolfe's modified simplex method and Beale's method.

(30 hours)

UNIT IV

Theory of games, two person zero-sum games, fundamental theorem of matrix games, dominance property, graphical method of solution of 2xn and mx2 games, Rectangular games as LPP.

(15 hours)

Reference Books:

1. Ravindran A, Philips D.T and Soleberg, Operations Research – Principles and Practice, John Wiley and Sons.
2. J K Sharma (2012) Operations research – Theory and Applications, Fifth edn., Macmillan.
3. Frederick S Hiller and Gerala Jlieberman, Introduction to Operations Research Tata Mcgraw Hill.
4. Kanti Swarup, Gupta, Manmohan (2004) 10^{th} edition, Operations Research – Principles and Practice.
5. Thaha H A, Operations Research – An Introduction, Prentice Hall.
6. Mittal K.V (1983) Optimization methods in OR system analysis, Wiley Eastern.
7. A.M.Natarajan, P. Balasubramanie, A.Tamilarasi, Operations research, 2^{nd}edn. (2014), Dorling Kindersley Pvt.Ltd.Licensees of Pearson edn.In South Asia.
8. Kalavathy.S (2012) , Operations Research, Vikas Publishing house, Pvt.Ltd.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Explain the basic concepts of LPP.	K2	1
2	Describe basic concepts of inventory problems and solve various types of EOQ models	K1	3,4
3	Explain sequencing problems, travelling salesman problem and various methods to solve sequencing problems.	K2	2
4	Identify strategic situations and represent them as games.	K1	3

5	Evaluate simple games using various techniques.	K6	2
6	Illustrate the theory and applications of NLPP.	K3	5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

ELECTIVE 02 : STATISTICAL QUALITY CONTROL

Objectives

- This course present the theory and methods of quality monitoring including process capability, control limits, acceptance sampling by attribute and acceptance sampling by variables.

UNIT I

Statistical process control, theory of control charts, Shewhart control charts for variables-$\bar{x}$, R, s charts, attribute control charts - p, np, c, u charts, modified control charts.

(25 hours)

UNIT II

O.C and ARL curves of control charts, moving average control charts, EWMA charts, CUSUM charts, process capability analysis, process capability indices – C_p and C_{pk}.

(20 hours)

UNIT III

Acceptance sampling for attributes, single sampling, double sampling, multiple sampling and sequential sampling plans, rectifying inspection plans, measuring performance of the sampling plans- OC, AOQ, ASN, ATI curves.

(25 hours)

UNIT IV

Acceptance sampling plans by variables, designing a variable sampling plan with a specified OC curve, sampling plan for a single specification limit with known and unknown variance.

(20 hours)

Reference books:

1. Montgomery D. C. (2009) Introduction to Statistical Quality control, 7th edition, Wiley.
2. Grant E. L. and Leavenworth R. S. (1980) Statistical Quality control, McGraw Hill.
3. Duncan A. J. (1980) Quality control and Industrial Statistics, 3rd edition Irwin Homewood.
4. Schilling E. G. (2017) Acceptance Sampling in Quality Control, Marcel Decker.
5. Mittag H. J. and Rinne, H. (1993) Statistical Methods for Quality Assurance, Chapman and Hall.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Outline the basic concepts of quality monitoring.	K1	4
2	Construct various types of control charts such as X bar, R ,X ,s, p charts, EWMA, CUSUM charts etc and draw conclusions.	K5	4, 5
3	Explain Various sampling inspection techniques.	K2	5
4	List different performance measures of control chart such as OC,ARL etc.	K1	3
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

ELECTIVE 03-STATISTICAL RELIABILITY ANALYSIS

Objective

- To explain how system reliability can be measured and how reliability growth models can be used for reliability prediction.
- This course aims at familiarizing the students with various reliability models and Reliability estimation using MLE.

UNIT I

Basic concepts in reliability, series and parallel systems, k out of n systems and its reliability, coherent systems, reliability of coherent systems, cuts and paths, bounds on system reliability.

(20 hours)

UNIT II

Life distributions; reliability function, hazard rate and mean residual life function, one-one correspondence of these functions, Study of life time models viz, exponential, Weibull, Lognormal, Pareto, Gamma, Makeham, Reliegh distributions, proportional hazard models and their characteristics.

(25 hours)

UNIT III

Notions of ageing; increasing failure rate (IFR), increasing failure rate average (IFRA), new better than used (NBU), decreasing mean residual life (DMRL) and new better than used in expectation (NBUE), classes and their duals; loss of memory property of the exponential distribution, closures of these classes under formation of coherent systems, convolutions and mixtures.

(25 hours)

UNIT IV

Reliability estimation using MLE - Exponential, Weibull and Gamma distributions based on censored and non-censored samples, Kaplan-Meier estimates of the distribution function, stress-strength reliability and its estimation.

(20 hours)

Reference Books:

1. Barlow R.E. and Proschan F. (1965) Mathematical Theory of Reliability, Wiley, New York.
2. Sinha S. K. (1986) Reliability and Life Testing, Wiley Eastern.
3. Barlow R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.
4. Rao S.S. (1992) Reliability-based design, McGraw Hill, New York.
5. Lai C.D and Xie M. (2006) Stochastic ageing and dependence in reliability, Springer.

Course Outcomes

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level	PSO No.
1	Describe the basic concepts of reliability.	K1	2
2	Explain coherent systems are, and can represent such systems by paths and cuts.	K2	3
3	Calculate the reliability of components in a complicated systems.	K3	4,5
4	Explain different reliability measures.	K2	5
Knowledge Levels: K1-Remembering; K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-Creating.			

Bunch B

ELECTIVE 01-SURVIVAL ANALYSIS

Objectives

- Survival Analysis is highly applied in clinical data. This course will help them in handling clinical data and related analysis.

UNIT I

Basic Quantities and Models - Survival function, Hazard function, Mean residual life function and Median life, Common Parametric Models for Survival Data; Censoring and Truncation - Right Censoring, Left or Interval Censoring, Truncation, Likelihood Construction for Censored and Truncated Data.

(20 hours)

UNIT II

Nonparametric Estimation of a Survivor Function and Quantiles**,** The Product-Limit Estimator, Nelson-Aalen Estimator Interval Estimation of Survival Probabilities or Quantiles, Asymptotic Properties of Estimators, Descriptive and Diagnostic Plots, Plots Involving Survivor or Cumulative Hazard Functions, Classic Probability Plots, Estimation of Hazard or

Density Functions**,** Methods for Truncated and Interval Censored Data, Left-Truncated Data, Right-Truncated Data, Interval-Censored Data.

(25 hours)

UNIT III

Semi-parametric Proportional Hazards Regression with Fixed Covariates – Coding Covariates, Partial Likelihoods for Distinct-Event Time Data, Partial Likelihoods when Ties are present, Local Tests, Discretizing a Continuous Covariate, Model Building using the Proportional Hazards Model, Estimation for the Survival Function; Introduction to Time-Dependent Covariates; Regression Diagnostics :- Cox-Snell Residuals for assessing the fit of a Cox Model, Graphical Checks of the Proportional Hazards Assumption, Deviance Residuals, Checking the Influence of Individual Observations.

(25 hours)

UNIT IV

Inference for Parametric Regression Models - Exponential, Gamma and Weibull Distributions, Nonparametric procedure for comparison of survival function, Competing risk models – Basic Characteristics and Model Specification.

(20 hours)

Text Books

1. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York,

Reference Books

1. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons.
2. Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure TimeData, Second Edition, John Wiley & Sons Inc.
3. Hosmer Jr. D.W and Lemeshow S (1999) Applied Survival Analysis – Regression Modelling of Time to event Data, John Wiley & Sons. Inc. 3. Nelson. W (1982)Applied Life Data Analysis.
4. Miller, R.G. (1981) Survival Analysis, John Wiley.

Course Outcomes

CO NO.	Upon completion of this course, the students will be able to:	Knowledge level	PSO No.
1	Decide the type of censoring and truncation that is the basis for survival data.	K2	1, 2
2	Compare survival functions of two or more populations.	K4	1,2,3
3	Estimate nonparametric survival function of the data.	K6	5
4	Use software for survival analysis.	K3	5
Knowledge Levels: K1-Remembering;K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-creating.			

ELECTIVE 02 : POPULATION DYNAMICS

Objectives

- By the end of this course students are expected to be able to understand and use various mortality rates, to construct life tables, to calculate and use various characteristics of life time models and population growth models.

UNIT I

Sources of mortality data-mortality measures-ratios and proportions, crude mortality rates, specific rates-standardization of mortality rates, direct and indirect methods, gradation of mortality data, fitting Gompertz and Makeham curves.

(15 hours)

UNIT II

Life tables-complete life table-relation between life table functions, abridged life table relation between abridged life table functions, construction of life tables, Greville's formula, Reed and Merrell's formula- sampling distribution of life table functions, multivariate pgf – estimation of survival probability by method of MLE.

(30 hours)

UNIT III

Fertility models, fertility indices relation between CBR,GFR,TFR and NRR, stochastic models on fertility and human reproductive process, Dandekar's modified binomial land Poisson models, Brass, Singh models for waiting time distributions, Shepsand Perrin model.

(25 hours)

UNIT IV

Population growth indices, logistic model, fitting logistic, other growth models, Lotka's stable population, analysis, quasi stable population, effect of declining mortality and fertility on age structure, population projections, component method-Leslie matrix technique, properties of time independent Leslie matrix-models under random environment.

(20 hours)

Text Books :

1. Biswas S (2007) Applied Stochastic Processes-A Biostatistical and Population Oriented Approach, Second Edition, New Central Book Agency 45.
2. Pollard J.H (1975) Mathematical Models for the growth of Human population, Cambridge University Press.

Reference Books

1. Biswas S (1988) Stochastics processes in Demography and applications, Wiley Eastern.
2. Keyfitz N (1977) Applied Mathematical Demography A Wiley Interscience publication.
3. Ramkumar R (1986) Technical Demography, Wiley Eastern.
4. Srinivasan K (1970) Basic Demographic Techniques and Applications.

Course Outcome

CO NO.	Upon completion of this course, the students will be able to:	Knowledge level	PSO No.
1	Demonstrate critical understanding of how and why patterns of population, fertility, mortality and migration vary over time and space.	K3	3,4
2	Show a critical awareness of the relationship between population and policy making.	K1	1,2
3	Demonstrate knowledge and critical understanding of the key population indicators and concepts such as: TFRs, net migration, replacement migration, child and infant mortality, life expectancy, dependency, urbanization and megacities.	K3	4,5

5	Apply a variety of conceptual and theoretical lenses to the study and critical analysis of population change.	K3	3,4,5
Knowledge Levels:K1-Remembering;K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-creating.			

ELECTIVE 03 : CATEGORICAL DATA ANALYSIS

Objectives

- To enable the students familiar with categorical data and various probability models associated with it.

UNIT I

Categorical variables, Introduction to Binary data, The linear probability models, Thelogit model, The Probit model, the latent variable approach, the odds ratio, Relarive risks, Sensitivity and specificity, MNemar's test, Binomial response models, log-log models, Likelihood ration Chi-squared statistic, Log-rate models, Time Hazard models, Semiparametric rate models.

(20 hours)

UNIT II

Logistic Regression Analysis: Logit Models with Categorical Predictors Logistic Regression models, regression diagnostics, Predictions, Interpreting parameters in logistic Regression. Inference for logistic Regression, Multiple logistic regression.

(25 hours)

UNIT III

Poisson regression: interpretations, regression diagnostics, Predictions**,** negative binomial regression**,** Proportional hazards regression.

(20 hours)

UNIT IV

Principles of Bayesian statistics, Inference using simulations - Standard distributions**,** Understanding Markov Chain Monte Carlo, The Gibbs sampler and the Win BUGS[Necessary topics from Chapter 1-5 of Ioannis Ntzoufras (2009)]

(25 hours)

Reference Books

1. Agresti, A. (1990) Categorical Data Analysis. New York: John Wiley.
2. Carlin, B.P. and Louis, T.A. (2000) Bayes and Emperical Bayes Methods for Data Analysis, Second Edition46

3. Congdon P. (2006) Bayesian Statistical Modelling, Second Edition, John Wiley & Sons,Ltd. ISBN: 0-470-01875-5
4. Ntzoufras I. (2009) Bayesian Modeling using WinBUGS John Wiley & Sons Inc.
5. Powers D.A. (1999) Statistical methods for Categorical data analysis. Academic pressInc.
6. Shewhart,W.A. and Wilks, S.S. (2013) Case Studies in Bayesian Statistical Modelling and Analysis. Wiely.

Course Outcomes

CO NO.	Upon completion of this course, the students will be able to:	Knowledge level	PSO No.
1	Dramatize categorical data, compute measures of association and structural models for discrete data.	K3,K4	4, 5
2	Fit logistic models and Poisson models to data set.	K5	5, 6
3	Check model assumptions and analyze residuals and goodness-of-fit, Conduct Inference for model parameters.	K4	3
4	Understand path and structural equation modeling.	K2	1, 2
Knowledge Levels: K1-Remembering;K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-creating.			

Bunch C

ELECTIVE 01 : ACTUARIAL STATISTICS

Objectives

- To enable the students to get basics in the emerging field of actuaries and insurance and to determine the annuity, and determine the same based of the residual life

UNIT I

Insurance Business – Introduction, Insurance Companies as Business Organizations, Concept of Risk; Future Lifetime Distribution and Life Tables –Future Lifetime Random Variable, Curtate Future Lifetime, Life Tables, Assumptions for Fractional Ages, Select and Ultimate Life Tables.

(25 hours)

UNIT II

Actuarial Present Values or Benefit in Life Insurance Products –Compound Interest and Discount Factor, Benefit Payable at the Moment of Death, Benefit Payable at the End of Year of Death, , Relation between □and □̄.

(20 hours)

UNIT III

Annuities – Annuities Certain, Continuous Life Annuities, Discrete Life Annuities, Life Annuities with *m*thly Payments; Premiums – Loss at Issue Random Variable, Fully Continuous Premiums, Fully Discrete Premiums, True *m*thly Payment Premiums, Gross Premiums.

(25 hours)

UNIT IV

Reserves – Fully Continuous Reserves, Fully Discrete Reserves; Multiple Life Contracts – Joint Life Status, Last Survivor Status.

(20 hours)

Text Books

1. Deshmukh, S.R. (2009) Actuarial Statistics – An Introduction using R, University Press(India) Pvt Ltd., Hyderabad, Chapters 1, 4, 5, 6, 7, 8 and 9.47

Reference Books

2. Daykin, C.D, Pentikainen,T. et al, Practical Risk Theory of Acturies, Chapman andHill .
3. Promislow, S.D (2006) Fundamentals of Actuarial Mathematics, John Wiley.Chapters 2-11 &14
4. Neill, A (1977) Life Contingencies, Heinemann , London.
5. King,G. Institute of Actuaries Text Book. Part 11, Second Edition, Charles and Edwin Layton, London.
6. Donald D.W.A.(1970) Compound Interest and Annuities, Heinemann, London.
7. Jordan, C.W.Jr.(1967) Life Contigencies, Second Edition, Chicago Society of Actuaries.
8. Spurgeen, E.T. Life Contigencies, 3rd Edition, Cambridge University Press.
9. Benjamin, B. and Pollard, J.H.(1980) Analysis of Mortality and other Actuarial Statistics, Second Edition, Heinemann, London.
10. Freeman,H.(1960) Finite Differences for Actuarial Students, Cambridge University Press.

11. Biandt-Johnson, R.C.and Johnson ,N.L(1980) Survival Models and Data Analysis, John Wiley

Course Outcomes

CO NO.	Upon completion of this course, the students will be able to:	Knowledge level	PSO No.
1	Understand the utility theory, insurance products and life tables.	K2	2,3
2	Understand the concept of interest.	K2	1
3	Understand the concept of life insurance and the existing insurance products of different insurance company.	K2	1,2
4	Know life annuities, net premium, and net premium reserves.	K1	3,4
Knowledge Levels:K1-Remembering;K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-creating.			

ELECTIVE 02 :APPLIED REGRESSION ANALYSIS

Objectives

- By the end of this course they will be able to deal with various regression models and their interpretations.

UNIT I

Mathematical & Statistical models, Linear Model- estimability of parameters, Linear Regression Model, Least squares estimation, Gauss Markov Theorem, BLUE, Properties of the estimates, Distribution Theory, Maximum likelihood estimation, Estimation with linear restrictions, Generalised least squares; Hypothesis testing - likelihood ratio test, F-test; Confidence intervals, Residual analysis, Departures from underlying assumptions.

(25 hours)

UNIT II

Polynomial regression in one and several variables, Orthogonal polynomials, Indicator variables, Subset selection of explanatory variables, stepwise regression and Mallows Cp - statistics, Introduction to non-parametric regression.

(15 hours)

UNIT III

Introduction to nonlinear regression, Least squares in the nonlinear case and estimation of parameters, Models for binary response variables, estimation and diagnosis methods for logistic and Poisson regressions**.** Prediction and residual analysis, Generalized Linear Models – estimation and diagnostics.

(20 hours)

UNIT IV

Transformations and weighting to correct model inadequacies, Analytical methods for selecting a transformation, The Box-Cox method, Transformation on the regress or variables, Ridge regression, Basic form of ridge regression , Robust regression Least absolute deviation regression, Least median of squares regression, Inverse estimation- The calibration problem, Re sampling procedures for regression models(Bootstrapping).

(30 hours)

Text Books:

1. Seber, A.F. and Lee, A.J. (2003) Linear Regression Analysis, John Wiley, Relevant sections from chapters 3, 4, 5, 6, 7, 9, 10.
2. Montegomery, D.C., Peck, E.A. and Vining, G.G. (2001) Introduction to Regression Analysis, Third edition. Wiley.
3. B.Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley &Sons.

Reference Books:

1. Searle, S.R. (1971) Linear models, John Wiley & Sons, Inc.
2. N.Draper and H. Smith (1986) Applied Regression Analysis – John Wiley & Sons.
3. Fox, J. (1984) Linear Statistical Models and Related methods, John Wiley, Chapter 5.
4. Christensen, R. (2001) Advanced Linear Modeling, Chapter 7.49

Course Outcome

CO NO.	Upon completion of this course, the students will be able to:	Knowledge level	PSO No.
1	Demonstrate knowledge of the basic ideas behind regression analysis using data with more than one explanatory variable.	K3	4
2	Develop understanding of two common regression analysis techniques as well as an appreciation of the need for the further regression techniques related to the type of data.	K5	4, 5
3	Analyze real data by applying these techniques and interpret resulting output.	K4	3, 4
4	Write short statistical reports based on these analyses.	K5	5
5	Apply simple linear regression model to real life examples.	K3	3, 4
6	Apply Logistic and Non-linear regression models and its implementation in real life situation.	K3	3, 4
Knowledge Levels: K1-Remembering;K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-creating**.**			

ELECTIVE 03 :DATA MINING

Objectives

- To enable the students to handle data mining and the related methodologies and problems.

UNIT I

Introduction to Data Mining**:** Data Mining for Business Intelligence, Data Mining Goes to Hollywood**!,** Data Mining Concepts and Definitions, Characteristics, and Benefits, How Data Mining Works, Data Mining Applications.

(20 hours)

UNIT II

Data Mining Process **:** Data Mining Process, Step 1: Business Understanding, Step 2: Data Understanding, Step3: Data Preparation, Step 4: Modelling Building, Step 5: Testing and Evaluation, Step 6:Deployment, Other Data Mining Standardized Processes and Methodologies.

(25 hours)

UNIT III

Data Mining Methods **:** Data Mining Methods, Classification, Estimating the True Accuracy of Classification Models**,** Cluster Analysis for Data Mining.

(20 hours)

UNIT IV

Artificial Neural Networks **:** Association Rule Mining, Artificial Neural Networks for Data Mining, Elements of ANN, Applications of ANN. Data Mining Software Tools, Data Mining Myths and Blunders.

(25 hours)

References

1. Turban, Sharda Efraim, Ramesh, Dursun Delen and King, David. (2011).Business Intelligence : A Managerial Approach, 2nd Edition. Publisher :Prentice Hall.
2. Han, Jiawei and Kamber, Micheline. (2012). Data Mining: Concepts and Techniques,3rd edition. Morgan Kaufman Publishers.
3. Tang, P.N., Steinbackm, M. And Kumar, V. (2006). Introduction to Data Mining. Addison Wesley.
4. Myatt, Glenn and Johnson, Wayne. (2009). Making Sense of Data II. John Wiley& Sons, Rajaraman, Anand. (2011). Mining of Massive Datasets. New York: Cambridge University Press.

Course Outcome

CO NO.	Upon completion of this course, the students will be able to:	Knowledge level	PSO No.
1	Understanding of what data mining is all about.	K2	2
2	Demonstrate an understanding of the alternative knowledge representations such as rules, decision trees, decision tables, and Bayesian networks.	K3	4
3	Demonstrate an understanding of the basic machine learning algorithmic methods that support knowledge discovery.	K3	4,5
4	Evaluate what has been learned through the application of the appropriate statistics.	K5	5,6
Knowledge Levels: K1-Remembering;K2-Understanding; K3-Applying; K4-Analyzing; K5-Evaluating; K6-creating.			

MODEL QUESTION PAPERS

Semester I

Model Question Paper

PG20ST101– PROBABILITY DISTRIBUTIONS

(2020 admission onwards)

Time: 3 Hours Total Weights: 30

Part A

(Answer any eight questions. Weightage 1 for each question.)

1. Define p.g.f . Obtain the p.g.f of geometric distribution and hence find its mean.
2. Define chi- square distribution and F distribution.
3. Discuss the concept of truncated random variables.
4. Define an order statistic.
5. If X and Y are independent standard normal variates, write down the p.d.f of
   a) U= $\frac{X}{Y}$ b) V=X +Y
6. Find the distribution function of an exponential random variable.
7. Let X has uniform distribution over [0, 1]. What is the distribution of -2log X.?
8. What is meant by lognormal distribution? How is it related to normal distribution?
9. Define a non-central t statistics, mentioning its parameters.
10. If $X_1, X_2,\ldots\ldots X_n$ are iid random variables having logistic distribution, obtain the p.d.f
    $X_{(1)} = \min(X_1, X_2,\ldots\ldots X_n)$.

Part B

(Answer any six questions. Weightage 2 for each question.)

11. Derive the recurrence relation satisfied by Poisson probabilities. Also find mode of Poisson distribution.
12. Let X and Y be two independent Gama variates with parameters (α_1, β) and (α_2, β) respectively. Find the distribution of $\frac{X}{Y}$.
13. Derive the mean and mode of F distribution with (m,n) d.f.
14. Define Pareto distribution and derive its mean and variance.
15. If X and Y are independent U (0, 1) variates, obtain the p.d.f of X+Y.
16. Derive the joint p.d.f of r^{th} and s^{th} order statistics.
17. Find the probability generating function of negative binomial distribution. Hence find its mean and variance.
18. What is meant by Cauchy distribution? Show that expectation does not exist for this distribution.

Part C

(Answer any two questions. Weightage 5 for each question.)

19. For a normal distribution $N(\mu,\sigma^2)$, a) Show that mean, median and mode are equal; b) Obtain the mean deviation about mean.
20. Let X and Y be two independent standard Cauchy random variables. Find the the p.d.f of
    a) U= X/Y b) V= X+Y c) W= X^2
21. Let $Y_1<Y_2<$ ……..$<Y_n$ be the order statistics from a Weibull distribution. Find the distribution function and p.d.f of Y_1.
22. Derive the m.g.f of power series distribution and hence derive the recurrence relation for cumulants. Using the recurrence relation, obtain the mean and variance of Poisson distribution.

Model Question Paper

PG20ST102 - MEASURE AND PROBABILITY

(2020 admission onwards)

Time: 3 hours Maximum Weight: 30

Part A

(Answer any eight questions. Weight 1 for each question)

1. Define Limit infimum and suprimum of a sequence of sets.
2. Define a σ field. S.T. σ field is a field.
3. Define a measurable function.
4. Define Probability Space and Induced Probability Space.
5. State Borel Canteli Lemma.
6. Define Distribution function of a random variable and state its properties.
7. Define Mathematical Expectation of a random variable.
8. Discuss the concept of Almost Sure Convergence and Convergence in Probability.
9. State Helly Bray theorem.
10. State Jensen's inequality.

Part B

(Answer any six questions. Weight 2 for each question)

11. S.T. Intersection of arbitrary number of field is also a field. But union of field need not be a field.
12. State and prove continuity property of measures.
13. Define Random variable and S.T. If X is a random variable, then X^+, X^- and $|X|$ are all random variables.
14. Show that the events A and B are independent if and only if A and B^C are independent.

15. State and prove Bayes theorem for a finite number of events.
16. State and Prove Chebychev's inequality.
17. Let $h(x)$ be a non-negative Borel-Measurable function of a random variable X and let $E\left(h(x)\right)$ exists. Then S.T $P\left\{h(x)\geq\varepsilon\right\}\leq\frac{E\left[h(x)\right]}{\varepsilon}$ for every $\varepsilon>0$.
18. S.T. $X_n\xrightarrow{a.s}X\Rightarrow X_n\xrightarrow{p}X$.

Part C

(Answer any two questions. Weight 5 for each question)

19. If Z=(X,Y) is a two-dimensional random variable, then show that X+Y, X-Y, XY, $\frac{X}{Y}, Y\neq 0$, max(X,Y) and min(X,Y) are random variable.
20. State and prove dominated convergence theorem.
21. If X is a non negative random variable with distribution function F, then show that $E(x)=\int_0^\infty\left(1-F(x)\right)dx$.
22. I Prove that $X_n\xrightarrow{p}0$ iff $E\left[\frac{|X_n|}{1+|X_n|}\right]\to 0$ as $n\to\infty$.

    II If $X_n\xrightarrow{a.s}X$ and $Y_n\xrightarrow{a.s}Y$, then show that

    $X_n+Y_n\xrightarrow{a.s}X+Y$ and

    $X_nY_n\xrightarrow{a.s}XY$

Model Question Paper

PG20ST103 - SAMPLING THEORY

(2020 admission onwards)

Time: 3 Hours Total Weights: 30

Part A

Answer any 8 questions. Weightage 1 for each question.

1. State briefly the advantages of sampling over complete enumeration.
2. Distinguish between Sampling and Non Sampling errors.
3. Define SRSWR and SRSWOR.
4. When do you go for Stratification?
5. What is meant by Ordered and Unordered Estimators.
6. Show that the ratio estimators are biased. Derive the expression for its bias term.
7. Define Cluster Sampling. Give an example.
8. Distinguish between multistage and multiphase sampling.

9. Describe the Lahiri's method of selection under PPS sampling.
10. Explain Murthy's unordered estimator.

Part B

Answer any 6 questions. Weightage 2 for each question.

11. How can you determine the sample size in SRSWOR.
12. Show that in SRSWR, the sample mean square error is an unbiased estimator of the population variance.
13. In case of stratified random sampling, explain the Neyman allocation.
14. Show that, the mean of systematic sample is more precise than the mean of SRS, if and only if $S_{wsy}^2 > S^2$, with usual notations.
15. Define Ratio Estimator. S.T $B\left(\hat{R}\right) \approx \frac{N-n}{Nn}\frac{R}{\bar{X}\bar{Y}}\left(RS_x^2 - \rho S_x S_y\right)$
16. What are differences between Cluster Sampling and Stratified Sampling
17. Describe Zen – Midzuno scheme of sampling and derive the expression for the first order and second order inclusion probabilities.
18. Define Harwitz – Thompson estimator under PPSWOR scheme for the population total. Is it unbiased? Obtain an expression for its variance.

Part C

Answer any 2 questions. Weightage 5 for each question.

19. Show that the sample mean is the BLUE of the population mean in a SRSWOR procedure.
20. In case of stratified sampling show that $V_{opt} \leq V_{prop} \leq V_{srs}$.
21. What is meant by linear regression estimator for the population mean? Compare the efficiency of the regression estimator with those based on mean per unit and ratio estimation procedure.
22. Define Desraj's ordered estimator for the population total using a sample of size 2 and show that it is unbiased and find its variance.

Model Question Paper

PG20ST104 – ANALYTICAL TOOLS FOR STATISTICS

(2020 admission onwards)

Time: 3 Hours Maximum weight: 30

Part A

Answer any eight questions. Weightage 1 for each question.

1. Define linearly independent and dependent set of vectors.
2. Obtain the matrix corresponding to the Q.F:
   $x_1^2 + 2x_2^2 + 3x_3^2 + 4x_1x_2 + 5x_2x_3 + 6x_3x_1$.

3. Define uniform continuity of a real valued function with an example.
4. Show that the set $\{1, x, x^2, ...x^n\}$ is linearly independent for any $[a, b]$.
5. Define characteristic subspace of a matrix.
6. State the properties of g-inverse.
7. If A is a positive definite matrix, show that $|A| > 0$.
8. Show that $\rho(A) = tr(A)$ if A is an idempotent matrix.
9. If $L\{f(t)\} = f(s)$, then find $L\{f(at)\}$.
10. Define geometric multiplicity of an eigen value

Part B

Answer any six questions. Weightage 2 for each question

11. Explain the spectral decomposition of a Hermitian matrix.
12. Show that every square matrix is unitary similar to a triangular matrix.
13. State and prove Cayley -Hamilton theorem.
14. Define g-inverse of a matrix. Show that a matrix A^- is a g-inverse of A if and only if $AA^-A = A$.
15. Show that union of two subspaces is a sub space if and only if one is contained in the other.
16. Using Laplace transform to solve the following differential equation $y' + y = 3e^{2t}, y(0) = 0$
17. Show that the function defined by

$$f(x) = \begin{cases} x \operatorname{Sin} \frac{1}{x}; x \neq 0 \\ 0; x = 0 \end{cases}$$

Is continuous at $x = 0$.

18. Examine whether the vectors (0, 1,-2), (1,-1, 1) and (1, 2, 1) are linearly independent.

Part C

Answer any two questions. Weightage 5 for each question

19. State and prove Gram-Schmidt orthogonalization process. Find an orthonormal basis for the linear manifold spanned by the vectors $(1,1,1), (1,-2,1), (1,2,3)$.
20. Derive the necessary and sufficient condition for the negative definiteness of a real quadratic form.
21. Define algebraic and geometric multiplicity of a characteristic roots. Show that geometric multiplicity of a characteristic root cannot exceed its algebraic multiplicity.
22. Find the maxima and minima of the function $f(x, y) = x^3 + y^3 - 3x - 12y + 20$.

Model Question Paper

PG20ST105 –STATISTICAL COMPUTING - I

(2020 admission onwards)

Time: 3 Hours Maximum Weight: 30

(Answer any three questions Each question carries Weight 10)

1. **a)**Heights(in cm) of father and son are given as follows. Calculate karl pearson's correlation coefficient and Fit a regression line predict the height of son given the height of father and predict the height of son when height of father is 158.

Father(X)	150	152	155	157	160	161	164	165
Son(Y)	154	156	158	159	160	162	161	164

b) Explain different control loops and statements in R. Write a program in R to find factorial of a number using while loop.

2. **a)**Using R functions, write a program to generate random sample of size 100 from a normal population with mean 2 variance 9 and then construct P-P plot of the generated sample.

b) Fit a Negative Binomial distribution to the following data

X	0	1	2	3	4	5	6	7
f	5	7	12	15	11	9	6	5

Also test the adequacy of model using goodness of fit in R.

3. **a)** A sample survey is to be under taken to ascertain the mean annual income of farms in a certain area. The farms where stratified according to their principal products. A Census conducted several years earlier gave the following information

Type of Farm	**Number of Farm**	**Mean Income**	**Annual S.D**
Sheep	161	10946	2236
Wheat	195	6402	2614
Dairing	274	2228	606
Others	382	1458	230

For a sample of 12 farms compute the sample sizes in each stratum under Proportion allocation and optimum allocation. Compare the precision of these methods with that of simple random sampling.

b)Write R code to find the optimum sample size and variance under proportion allocation and optimum allocation for the above data.

4. For estimating the total number of absentees in 325 factories situated in a state, a sample of 40 factories was drawn with S. R. S without replacement. The data given below shows the no of workers (x) and the no. of absentees (y) for each of the 40factories. Total no. of workers in all the factories is known to be 27,000.

Sl. No :	1	2	3	4	5	6	7	8	9	10
X :	96	80	31	46	29	141	124	80	42	52
Y :	9	7	8	3	2	9	8	11	5	3
Sl. No :	11	12	13	14	15	16	17	18	19	20
X :	141	90	56	130	46	44	116	64	102	51
Y :	14	5	4	12	3	10	11	9	8	8

Estimate the total number of absentees in all a 325 factories of the state using regression method of estimation with number of workers as auxiliary variable. Compute the relative precision of the regression estimate to the ration estimate and comment.

b) Write R code to estimate the population mean using linear regression method for the above data. Also write R code to find the variance of the estimates under regression method and ratio method of estimation.

5. a) Examine the definite nature of the quadratic form

$$x_1^2 + 5x_2^2 + 2x_3^2 + x_4^2 + 2x_1x_2 + 4x_2x_3 + 2x_3x_4$$

b) Obtain Moore-Penrose g-inverse of $\begin{bmatrix} 3 & 1 & 0 & 1 \\ 1 & 4 & -1 & 2 \\ 0 & -1 & 6 & 2 \end{bmatrix}$

6. a) Describe different types of data objects/structures and their operations in R? Explain the difference between data frame and a matrix in R?

b) Write down the spectral decomposition of $A = \begin{bmatrix} 5 & 2 & 2 \\ 2 & 2 & 1 \\ 2 & 1 & 2 \end{bmatrix}$ and obtain A^{100}

Semester II

Model Question Paper

PG20ST206 –MULTIVARIATE DISTRIBUTIONS

(2020 admission onwards)

Time: 3 Hours Maximum weight: 30

Part A

(Answer any eight questions. Weightage 1 for each question)

1. Define non-singular multivariate normal distribution. Identify the parameters justifying your answer.
2. Define Gumbel's bivariate exponential distribution. Find E(X/Y).
3. Find the charactarestic function of $X \xrightarrow{d} N_P(\mu, \sum)$.
4. Define generalized variance.
5. Define multiple and partial correlation coefficients.
6. Write down the probability density function of Wishart distribution. State it's additive property.
7. If X and Y are standard normal variate with coefficient of correlation δ. Show that $X+Y$ and $X-Y$ are independently distributed.
8. Explain a multinomial distribution.
9. Define bivariate normal distribution
10. Explain the matrix variate Gamma distribution.

Part B

(Answer any six questions. Weightage 2 for each question)

11. Find the MGF of bivariate normal distribution and also find the standard bivariate normal distribution.
12. Define the bivariate Marshall Olkin exponential distribution and derive its moment generating function.
13. If $X = \begin{bmatrix} X^{(1)} \\ X^{(2)} \end{bmatrix} \sim N_p(\mu, \sum)$, find the distribution of $X^{(1)}$ on $X^{(2)}$. Show that the regression of $X^{(1)}$ on $X^{(2)}$ is linear.
14. State and prove reproductive property of Wishart distribution and define the charactarestic function.
15. If $X \sim N_p(0, I)$ show that $X^I AX$ and $X^I BX$ are independent iff $AB = 0$.
16. Show that the random vector X distributed as multivariate normal if and only if every linear combination of its components is univariate normal.

17. If $X \xrightarrow{d} N(\mu, \sum)$ and $\sum$ is non-singular, show that $(X-\mu)^I \sum^{-1}(X-\mu) \xrightarrow{d} \chi^2_{(p)}$.
18. Show that $X \sim N_p(\mu, \sum)$ if and only if X can be written in the form $X = \mu + BY$. Under conditions to be satisfied.

Part C

(Answer any two questions. Weightage 5 for each question)

19. State and prove Fisher-Cochran Theorem of quadratic forms.
20. Obtain the distribution of the sample multiple correlation coefficient when the population multiple correlation coefficient is zero.
21. Obtain the MLE of μ and $\sum$ in $N_p(\mu, \sum)$.
22. Derive the charactarestic function of a Wishart matrix and hence derive its distributions.

Model Question Paper

PG20ST207–ADVANCED PROBABILITY THEORY

(2020 admission onwards)

Time: 3 Hours Maximum weight: 30

Part A

(Answer any eight questions. Weightage 1 for each question)

1. Define conditional expectation of a random variable.
2. Define a Random vector. Give an example.
3. Obtain the characteristic function of standard Laplas distribution.
4. State a weak law of large numbers for independent and identically distributed random variables.
5. State classical central limit theorem.
6. State Bochners theorem and give an application of the same.
7. Distinguish between WLLN and SLLN.
8. Define stable distribution and show that normal distribution is stable.
9. State Fusin's theorem.
10. Check whether $\phi(t) = \cos t + i \sin t$ is a characteristic function.

Part B

(Answer any six questions. Weightage 2 for each question)

11. Define Radon–Nikodym derivative and prove that it is unique up to sets of P-measure zero.
12. Show that $Z_n = X_1 X_2 .... X_n$ of independent and identically distributed random variables X_j's each with unit mean form a martingale.

13. Derive the probability density function of the distribution whose characteristic function is: $\phi(t) = \frac{1}{1+t^2}, t \in R$
14. Let X be a random variable with characteristic function ϕ.Show that X is symmetric if and only if ϕ is real.
15. State and prove Chebychev's weak law of large numbers.
16. Illustrate a situation where WLLN doesn't hold.
17. State Lindberg-Feller Central limit theorem. Prove or disprove: Liapounov condition for Central limit theorem implies Lindberg condition for central limit theorem.
18. Using CLT to show that $\lim_{n\to\infty} e^{-n}\sum_{k=0}^{n}\frac{n^k}{k!} = \frac{1}{2}$

Part C

(Answer any two questions. Weightage 5 for each question)

19. State and prove inversion theorem for characteristic function.
20. State and prove Hann decomposition theorem.
21. State and prove Liapunov's CLT.
22. State and prove kolmogrove strong law of large numbers for i.i.d random variable.

Model Question Paper

PG20ST208 -STATISTICAL INFERENCE I

(2020 admission onwards)

Time: 3 hours Total Weights: 30

Part A

(Answer any eight questions. Weightage 1 for each question)

1. Define unbiased estimator. Let X be a r.v with p.m.f. b(1,p), then show that unbiased estimator for p^2 does not exist.
2. Explain sufficient condition for consistency.
3. S.T. Mean square error consistency implies weak consistency.
4. State Rao-Blackwell theorem.
5. Define Sufficiency. Let $X_1, X_2, \ldots X_n$ be an independent sample from $p(\lambda)$. Examine Whether is $t = \sum x_i$ sufficient for λ.
6. Define ancillary statistics. Give an example.
7. Define UMVU estimator and give an example.
8. P.T. Maximum likelihood estimator need not be unique.
9. Define complete class and Minimal Complete class.
10. Define Loss function.

Part B

(Answer any six questions. Weightage 2 for each question)

11. S.T. $S^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$ is not an unbiased estimator for σ^2 . Can you suggest an unbiased estimator?
12. P.T.Minimum Variance Bound is unique.
13. State and prove Basu's theorem.
14. Find Cramer Rao lower bound for any unbiased estimator of θ based on n iid observations from population with p.d.f $f(x) = \frac{1}{\pi\left(1+(x-\theta)^2\right)}; -\infty < x < \infty, -\infty < \theta < \infty$.
15. Let $X_1, X_2, ...X_n$ be iid $U(0,\theta)$. S.T. $M_n = Max(X_1, X_2, ...X_n)$ is Complete sufficient for θ .
16. State and Prove Lehman-Scheffes Theorem.
17. Let $X \sim N(\mu,1)$ and let the prior p.d.f of μ be $N(0,1)$. Find the Bayes estimate of μ using quadratic error loss. Also find the Bayes risk.
18. Show that estimation and testing can be viewed as particular cases of a decision problem.

Part C

(Answer any two questions. Weightage 5 for each question)

19. State and Prove the Cramer Rao lower bound for the variance of an unbiased estimator of a parametric function.
20. State and prove Fisher-Neymann Factorization theorem.
21. If $X_1, X_2, ...X_n$ are independent observations from $P(\theta)$.

    S.T. $U(x_1) = 1$ if $x_1 = 0$

    0 if $x_1 > 0$

    i) Unbiased for $e^{-\theta}$
    ii) Obtain UMVUE for $e^{-\theta}$
    iii) Find the variance of UMVUE
    iv) Compute the Cramer-Rao Lower bound of $e^{-\theta}$
22. Let $X_1, X_2, ...X_n$ be iid observations from $P(\lambda)$ for estimating λ using quadratic loss function and prior distribution of λ is given by $\pi(\lambda) = e^{-\lambda}, \lambda > 0$.
    1) Find the Bayes estimator of λ .
    2) If it is required to estimate $\phi(\lambda) = e^{-\lambda}$ with same loss function and same p.d.f.

Model Question Paper

PG20ST209 – STOCHASTIC PROCESSES

(2020 admission onwards)

Time: 3 hours Maximum Weight: 30

Part A
(Answer any eight questions. Weightage 1 for each question)

1. Define stochastic process and classify it.
2. Explain communication state in a Markov Chain.
3. Define a continuous time Markov chain.
4. Define a renewal process.
5. Define a Yule process.
6. State the properties of a transition probability matrix.
7. Define a counting process and give an example.
8. Give the postulates of a Poisson process.
9. Give the transition probability matrix of classical gambler's ruin problem.
10. What you mean by delayed renewal process.

Part B

(Answer any six questions. Weightage 2 for each question)

11. Explain (i) Communication; (ii) Recurrence; and (iii) Transience in connection with stages of a Markov Chain.
12. State and prove elementary renewal theorem.
13. Define an irreducible Markov chain. Show that in such a Markov chain either all states are recurrent or all are transient.
14. Distinguish between absorbing and non absorbing Markov Chain, with suitable example.
15. State and establish Chapman-Kolmogorov equations of a Markov Chain.
16. Define a one dimensional random walk and prove that it is recurrent.
17. Define: Birth and Death process. Obtain any one differential equation for this process.
18. Define stopping time. If N(t) is a renewal process associated with the i.i.d sequence $\{X_n\}$, show that N(t)+1 is a stopping time for $\{X_n\}$.

Part C
(Answer any two questions. Weightage 5 for each question)

19. What is Gambler's ruin problem? Find the problem of ultimate ruin of the Gambler.
20. Define: (i) Ergodic Markov Chain (MC); and (ii) Stationary distribution of MC. For an Ergodic MC show that the stationary distribution exists uniquely.
21. Derive the limiting distribution of excess and current life for a renewal process. Give an example.

22. For an M/M/1 queuing system, derive the distribution for waiting time in the system. Also find expected waiting time in the system.

Model Question Paper

PG20ST210 -STATISTICAL COMPUTING - II

(2020 admission onwards)

Time: 3 Hours Maximum Weight: 30

(Answer any three questions without omitting any part.
Each question carries Weight 10)

Section A

1. Suppose X=(X1 X2 X3)'~$N_3(\mu,\sum)$ where $\mu=\begin{bmatrix}3\\10\\8\end{bmatrix}$,$\sum=\begin{bmatrix}1&3&1\\3&16&2\\1&2&4\end{bmatrix}$.Find the distribution of 1.$f(X_1)$ 2.$f(X_1,X_2)$ 3. X_1+X2+X_3 4. $f(X_1/X_2=5,X_3=3)$5. $r_{1\,2.\,34}$

2. Given below are the means and variance co-variance matrix for 4 variables X_1,X_2,X_3 and X_4 based on a random sample of size 30 observations from a multivariate normal distribution.

X_1	X_2	X_3	X_4	Mean
16.81	13.12	4.51	5.74	4.16
	14.24	5.92	9.08	3.89
		14.21	14.16	6.52
			17.91	5.07

   a) Compute Multiple correlation coefficient $R_{1(2,3,4)}$. Test whether the population correlation coefficient is zero.
   b) Calculate the partial correlation coefficient $r_{1\,2.\,34}$ and test for significance.

Section B

3. The table below gives the probability and observed frequencies in 4 phenotype classes in a genetic experiment.

Class	:	AB	Ab	aB	ab

Observed Frequency	:	125	18	20	34
Probability	:	$\frac{2+\theta}{4}$	$\frac{1-\theta}{4}$	$\frac{1-\theta}{4}$	$\frac{\theta}{4}$

a) Estimate θ,
   i. By the method of likelihood.
   ii. By the method of modified minimum chi-square.
b) Obtain the information on θ supplied by the sample.
c) Find the standard error of the estimate.

4. The following table gives the number of bomb attack planes on London city during Second World War.

X	0	1	2	3	4	5
F	229	211	93	35	7	1

Assuming that this is a sample from Poisson population with parameter λ. Estimate λ by the method of minimum chi-square. Apply the procedure of iteration up to fourth approximation. Use this value of λ to calculate the expected frequencies and the goodness of fit.

Section C

5. Classify the states and obtain the stationary distribution for the Markov Chain with following P.

$$P=\begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ \frac{1}{3} & \frac{1}{3} & \frac{1}{3} & 0 \\ \frac{1}{4} & \frac{1}{4} & \frac{1}{4} & \frac{1}{4} \end{bmatrix}$$

6. Consider a Markov Chain on the states (1,2,3,4) with the transition matrix,

$$P=\begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{1}{3} & 0 & \frac{2}{3} & 0 \\ 0 & \frac{2}{3} & 0 & \frac{1}{3} \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

a) Show that the chain is ergodic and calculate the mean recurrence times.
b) Calculate the mean first passage time for the system to the state 2 from state 3.
c) Obtain the expected number of visits to each of the states from state 3 out of 100 transitions of the system.

Semester III

Model Question Paper

PG20ST311 –STATISTICAL INFERENCE - II

(2020 admission onwards)

Time: 3 Hours Total Weights: 30

Part A

(Answer any eight questions. Weightage 1 for each question.)

1. Define an unbiased test.
2. What is the significance of MLR property in testing of hypotheses?
3. Define LMPU tests and UMPU tests.
4. Define similar region tests.
5. Explain test function and power function.
6. What are the advantages of SPRT over fixed sample size tests?
7. Define UMAU confidence intervals.
8. What are the advantages of non-parametric tests over parametric tests?
9. Define a run. Give a sequence having three runs using + and – symbols.
10. Define Neymann structure test.

Part B

(Answer any six questions. Weightage 2 for each question.)

11. Describe Chi – square test for independence.
12. Describe how a UMA confidence interval can be obtained based on a UMP test.
13. State and prove Wald's identity.
14. For an SPRT with bounds A and B and strength (α, β), obtain the inequalities connecting the tests.
15. Let X follows Poisson distribution with mean λ. Find SPRT for testing H_0: λ = 1 against H_1: λ = 2 where α =β = 0.1.
16. Compare Kolmogorov-Smirnov and Chi-square tests for goodness of fit.
17. State and prove the necessary and sufficient condition for all similar tests have Neymann structure.
18. Give a suitable non parametric test for testing the equality of medians.

Part C

(Answer any two questions. Weightage 5 for each question.)

19. State and prove Neymann Pearson Lemma. Show that if a sufficient statistics exists for the family, the Neymann Pearson most powerful test is a function of it.
20. Derive the asymptotic distribution of likelihood ratio test statistic.
21. Show that SPRT terminates with probability one.

22. (a) Explain Wilicoxon signed rank test procedure for location, stating the assumptions made.
    (b) Describe Mann-Whitney U-test.

Model Question Paper
PG20ST312 –DESIGN AND ANALYSIS OF EXPERIMENTS

(2020 admission onwards)

Time: 3 hours Total Weights: 30

Part A

(Answer any eight questions. Each question carries Weight 1)

1. Define BLUE.
2. What do you mean by Gauss-Markoff's setup?
3. Distinguish between ANOVA and ANOCOVA.
4. Give the assumptions of ANOVA.
5. Explain Incidence matrix of a BIBD.
6. Distinguish between total confounding and partial confounding.
7. What do you mean by symmetrical factorial experiments? Give an example.
8. What do you mean by orthogonal data?
9. Define factorial experiments. What is its use?
10. How is the measure of local control achieved in RBD and LSD?

Part B

(Answer any six questions. Each question carries Weight 2)

11. Obtain relative efficiency of RBD in comparison to CRD.
12. State and prove a necessary and sufficient condition for an estimability of a linear parametric function $b'\theta$ based on a linear model $y = A\theta + \varepsilon$.
13. In a BIBD, show that (a) b k = v r (b) λ (v-1) = r (k-1).
14. Explain the analysis of 2^2 factorial experiment.
15. Show that the treatment mean sum of square is positively biased for error variance.
16. Derive the ANOVA of a CRD.
17. Explain the Yates procedure for obtaining the various effect totals in a 2^3 factorial experiment.
18. State the form of a general linear hypothesis, and the test statistic to test it.

Part C

(Answer any two questions. Each question carries Weight 5)

19. Derive the intra –block analysis of a BIBD.
20. Derive the ANOVA of an RBD with single observation per cell.
21. State and prove Gauss-Markov theorem.
22. Construct a 2^5design in blocks of 8 plots confounding ABC, ADE and BCDE. Give the analysis of such a design with r replications.

Model Question Paper

PG20ST313 –MULTIVARIATE ANALYSIS

(2020 admission onwards)

Time: 3 Hours **Maximum weight: 30**

Part A

Answer any eight questions. Weightage 1 for each question.

1.Define Mahalanobi's D^2 statistic and explain its relationship with T^2 statistic.
2.Write down any four uses of T^2 statistic.
3.What are canonical correlations and variates?
4.Bring out the relationship between factor analysis and principal component analysis.
5.What are the goals of discriminant analysis and classification problems?
6.State the problem of sphericity test.
7.What are the different distant measures?
8.What are the objectives of cluster analysis?
9.Show that D^2 statistic is invariant with respect to linear transformations.
10. Define the problem of symmetry.

Part B

Answer any six questions. Weightage 2 for each question.

11. Derive the distribution of Hotellings T^2 statistic
12. Explain multivariate Fisher –Behren problem
13. Describe the iterative procedure to extract the first two principal components.
14. Explain the term factor loading. State the factor model and obtain the maximum likelihood estimates of the factor loadings.
15. Describe the Baye's classification problem.
16. Explain the test for testing the independence of sets of variates of a p-variate normal population.
17. Describe complete linkage method of clustering.
18. Explain the non-hierarchical clustering methods.

Part C

Answer any two questions. Weightage 5 for each question.

19. Stating the assumptions describe a MANOVA model with two-way classified data. Explain how you will test the hypothesis.
20. Show that canonical correlation can be obtained as the non- zero root of a determinantal equation.
21. What is profile analysis? Explain how we test for:

a) parallel profile

b) Coincident profile

22. Derive the test , for testing equality of co-variance matrices of several multivariate normal populations.

Model Question Paper

PG20ST314 –TIME SERIES ANALYSIS
(2020 admission onwards)

Time : 3 Hours Total Weights :30

Part A

(**Answer any eight questions. Weightage 1 for each question.)**

1. Explain a time series as a stochastic process.
2. Distinguish between additive and multiplicative models of time series.
3. Define auto-covariance and auto-correlation functions.
4. Distinguish between a strict stationary and weak stationary process.
5. Explain Wold Decomposition of a linear stationary process.
6. Describe (i) AR(p) model and (ii) MA(q) model .
7. What is an ARIMA model?
8. Define spectral density function and state its 3 properties.
9. What is a periodogram? What are its uses?
10. Define an ARCH model stating all assumptions.

Part B

(**Answer any six questions. Weightage 2 for each question.)**

11. Describe the components of a time series. Explain how you will estimate trend.
12. Describe simple exponential smoothing.
13. Define partial autocorrelation function. What are its properties and uses?
14. Show that an AR(1) model can be expressed as an infinite order MA model. Hence obtain its ACF.
15. What are Yule-Walker equations? Explain how they are used for estimating partial autocorrelations of an AR(k) model.
16. Explain the least square method for estimating the parameters of an ARMA(p,q) model. Illustrate it for an ARMA(1,1) model.
17. Derive the spectral density function of an (i) AR(2) process (ii)MA(2) process.
18. Explain a GARCH model and describe its importance in time series modeling.

Part C

(Answer any two questions. Weightage 5 for each question.)

19. Explain Holt-Winter's exponential smoothing and forecasting. What are its advantages and disadvantages?
20. Explain the important steps in Box-Jenkin's approach to time series modeling.
21. Describe residual analysis and diagnostic checking of an ARIMA model. Explain how you will choose the AR and MA periods.
22. Derive the spectral density of an ARMA(p,q) process. Also describe the basics of seasonalARIMA modeling.

Model Question Paper

PG20ST315 –STATISTICAL COMPUTING - III
(2020 admission onwards)

Time: 3 Hours Total Weights: 30

(Answer any three questions without omitting any part.
Each question carries Weight 10)

Section A

1. Samples of sizes 100 and 60 from two districts on 3 characters are given below

$$\bar{X}_1 = \begin{bmatrix} 71 \\ 87 \\ 95 \end{bmatrix} \qquad \bar{X}_2 = \begin{bmatrix} 75 \\ 76.7 \\ 93.3 \end{bmatrix}$$

$$A_1 = \begin{bmatrix} 2049 & -447 & 2275 \\ & 1681 & -735 \\ & & 2965 \end{bmatrix} \qquad A_2 = \begin{bmatrix} 1435 & -421 & 1329 \\ & 1680 & -312 \\ & & 1435 \end{bmatrix}$$

Test for equality of population mean vectors, stating assumptions.

2. A sample of size 50 from a trivariate normal population gives the following result for the sample means and sample dispersion matrix.

$$\text{Mean} = \begin{bmatrix} 2.54 \\ -1.72 \\ 0.94 \end{bmatrix}, \quad \text{Dispersion matrix} = \begin{bmatrix} 16.9 & 22.01 & 12.35 \\ & 51.72 & 19.46 \\ & & 28.76 \end{bmatrix}$$

Test at 5% level of significance of hypothesis that the population mean vector is $(2 \quad -2 \quad 1)^{I}$.

Section B

3. An experiment was carried out in RBD layout with 5 varieties of wheat in 3 replications. The results of the experiment are given below with two missing observations. Estimate the missing observations and analyse the data draw your conclusions.

	Varieties				
Blocks	A	B	C	D	E
1	185	157	162	141	136
2	154	-	155	157	184
3	165	186	135	-	215

4. Analyze the following balanced incomplete block design with v=6, b=10

BLOCKS	1	2	3	4	5	6
1	11	13		...	12	....
2	18	22	...	...	....	23
3	19	....	21	23	....	...
4	19	....	14	...	...	15
5	3	....	....	9	3	....
6	....	23	21	16	...	....
7	....	28	13	...	19	....
8	....	19	....	13	….	25
9	....	....	19	….	15	26
10	....	....	....	5	6	7

Section C

5. For a Poisson population, construct an SPRT of strength (0.05, 0.01) to test the hypothesis mean = 1.75 against mean = 2.25.
    a. Plot the acceptance and rejection regions on a graph.
    b. Draw the OC and ASN curves taking 5 appropriate points.
    c. Carry out the test for the following data on the number of defects observed in successively produced units in a factory.

       2, 1, 0, 3, 4, 1, 3, 1, 0, 6, 2, 3, 4, 5, 1, 1.

6. A random variable X has the following density function $f(x, \Theta) = \Theta e^{-\Theta x}$; $\Theta > 0$, $X > 0$. Determine the best critical region for testing $H_0: \Theta \geq 3$ against $H_1: \Theta < 3$ based on a random sample of size 10 on X. Draw the power curve for the region choosing at least 5 alternatives of Θ.

Semester IV

Model Question Paper

PG20ST416– ECONOMETRIC METHODS

(2020 admission onwards)

Time: 3 hours Total Weights: 30

Part A

(Answer any eight questions. Weightage 1 for each question.)

1. Define Cobb-Douglas production function.
2. Write notes on (i) Marginal Revenue Curves (ii) Average Revenue Curves.
3. Define price elasticity of demand. Give the conditions for a normal demand function.
4. Distinguish between model and structure.
5. What do you mean by adjusted R^2?
6. Explain K class estimators.
7. Describe Von-Neumann Ratio test for autocorrelation.
8. Explain logistic regression and state its basic assumptions.
9. What you mean by Distributed lag model ?
10. Consider the model.

$$b_{11}y_1 + b_{12}y_2 + c_{11}x_1 + c_{12}x_2 = u_1$$
$$b_{21}y_1 + b_{22}y_2 + c_{21}x_1 + c_{22}x_2 = u_2$$

Investigate if the equations are identifiable. Is the model identified when the Apriori restrictions $c_{12} = 0$ and $c_{21} = 0$ are given?

Part B

(Answer any six questions. Weightage 2 for each question.)

11. Discuss the Leontief input-output static model for an open system.
12. Explain Cobb-Web Model.
13. Define a recursive model. Show that a recursive model is always identifiable.
14. Define a general linear regression model and state the assumptions. Obtain the OLS estimates of the parameters.
15. What is meant by heteroscedasticity? Explain any 2 methods of estimation when it is present.
16. Examine the consequences of the presence of errors in variables while estimating the parameters of a structural equation.
17. Explain LVR method of estimation.
18. Explain "instrumental variable" technique of estimation.

Part C

(Answer any two questions. Weightage 5 for each question.)

19. Explain Aitken's generalized least squares method of estimation with proper assumptions.
20. What is meant by multicollinearity? Indicate its consequences. Discuss Farrar-Glabuer test.
21. Explain what is meant by identification. Obtain a necessary and sufficient condition for identification.
22. Describe the 2SLS method of estimation. State the asymptotic properties of the estimates obtained by this method.

Model Question Paper

PG20ST417– OPERATIONS RESEARCH

(2020 admission onwards)

Time: 3 hours Total Weights: 30

Part A

(Answer any eight questions. Weightage 1 for each question.)

1. Define a travelling salesman problem and obtain the mathematical model.
2. Find the solution of the game with pay off matrix P= $\begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix}$
3. Discuss the various costs involved in inventory problems with suitable examples.
4. What is lead time? Why is it important in the analysis of inventory problems?
5. Discuss Bellmann's principle of optimality.
6. Write the Kuhn-Tucker conditions for the problem.

   Minimize f == $(X_1\text{-}2)^2 + X_2^2$

   subject to

   $$X_1^2 + X_2 - 1 \leq 0;$$

   $$X_1 \geq 0;\ X_2 \geq 0:$$

7. Distinguish between pure strategy and mixed strategy.
8. What do you mean by inventory control?
9. Explain sequencing problem.
10. Define a QPP.

Part B

(Answer any six questions. Weightage 2 for each question.)

11. Explain transportation problem. Give its mathematical model. Give an algorithm to solve it.

12. Describe the concept of maximin - minimax principle of game theory.
13. Discuss EOQ problems with price breaks. Analyse the inventory model with two price breaks.
14. Explain "Newspaper boy type" problems. How do you analyze such problems.
15. Using dynamic programming and the minimum value of $Z = y_1^2 + y_2^2 + \ldots + y_n^2$ subject to the constraints $y_1 y_2 \ldots y_n = C$; $y_1 \geq 0$, $y_2 \geq 0, \ldots, y_n \geq 0$.
16. Explain Beale's method for solving quadratic programming problem.
17. Discuss and analyze a single period inventory model with stochastic demand.
18. Describe seq**u**encing problems. Give an algorithm to determine the optimal sequence for processing n jobs through three machines.

Part C

(Answer any two questions. Weightage 5 for each question.)

19. Describe an Assignment problem. How is it related to Transportation problem? Discuss Hungarian method to solve an Assignment problem.
20. Consider an inventory model in which the cost of holding one unit in the inventory for a specified period is C_1 and the cost of shortage per unit is C_2. Also suppose the demand follows a known continuous probability distribution. Determine the optimum inventory level at the beginning of the period.
21. Use dynamic programming to show that $\sum_{i=1}^{n} P_i \log P_i$ subject to the constraint $\sum_{i=1}^{n} P_i = 1$ and $P_i > 0$ is minimum when $P_i = 1/n$ for i = 1, 2,… ,n
22. Explain how an m×n two person zero sum game can be transformed in to an L.P.P. Hence state and prove fundamental theorem of game.

Model Question Paper

PG20ST418– STATISTICAL QUALITY CONTROL

(2020 admission onwards)

Time: 3 Hours Total Weights: 30

Part A

Answer any eight questions. Weightage 1 for each question.

1. Distinguish between process control and product control in SQC.
2. Justify the 3σ limits as control limits in any control chart.
3. Distinguish between chance causes and assignable causes.
4. Define the terms: Producers risk, consumers risk.
5. Define operating characteristic function of a control chart. What is its importance in process control?
6. What is a *c* – chart. When and where it is used.
7. Explain *CUSUM* charts.
8. Define the terms: *AQL and LTPD*.

9. Distinguish between multiple sampling plans and sequential sampling plans.
10. Explain the technique of curtailed inspection.

Part B

Answer any six questions. Weightage 2 for each question.

11. Explain the terms: control limits, tolerance limits and specification limits.
12. What is meant by Average Sample Number ASN and ASN curve?
13. Distinguish between defects and defectives. Explain the construction and operation of a *p* chart.
14. What are acceptance sampling plans? Explain the *SSP*.
15. Describe a procedure to derive a SSP using attributes with a specified α and β.
16. What is meant by rectifying inspection? Obtain the *AOQ* function of a *SSP*.
17. Explain the method of construction of the *O. C.* curves for an attribute *DSP*.
18. Explain V-Mask procedure.

Part C

Answer any two questions. Weightage 5 for each question.

19. Explain the construction and interpretation of mean chart and range chart.
20. How will you study the process capability of a production process? What are the important indices for measuring the process capability?
21. Derive the *ASN* and *ATI* functions for a *DSP* and draw their general shapes.
22. Explain the double sampling inspection plan.

Model Question Paper

PG20ST419– STATSTICAL RELIABILITY ANALYSIS

(2020 admission onwards)

Time : 3 Hours Total Weights :30

Part A

(**Answer any eight questions. Weightage 1 for each question.)**

1. Explain reliability of ‘k’ out of ‘n ‘system with suitable assumptions.
2. Explain the bounds on system-reliability.
3. Explain the residual life time and survival function of residual life time.
4. Show that hazard rate is constant if and only if the life time distribution is exponential.
5. Define DMRL distributions. Give an example.
6. Define Kaplan- Meir estimators.

7. Explain the estimation mean lifetime in failure censored sample
8. Explain the concept of reliability of Coherent systems.
9. Let X be a non-negative random variable with distribution function F. Then show that F is IFR implies IFRA.
10. Define type II censoring.

Part B

(**Answer any six questions. Weightage 2for each question.)**

11. Describe proportional hazards model.
12. Describe the Weibull model and find the hazard rate. Examine the monotonic nature of hazard rate.
13. Discuss the reliability of series and parallel systems.
14. State and prove the IFRA closure theorem in coherent systems.
15. Prove that if F is IFR, then F is IFRA. Construct a counter example to show that the converse is not true.
16. Obtain the MLE for the reliability function based on complete sample from gamma distribution.
17. Define (i) decreasing failure rate(DFR) class;(ii) increasing mean residual life(IMRL) class. Illustrate with an example to show DFR implies IMRL.
18. Describe gamma distribution in the contact of reliability function.

Part C

(**Answer any two questions. Weightage 5for each question.)**

19. Describe lognormal and pareto distribution in the context of reliability analysis.
20. Represent the bridge structure as a series structures of the minimal cut parallel structures and also as a parallel structure of the minimal path series structures.
21. Explain the term ‘censored observations. Describe the different types of censoring commonly used in reliability analysis.
22. (a) Explain the nature of failure rate of a Weibull distribution.
    (b)What is NBU and NBUE. Explain its classes and their duals.

Model Question Paper

PG20ST420– STATISTICAL COMPUTING - IV

(2020 admission onwards)

Time: 3 hours Total Weights: 30

(Answer any three questions without omitting any part.
Each question carries Weight 10)

Section A

1. The following table shows the quantity demanded of a certain commodity its price and the consumers income. Test whether there is any multicollinearity among these exogenous variables.

Year	:	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Demand	:	3.8	4.2	5.1	6.2	7.1	9.1	8.1	10.2	12.1	13.8
Price	:	17	12	10	7	7	4	4	3	3	2
Income	:	15	19	28	41	51	53	53	71	84	90

2. For the simultaneous equation model:

$$Y_{11} = \beta_{12} Y_{2t} + \gamma_{11} X_{1t} + U_{1t}$$
$$Y_{11} = \beta_{21} Y_{1t} + \gamma_{22} X_{2t} + U_{2t}$$

Where Y's are endogenous, X' are exogenous. U's are random variables. Find two stage least squares estimate of parameters β_{12} and γ_{11} given the matrix of the following sum of products of observed values of X's and Y's.

	Y1	Y2	X1	X2	X3
Y1	100	210	30	20	40
Y2	210	500	5	50	160
X1	30	5	100	5	10
X2	20	50	5	50	5
X3	40	160	10	5	40

Section B

3. Use dominance principle to simplify the rectangular game with the following payoff matrix and solve it graphically.

		Player A			
Player B		I	II	III	IV
	1	18	4	6	4
	2	6	2	13	7
	3	11	5	17	3
	4	7	6	12	2

4. a) A book binder has one printing press, one holding machine and manuscripts of 7 different books the time required for performing printing and binding operations for different books are shown below:

Book	: 1	2	3	4	5	6	7
Printing time (days)	: 20	90	80	20	120	15	65
Binding time (days)	: 25	60	75	30	90	35	50

Decide the optimum sequence of processing of books in order to minimize the total time required to turn out all the books.

b) Solve the following transportation problem to maximize profit:

Profit Rs./ unit destination

	origin	1	2	3	4	*supply*
A		42	27	24	35	200
	B	46	37	32	32	60
	C	40	40	30	32	140
Demand		80	40	120	60	

Section C

5. The data below are $\overline{X}$ and R values for 24 samples of size $n=5$ taken from a process producing bearings. The measurements are made on the inside diameter of the bearing.

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12
$\overline{X}$	34.5	34.2	31.6	31.5	35	34.1	32.6	33.8	34.8	33.6	31.9	38.6
R	3	4	4	4	5	6	4	3	7	8	3	9

Sample No.	13	14	15	16	17	18	19	20	21	22	23	24
$\overline{X}$	35.4	34	37.1	34.9	33.5	31.7	34	35.1	33.7	32.8	33.5	34.2
R	8	6	5	7	4	3	8	4	2	1	3	2

1. Set up $\overline{X}$ and R charts on this process. Does the process seem to be in statistical quality control? If necessary, revise the trial control limits.
2. If specifications on this diameter are 0.5030 ± 0.0010, find the percentage non-conforming bearings produced by this process. Assume that the diameter is normally distributed.
3. If the process mean shift to 24, what is the probability of not detecting this shift on the first subsequent sample.

6. Derive an item by item sequential sampling plan for which $p_1 = 0.01$, $\alpha = 0.05$, $p_2 = 0.10$ and $\beta = 0.10$ .Also draw the O.C curve for this plan.