**MAHATMA GANDHI UNIVERSITY,**

**KOTTAYAM, KERALA**

**SCHOOL OF MATHEMATICS & STATISTICS**

**FACULTY OF SCIENCE**

**CURRICULUM AND SYLLABUS OF**

**M. Sc. STATISTICS**

**UNDER MAHATMA GANDHI UNIVERSITY CSS REGULATIONS 2020**

**(Revised According to OBE Scheme and 2021 Modifications)**

**EFFECTIVE FROM 2021-22 ACADEMIC YEAR ONWARDS**



**DEPARTMENT OF STATISTICS**

**MAHATMA GANDHI UNIVERSITY, KOTTAYAM**

**2021**

**Preface**

**Mahatma Gandhi University, Kottayam**

Mahatma Gandhi University is an Indian University based in Kottayam, Kerala State, established by the Govt. of Kerala in 1983, approved by UGC, and accredited with NAAC “A” Grade, 3.24 CGPA. With its academic excellence, the University has bagged Chancellor’s Award twice for the best University (2015-16 and 2017-18) within the state of Kerala. It has also secured 30thposition in NIRF ranking (April 2019) and 11th position in India Today-MDRA ranking,2018. CSIR has ranked the University 13th for its intellectual productivity and NISTADS has rated it as 19thin terms of h-index.

At present, Mahatma Gandhi University offers research programs in forty disciplines through its own Schools and approved Research Centers. It has close collaboration for academic, research and extension programs with a number of national agencies and institutions including the UGC, DST-FIST, DRS, ISRO, COSIT, DIT, DST (Nano Mission),CSIR, DAAD, STEC, ICMR, BARC and MOEF. The University is also involved in active collaboration with research institutions of international reputation such as the Max Planck Institute of Technology, Germany; Brown University, USA; University of Nantes, France;CaliforniaInstituteofTechnology,USA;UniversityofToronto,Canada;CatholicUniversity,Belgium;HeidelbergUniversity,Germany;the Institute of Political Studies, Rennes, France; Trent University, Canada; IPF Dresden, Germany; University of Paris and University of Strasbourg.

Mahatma Gandhi University has made immense strides in the fields of inter disciplinary teaching and research. The faculty comprises of outstanding scholars, many of whom have made original contributions in their respective fields of specialization. The faculty members and research scholars of several departments have gained wide spread recognition for the commendable quality of their research publications. The web enabled University library has large collection of books, journals, e-journals and online theses. The digital library provides open access to its enviable collection of digitized Ph.D. dissertations. All these work in tandem with the academic business transacted by the University, making the whole experience a holistic one. The University has well established and internationally reputed facility and academic expertise in various areas like Nano Science, Environmental Science, Bio Science, Chemical Science, Mathematical Science, Physics, Arts, Management and Business Studies and Humanities.

**Vision and Mission of MGU**

**Vision of Mahatma Gandhi University**

**“Mahatma Gandhi University envisions to excel in the field of higher education and cater to the scholastic and developmental needs of the individual, through continuous creation of critical knowledge base for the society’s sustained and inclusive growth.”​**

**Mission of Mahatma Gandhi University**

* **To conduct and support undergraduate, postgraduate and research-level programs of quality in different disciplines​**
* **To foster teaching, research and extension activities for the creation of new knowledge for the development of society​**
* **To help in the creation and development of manpower that would provide intellectual leadership to the community​**
* **To provide skilled manpower to the professional, industrial and service sectors in the country so as to meet global demands​**
* **To help promote the cultural heritage of the nation and preserve the environmental sustainability and quality of life ​**
* **To cater to the holistic development of the region through academic leadership, innovative ideas and team work.**

**Preamble**

**OUTCOME BASED EDUCATION (OBE) FROM THE ACADEMIC YEAR 2020-21 MAHATMA GANDHI UNIVERSITY KOTTAYAM**

**SCHOOL OF MATHEMATICS AND STATISTICS**

**Introduction**

A high priority task in the context of education in India is improvement of quality ofhighereducationforequippingyoungpeoplewithskillsrelevantforglobalandnationalstandards and enhancing the opportunities for social mobility. Mahatma Gandhi University has initiated an Outcome Based Education (OBE) for developing employable graduates through curriculum reforms based on a learning outcomes-based curriculum framework, upgrading academic resources and learning environment.

Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. The fundamental premise underlying the learning outcomes -based approach to curriculum development is that higher education qualifications are awarded on the basis of demonstrated achievement of outcomes, expressed in terms of knowledge, understanding, skills, attitudes and values. Outcomes provide the basis for an effective interaction among the various stakeholders. It is the results –oriented thinking and is the opposite of input-based education where the emphasis is on the educational process.

**Benefits of OBE**

1. TheOBEFrameworkisaparadigmshiftfromtraditionaleducationsystemintoOBEsystem where there is greater focus on programme and course outcomes. It guarantees thatcurriculum,teachingandlearningstrategiesandassessmenttoolsarecontinuouslyenhancedthroughacontinuousimprovementprocess.Alldecisionsincludingthoserelatedtocurriculum,deliveryofinstructionandassessmentarebasedonthebestwaytoachievethepredeterminedoutcomes.Traditionally,educators have measured learning in terms of standardized tests. In contrast, outcome-based education defines learning as what students can demonstrate that they know.

**Benefits of OBE:**

\*More directed & coherent curriculum.

\*Graduates willbemore“relevant”toindustry&otherstakeholders(morewell-roundedGraduates)

\*Continuous Quality Improvement is in place.

\*OBE shifts from measuring in put and process to include measuring the output (outcome)

**Outcome Based Education (OBE) process**

OBE is a comprehensive approach to organize and operate a curriculum that is focused onand defined by the successful demonstrations of learning sought from each learner. The term clearly means focusing and organizing everything in an education system around “what is essential for all learners to be able to do successfully at the end of their learning experiences”.

OBE is an approach to education in which decisions about the curriculum and instructionaredrivenbytheexitlearningoutcomesthatthestudentsshoulddisplayattheendofaprogramme or a course. By the end of educational experience, each student should have achieved the outcomes.

Learning Outcomes based Curriculum Framework (LOCF) for Post Graduate Programmes - IQAC MG University

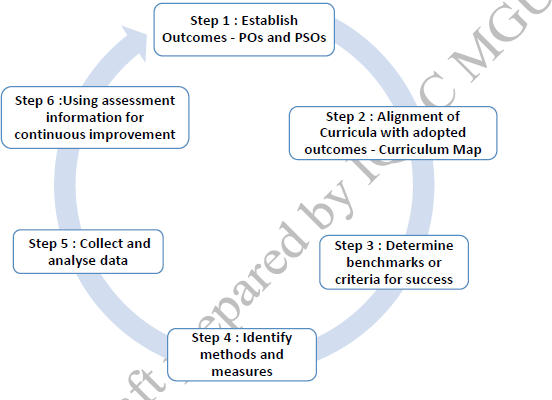
One of the main objectives of OBE is to ensure continuous improvement of programmes in terms of maintaining the relevance in curriculum as well as responding to the requirements of the stakeholders. In other words, it ensures that Post graduate programme next year is better than Postgraduate programme this year, offered by a department.

An OBE system has been proposed and to be implemented at various Departments ofMahatmaGandhiUniversity,asaquality-assuranceapproachtoimproveteachingandlearning outcomes and processes. This OBE plan incorporates the “outcomes assessment” process to befollowedinthedepartments.OBEshouldbeakeydriverofthecurriculummanagementinallthedepartments of the university.

The OBE is a six step process as shown in the figure.

**Figure: OBE Process**

The process is presented as a cycle or a loop. The cycle represents the continuous nature of assessing learning outcomes.



As envisaged by the IQAC of Mahatma Gandhi university, an OBE based curricular framework has been proposed for the School of Mathematics and Statistics from the academic year 2020-2021whichis presented hereafter.

|  |  |
| --- | --- |
| Mahatma Gandhi University Recruitment 2021-2022 mgu.ac.in MGU Jobs | **Mahatma Gandhi University**  **Graduate Attributes** |

|  |  |  |
| --- | --- | --- |
| Critical Thinking and Advice – The Entrepreneur's Tool | **Critical thinking and analytical reasoning** | Capability to analyze, evaluate and interpret evidence, arguments, claims, beliefs on the basis of empirical evidence; reflect relevant implications to the reality; formulate logical arguments; critically evaluate practices, policies and theories to develop knowledge and understanding; able to envisage the reflective thought to the implication on the society. |
| Productive problem-solving - Garden Center Magazine | **Scientific reasoning and Problem solving** | Ability to analyze, discuss, interpret and draw conclusions from quantitative/qualitative data and experimental evidences; and critically evaluate ideas, evidence and experiences from an unprejudiced and reasoned perspective; capacity to extrapolate from what one has learned and apply their competencies to solve problems and contextualize into researchand apply one’s learning to real life situations. |
| Avishkaar Maker Board Training | **Multidisciplinary/ Interdisciplinary/ Transdisciplinary approach** | Acquire interdisciplinary /multidisciplinary/ transdisciplinary knowledge base as a consequence of the learning they engage with their programme of study; develop a collaborative-multidisciplinary/interdisciplinary/transdisciplinary- approach for formulate constructive arguments and rational analysis for achieving common goals and objectives. |
| Drama in Education: Developing Personal and Interpersonal Skills | Paideia | **Intra and Interpersonal skills** | Ability to work effectively and respectfully with diverse teams;facilitate collaborative and coordinated effort on the part of a group,and act together as a group or a team in the interests of a common cause and work efficiently as a member of a team; lead the team to guide people to the right destination, in a smooth and efficient way. |
| 31 Best Digital Literacy Organizations: Bridging the Digital Gap | **Digital literacy** | Capability to use ICT in a variety of learning situations, demonstrate ability to access, choose, collect and evaluate, and use a variety of relevant information sources; structure and evaluate those data for decision making. |
| Playful, Elegant, Learning Logo Design for Enriching Lives - inspiring Global  Citizenship by Iban641 | Design #6559682 | **Global Citizenship** | Building a sense of belonging to a common humanity and to become responsible and active global citizens. Appreciation and adaptation of different sociocultural setting and embrace and promote equity. |
| Competence Social Stock Illustrations – 659 Competence Social Stock  Illustrations, Vectors & Clipart - Dreamstime | **Social competency** | Possess knowledge of the values and beliefs of multiple cultures, appreciate and adapt to a global perspective; and capability to effectively engage in a multicultural society and interact respectfully, manage and lead with diverse groups. |
| Council for Inclusive Capitalism with the Vatican | **Equity, Inclusiveness and Sustainability** | Appreciate and embrace equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity, secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity |
| Create a trusting symbol that illustrates lifelong learning | Logo design  contest | 99designs | **Lifelong learning** | Continuous acquisition of knowledge and skills. Learn, unlearn and re-learn based on changing ecosystem. “Learning how to learn”, that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/ training. |

|  |  |
| --- | --- |
| Mahatma Gandhi University Recruitment 2021-2022 mgu.ac.in MGU Jobs | **Mahatma Gandhi University**  **Programme Outcome** |

**Programme Outcomes (PO)**

**PO 1: Critical Thinking and Analytical Reasoning**

Capability to analyse, evaluate and interpret evidence, arguments, claims, beliefs on the basis of empirical evidence; reflect relevant implications to the reality; formulate logical arguments; critically evaluate practices, policies and theories to develop knowledge and understanding; able to envisage the reflective thought to the implication on the society.

**PO 2 : Scientific Reasoning and Problem Solving**

Ability to analyse, discuss, interpret and draw conclusions from quantitative/qualitative data and experimental evidences; and critically evaluate ideas, evidence and experiences from an unprejudiced and reasoned perspective; capacity to extrapolate from what one has learned and apply their competencies to solve problems and contextualise into researchand apply one’s learning to real life situations.

**PO 3: Multidisciplinary/Interdisciplinary/Transdisciplinary Approach**

Acquire interdisciplinary /multidisciplinary/transdisciplinary knowledge base as a consequence of the learning they engage with their programme of study; develop a collaborative-multidisciplinary/interdisciplinary/transdisciplinary-approach for formulate constructive arguments and rational analysis for achieving common goals and objectives.

**PO 4: Communication Skills**

Ability to reflect and express thoughts and ideas effectively in verbal and nonverbal way; Communicate with others using appropriate channel; confidently share one’s views and express herself/himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner and articulate in a specific context of communication.

**PO 5: Leadership Skills**

Ability to work effectively and lead respectfully with diverse teams; setting direction, formulating goal, building a team who can help achieve the goal, motivating and inspiring team members to engage with that goal, and using management skills to guide people to the right destination, in a smooth and efficient way.

**PO 6: Social Consciousness and Responsibility**

Ability to contemplate of the impact of research findings on conventional practices, and a clear understanding of responsibility towards societal needs and reaching the targets for attaining inclusive and sustainable development.

**PO 7: Equity, Inclusiveness and Sustainability**

Appreciate equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity, secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity, managing diversity and use of an inclusive approach to the extent possible.

**PO 8: Moral and Ethical Reasoning**

Ability to embrace moral/ethical values in conducting one’s life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one’s work and living as a dignified person in the society.

**PO 9: Networking and Collaboration**

Acquire skills to be able to collaborate and network with scholars in an educational institutions, professional organizations, research organizations and individuals in India and abroad.

**PO 10: Lifelong Learning**

Ability to acquire knowledge and skills, including “learning how to learn”, that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed atpersonal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling.

**SCHOOL OF MATHEMATICS & STATISTICS**

**M. Sc. STATISTICS DEGREE PROGRAMME**

**(Revised Under CSS Regulation 2020 and OBE Amendment 2021 w. e. from 2021-22 Admission)**

**1. Introduction** :

In the emerging data driven world, Statistics education is receiving much attention in the national and international levels for making wise decisions. With the establishment of Indian Statistical Institute by Professor P.C. Mahalanobis, India emerged out as a premier centre in statistics teaching, training and research. The decision to establish a School of Mathematics & Statistics in the Mahatma Gandhi University, Kottayam during 2020-21 is a befitting tribute to Professor C. R. Rao, the living legend in statistics, who celebrated his birth centenary on 10 September 2020.

In the proposed curriculum for M.Sc. Statistics, apart from teaching core Statistics subjects, the students are also offered training in programming languages and open softwares such as R, Python, etc to handle real life problems through the practical classes. As part of the program the students are also given training in computing softwares like SPSS, SAS etc. The program prepares the students for UGC-CSIR- JRF/NET/GATE examinations for providing teaching and research opportunities in addition to UPSC Examinations like Indian Statistical Services (ISS), Indian Economic Services (IES) , Indian Civil Services etc. The program is so designed that on successful completion, the students would be able to pursue research or higher studies in the areas of Statistics, Mathematics, Computer Science, Economics, Management, Data Science, Data Analytics and allied fields. Moreover, emerging areas like Bayesian Inference, Actuarial Science, Epidemiology, Biostatistics, Reliability and Survival Analysis, Stochastic Modeling, Time Series Modeling and Official Statistics are included in the curriculum. There will be an open course during third semester to encourage interdisciplinary studies and research. This can be selected from among courses offered by any other school/department/centre in the university.

There has been much interest in Bayesian Inference in Data Analysis in recent years. It is a way to get sharper predictions from the data, particularly when there is not much data available and when one want to utilize every 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. With the emergences of new diseases like AIDS, SARS, COVID 19 etc Epidemiology and Biostatistics has received prominence. Industrial Statistics and Quality Control have become indispensable tools for ensuring quality of industrial products. In the modern data driven world Data Science and Data Analytics are the principal tools for making wise decisions and drawing valid conclusions. We expect students to select the elective courses to ensure employment and research opportunities in emerging areas.

1. **Eligibility for admissions:**

B.Sc. Degree in Mathematics or Statistics main / B.Sc. (triple main) with Mathematics, Statistics and Computer Science as main subjects or B.Sc./B.Voc. Data Science/ Data Analytics or B.E./ B. Tech.(Computer Science) with at least 50% marks (CGPA 5.0 out of 10.00 under grading system) for the optional subjects taken together, provided the candidate has studied at least 4 courses in Probability / Statistics at degree level.

Admission will be made through a common admission procedure (CAP) on the basis of a Common Admission Test (CAT) or a special test conducted for specific programmes by the Departments, as the case may be. Admission may be based on the written test alone or written test and interview or on the basis of the marks obtained in the qualifying examinations as well as the marks obtained in the written test, the interview as decided by the Faculty Council of Schools / Centres / Institutes from time to time in accordance with CSS regulations 2020.

1. **Examination : Credit and Semester System (CSS)**

**Medium of instruction and assessment : English**

**Duration of the Course : 4 Semesters (2 years)**

This is a regular course in which no private / distance mode will not be conducted. However, under extreme situations like COVID 19 pandemic, classes may be conducted online as per UGC guidelines and university rules. The duration of PG program shall be 4 semesters. The duration of each semester shall be 90 working days including internal and external examinations. Odd semesters are normally from June to November and even semesters from December to May. A student shall be permitted to register for the program at the time of admission. A student who registers for the course shall complete the course within a period of 4 years from the date of commencement of the program.

1. **Courses and Credits:**

Every Program conducted under Credit Semester System shall be monitored by the Departmental Academic Committee. In all the programmes, three kinds of courses are offered; Core Courses (3-4 credits), Elective Courses (2-4 credits) and Open Courses (4credits). Core courses are offered by the Schools/Department/Centre/Institute conducting the programme. Elective Courses shall be selected either from the same School/Department or from some other School/ Centres /Institutes. Any course chosen by a student, from an unrelated discipline / subject, from Schools/ Centres / Institutes other than own School / Department / Center, with an intention to seek broad exposure, is called an Open course. Students are required to take one open course in the Third semester. The details are given in the Table of Courses and Credits. A Semester shall be worth a minimum of 16 credits. The minimum number of total credits for a postgraduate program shall be 80.

A minimum of 4 credits and maximum of 20 credits shall be set apart for the project work/dissertation. The compulsory project/dissertation to be completed in the 4th semester of a postgraduate programme shall be prepared by the student under the guidance of a member of the faculty or, in the case of subjects, which so demand, an external guide, to be decided by the school’s faculty council.

University Departments / Schools are permitted to offer online UGC approved MOOC courses from SWAYAM platform as electives during 3rd and 4th semesters subject to the condition that the aggregate credits for such online courses shall not exceed 20% of total credits. These shall be coordinated by a faculty coordinator subject to the approval of the faculty council.

1. **Outcome Based Education (OBE)**

M.G.University has implemented OBE Scheme in 2021. Outcome Based Education (OBE) is an educational approach and a learningphilosophy, which envisages organizing the entire academic programs(curriculum) and instructional efforts around clearly defined ‘outcomes’ that aninstitution want all students to accomplish when they complete the programme. Thepurpose of outcome based approach is to ensure that students achieve learningexpectations for the programs in which they participate. The fundamental premiseunderlying the learning outcomes-based approach to curriculum planning anddevelopment is that higher education qualifications are awarded on the basis ofdemonstrated achievement of outcomes (expressed in terms of knowledge,understanding, skills, attitudes and values) and academic standards expected. Theexpected learning outcomes are used as reference points that would help formulategraduate attributes, qualification descriptors, programme outcomes and courseoutcomes which in turn will help in curriculum planning and development, and in thedesign, delivery and review of academic programmes. They provide generalguidance for articulating the essential learning associated with programmes ofstudy and courses with in a programme.

**Key outcomes of Curriculum planning and development:** The key outcomes thatunderpin the curriculum planning and development reflect the Graduate Attributesvisible in the high level qualities, skills and knowledge that a student expected togain as a result of the learning and experiences they imbibe from a programme ofstudy. Outcomes for a post graduate programme is defined at three levels as: (1)Programme Outcomes (POs), (2) Programme Specific Outcomes (PSOs), and (3)Course Outcomes (COs).

**Graduate Attributes:** The graduate attributes reflect the particular quality andfeature or characteristics of an individual, including the knowledge, skills, attitudesand values that are expected to be acquired by a student through studies at a highereducation institution. The graduate attributes include capabilities that help strengthenone’s abilities for widening current knowledge base and skills, gaining newknowledge and skills, undertaking future studies, performing well in a chosen careerand playing a constructive role as a responsible citizen in the society. The graduateattributes define the characteristics of a student&#39;s university degree programme anddescribe a set of characteristics/competencies that are transferable beyond study ofa particular subject area and programme contexts in which they have beendeveloped.

**Programme Outcomes (PO):** A programme Outcome (PO) indicates the genericoutcomes and attributes expected for the award of a particular type of qualification.The qualification descriptors reflect both disciplinary knowledge and understandingas well as generic skills, including global competencies that all students in differentacademic fields of study should acquire/attain and demonstrate.

**Programme Specific outcome (PSO):** Programme specific outcome (PSO) will include subject-specific skills and generic skills, including transferable global skillsand competencies, the achievement of which the students of a specific programmeof study should be able to demonstrate for the award of a Degree qualification. Theprogramme outcomes are attained by learners through the essential learningacquired on completion of selected courses of study within a programme.

**Course outcome (CO):** Course outcomes are specific to the learning for a givencourse of study related to a disciplinary or interdisciplinary/multi-disciplinary area.Some programmes of study are highly structured, with a closely laid downprogression of compulsory/core courses to be taken at particular phases/stages oflearning. Course-level outcomes will be aligned to programme specific outcomes. Course outcomes are specific to a course of study within a given programme ofstudy.

1. **Teaching Learning and Assessment**

The teaching, learning and assessment strategies are coined with the outcomes setin the OBE teaching and learning framework. The teaching, learning, andassessment mechanism is designed within the principles of the behaviour elementsof educational activities such as cognitive, psychomotor, affective, and socialdomains.

**Question paper setting : The Overall weightage in the assessment, to each of Bloom’s learning levels**

Any question paper which assess the learning outcome should be set with the following learning levels in mind so as to assess the learning outcome attained by a specific learner.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl. No. | Learning level | Question cues | Range Marks (%) for each section | Range of Total Marks/60 |
| 1 | Creating | design, formulate, build, invent, create, compose, generate, derive, modify, develop, integrate | 10-20 | 6-12 |
| 2 | Evaluating | assess, decide, choose, rank, grade, test, measure, defend, recommend, convince, select, judge, support, conclude, argue, justify, compare, summarize, evaluate | 20-30 | 12-18 |
| 3 | Analyzing | classify, outline, break down, categorize, analyze, diagram, illustrate, infer, select. | 20-30 | 12-18 |
| 4 | Applying | apply, solve, illustrate, use, demonstrate, determine, model, experiment, show, examine, modify, calculate, predict | 40-50 | 24-30 |
| 5 | Understanding | describe, explain, paraphrase, restate, associate, contrast, summarize, differentiate interpret, discuss | 20-30 | 12-18 |
| 6 | Remembering | state, define, describe, recall, identify, show, label, tabulate, quote, name, who, when, where | 10-20 | 6-8 |
| Total | |  | 100 | 60 |

1. **Pattern of Question Paper for End-Semester Examination**

Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in new situations, critical evaluation of knowledge, the ability to synthesize knowledge and create new ideas out of knowledge. The question setter shall ensure that questions covering all skills are included. A question paper shall be a judicious mix of essay type, short answer, very short answer type and Multiple-Choice questions. The type of questions and the marks assigned to them are as follows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl. No. | Type of Question | No of questions to be answered | Marks for each question | Total Marks |
| 1 | Essay Type | 2 out of 4 | 10 | 20 |
| 2 | Short Answer Type | 5 out of 8 | 5 | 25 |
| 3 | Very Short Answer Type | 5 out of 8 | 2 | 10 |
| 4 | MCQ (Objective Type) | 5 out of 5 | 1 | 05 |
| Total | | 17 out of 25 | -- | 60 |

1. **Evaluation and Grading**

The evaluation and grading will be strictly in accordance with CSS regulations 2020 and Amendments for implementing OBE Scheme 2021 for University Departments and Schools . Evaluation scheme for each course shall contain 2 parts (a) Internal Evaluation will be in the form of Continuous Assessment (CA) and (b) End Semester Assessment (ESA). 40% weightage is given to continuous internal assessment and 60 % to end semester external evaluation. For Practicals there will be no end semester examination and the whole evaluation process is continuous internal assessment. Both internal and external evaluation is carried out in accordance with the grading system as given in the CSS regulations. Normally odd semester ESA is through examiners in the department. But for even semesters, external examiners will be included in the board of examiners and there will be double valuation.

1. **Process of Evaluation:**

The internal assessment will be a continuous assessment (CA) that accounts for 40% of the evaluation in theory. The end semester examination will account for the remaining 60% of the evaluation.There will be no End Semester examination for Practicals. For Practicals the evaluation is fully through continuous internal assessment.

**End-Semester Examination:** The end semester examination will account for 60% of the evaluation. The evaluation of the end-semester examination of the first and third semesters shall be done by the faculty who taught the course. Evaluation of the 2nd and 4th semester courses based on questions set by external question paper setters shall be evaluated by two examiners; one, the external (as far as possible the question paper setter shall evaluate the examination paper as well) and the other, internal examiner.The double valuation of answer scripts in the second and the fourth semester courses shall be done by external examiners and the concerned faculty respectively as approved by the Faculty Council.

The Head of the School/Department/Centre/Institute will make arrangements for the evaluation of the answer scripts. The project/dissertation shall be evaluated by two examiners, one of them the faculty member who supervised the project and the other an external examiner to be decided by the HOD from a panel recommended by faculty council and approved by the Vice Chancellor. The comprehensive viva-voce, if any, must be carried out along with project evaluation.There will be three members in the Viva-Voce Board approved by the Vice Chancellor.

**Continuous Assessment (CA):** The student’s participation and classroom performance as well as the feedback received from tests, tutorials, assignments and term papers shall form the basis for continuous assessment (CA). It accounts for 40% of the evaluation in both theory and practical. This assessment shall be based on a predetermined transparent system involving periodic written tests, assignments and seminars in respect of theory courses and based on tests, lab skill, records, viva voce, punctuality and participation in respect of practical courses.The percentage of marks assigned to various components for internal evaluation is as follows:

**a. Theory**

|  |  |  |
| --- | --- | --- |
|  | Component | % of internal marks |
| i. | Test papers | 50% |
| ii. | Assignments/Book review/debates | 25% |
| iii. | Seminars/Presentation of case study | 25% |

For each course there shall be at least two class tests during a semester. Average of the best of the marks obtained in the two tests (in the case of more than two tests) or the average of the tests ( if there is only two tests) will be counted as the internal test component of CA.

**b. Practicals**

|  |  |  |
| --- | --- | --- |
|  | Component | % of internal marks |
| i. | Lab / Experiment skill | 40 % |
| ii. | Lab Records / Reports | 20 % |
| iii. | Lab Discipline (punctuality, participation, accuracy) | 20% |
| iv. | Viva Voce | 20% |

**Test Paper:** Valued answer scripts shall be made available to the students for perusal within 10 working days from the date of the tests.

**Assignments:** Each student shall be required to do two assignments/book reviews for each course. Assignments/book review after valuation must be returned to the students. The teacher shall define the expected quality of the above in terms of structure, content, presentation and the like, and inform the same to the students. Punctuality in submission of assignments/records is to be given a weightage in the internal evaluation.

**Seminar:** Every student shall deliver one seminar as an internal component of every course and must be evaluated by the respective course teacher in terms of structure, content, presentation and interaction. The soft and hard copies of the seminar report are to be submitted to the teacher in charge/ Head/Director.

**Results of Continuous Assessment:** The results of the CA counter-signed by Head of the school shall be displayed on the notice board 5 days before the end semester examinations. The marks awarded for various components of the CA shall not be rounded off, if it has a decimal part. The total marks of the CA shall be rounded off to the nearest whole number. Relevant records of continuous assessment (CA) must be kept in the department and that must be made available for verification. Grievances if any may be redressed in the appropriate level as per CSS guidelines.

**Project Work:** There shall be a project/dissertation to be undertaken by all students. The dissertation entails field work, lab work, report writing, presentation and viva voce. The class hours allotted for project work may be clustered into a single slot so that students can do their work at a centre /location for a continuous period of time. However, appropriate changes can be made by the faculty council in this regard. Project/dissertation shall be carried out under the supervision of a teacher in the parent School/Centre/Institute or other research institutes or industrial establishment or university departments if they permit the students to do so, after getting permission from the Department Head.In such cases, one of the teachers from the schools/centres/institutes would be the co- supervisor/internal guide and an expert from the industry/ research organization concerned shall act as supervisor/ external guide. In the case of M Phil programme while forwarding the mark lists of the second semester to the CSS, director of the school/centre/institute shall ensure that both the hard and soft copies of the project/dissertation of all students will be handed over to the University Library immediately after the publication of the results.

**External Evaluation of Theory Answer Scripts:** The external evaluation shall be done after the examination at the earliest, preferably in a centralized valuation. As far as possible bar coded Answer Books shall be used to ensure confidentiality. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. End semester evaluation of Theory Answer Scripts shall be conducted and evaluated by one internal examiner for odd semesters. For even semesters, one external and one internal examiner shall do the process of evaluation. That is, there shall be double valuation system of answer books in the 2nd and 4th Semester evaluations. The final marks awarded will be the average of both valuations. If there is a variation of more than 10 % of the maximum marks, the answer books shall be valued by a third external examiner appointed by the director. The final marks to be awarded shall be the average of the nearest two best out of three awarded by all the examiners.

**Continuous Internal Assessment:** Internal Evaluation will be conducted as Continuous Assessment according to CSS Guidelines 2020 and will consist of Test Papers, Assignments and Seminars / presentations for theory courses. For Practical Courses timely submission of practical records, test papers, lab skills in practical works and viva voce / presentations.

## 7. Grading System:

The grading system followed is that of relative grading on a ten-point scale.

The grading system followed is on a ten-point scale.

The following table indicates the performance range and the relative value of the grades (grade points) on the scale and percentage equivalents.

|  |  |  |  |
| --- | --- | --- | --- |
| **Letter grade** | **Performance** | **Grade point** | **percentage** |
| **O**  A Plus A only B Plus B only C  P F  Ab | Outstanding Excellent Very good Good  Above Average Average  Pass Fail Absent | 10  9  8  7  6  5  4  0  0 | 95- 100  85- <95  75- <85  65- <75  55- <65  45- <55  40- <45  < 40  absent |

**8. Faculty under which the Degree is awarded** : Science

**9. Note on compliance with UGC Minimum Standards**

Present syllabus is in compliance with UGC Minimum Standards to award Post Graduate Degree. It is ideal if one enjoys Mathematics and Statistics and would like to use his skills to model future events and risk.

**M.Sc. Statistics**

**10. Program Specific Objectives :**

1. To provide advanced level teaching and training in theory and applications of statistics as well as skills in statistical computing and data analysis and interpretation.
2. To provide a platform for talented students to undergo higher studies in the subject as well as to train them to suit for the needs of the society.
3. To allow more flexibility to branch out into other emerging areas of Statistics, Mathematics, Computer Science, Data Science and Data Analytics.
4. To draw together a variety of subject areas to enable students to model real-world data from various contexts by exploring a blend of Applied Mathematics and Statistics with appropriate computing tools including free softwares.
5. To provide special attention to interdisciplinary areas in describing, exploring, analyzing and comparing data with an innovative research mind in a data driven world.
6. To make them familiar with official statistics and works of national level agencies like MOSPI, CSO, NSSO, NASA, ISI, IASRI,NIMS etc.
7. To impart training to become successful in national level tests like UGC-CSIR NET-JRF, GATE examinations, ISS and Civil Services examination etc. with a view to enable the students to get opportunities for teaching, research and employment in India and abroad.

**11. Program Specific Outcomes (PSO):**

1. After undergoing this program, students will get advanced knowledge in theory and applications in all areas of Statistics and Applied Statistics including Biostatistics, Epidemiology, Data Science, Data Analytics etc.
2. Students are able to plan and execute statistical surveys and projects for research and development and official purposes.
3. Students are able to undertake any work involving exploratory data analysis, statistical modeling, data learning etc.
4. Students have developed skills in statistical computing and data analysis using various statistical softwares.
5. Students are well trained to appear in national level tests like UGC-CSIR NET-JRF, GATE examinations, ISS and Civil Services examination etc.
6. Students are motivated to pursue teaching and research in all emerging areas of research in theoretical and applied branches of statistics and related disciplines.
7. Students have acquired necessary industrial skills for applications in industry.
8. **The Program Structure:**

**Table of Courses and Credits**

|  |  |  |  |
| --- | --- | --- | --- |
| Course Code | Course Title | Teaching L+T+P | Credits |
| **SEMESTER I Total Credits 24** | | | |
| MS M 21 C21 | Mathematical Tools for Statistics | 4 +0+0 | 4 |
| MS M 21 C22 | Probability Theory I | 4 +0+0 | 4 |
| MS M 21 C23 | Statistical Distribution Theory | 4 +0+0 | 4 |
| MS M 21 C24 | Statistical Estimation Theory | 4 +0+0 | 4 |
| MS M 21 C25 | Sampling Techniques & Official Statistics | 4 +0+0 | 4 |
| MS M 21 C26 | Statistical Computing I Practical  (using R) | 3+0+2 | 4 |
| **SEMESTER II Total Credits 24** | | | |
| MS M 21 C27 | Probability Theory II | 4 +0+0 | 4 |
| MS M 21 C28 | Testing of Hypotheses | 4 +0+0 | 4 |
| MS M 21 C29 | Design of Experiments | 4 +0+0 | 4 |
|  | Elective 1 | 4 +0+0 | 4 |
|  | Elective 2 | 4 +0+0 | 4 |
| MS M 21 C30 | Statistical Computing II Practical (using Python) | 3 +0+2 | 4 |
| **SEMESTER III Total Credits 24** | | | |
| MS M 21 C31 | Multivariate Statistical Analysis | 4 +0+0 | 4 |
| MS M 21 C32 | Stochastic Processes Modeling | 4 +0+0 | 4 |
|  | Elective 3 | 4 +0+0 | 4 |
|  | Elective 4 | 4 +0+0 | 4 |
| MS M 21 C33 | Advanced Statistical Computing Practical (using R and Python / SPSS & SAS) | 2 +0+2 | 4 |
|  | Open Course | 4 +0+0 | 4 |
| **SEMESTER IV Total Credits 16** | | | |
|  | Elective 5 | 4 +0+0 | 4 |
| MS M 21 C34 | Project Work / Dissertation | 20 | 12 |
|  | **Grand Total of Credits** |  | **88** |

**N.B. 1** In the present Program Structure there are 14 Core Courses with a total of 64 credits, 5 Elective courses with a total of 20 credits and an Open Course of 4 credits so that the grand total of credits is 88 for the whole program. Open Course is any course offered by a Department / School / Inter University Centre of the University other than the parent Department / School/ Centre, permitted by both Departments / Schools to encourage interdisciplinary studies and research in emerging areas. Students can select an open course with the permission of the Head of the Department / Director of the School in accordance with the CSS regulations 2020 and amendments.

**N.B. 2** In case students wish to undergo online MOOC Courses in SWAYAM PORTAL or offered by IITs and other reputed institutes of national importance, they can choose them as electives during Semester 3 and 4 with the permission of the Head of the Department / Director of the School and credits shall be assigned in accordance with the CSS regulations 2020 and amendments if any.

**N.B. 3** Project / Dissertation shall be carried out by each student, in a reputed research institute/ department or industry under the joint supervision of an internal faculty and external guide / expert approved by the Director/ Faculty Advisor. Initial works like literature survey, review of literature etc may be started at the end of Semester II itself and a brief report should be submitted at the end of Semester III. The students have to submit a bound copy and a soft copy of the Project Report (documented preferably in LaTex) of at least 50 pages certified by the supervisors, at least 7 days before the conduct of the Presentation and Viva Voce. The marks for Project Report and Viva Voce shall be in the ratio 80:20. There will be interim report presentations on the progress of work and will be part of continuous internal assessment. The Project/ Dissertation will be valued with respect to various criteria including content and presentation as decided by the University/ Department/School as per CSS Rules & Regulations 2020 and amendments.

**Table of Elective/ Open Courses:**

Students can select any 5 elective courses from the list of electives given below, in consultation with the Head of the Dept / Faculty Coordinator. More electives may be added and offered with the permission of the competent authorities.

|  |  |  |  |
| --- | --- | --- | --- |
| **Course Code** | **NAME OF THE COURSE** | **Teaching** | **Credits** |
| MS M 21 E21 | Applied Regression Analysis | 4 | 4 |
| MS M 21 E22 | Bayesian Inference and Computing | 4 | 4 |
| MS M 21 E23 | Data Science & Big Data Analytics | 4 | 4 |
| MS M 21 E24 | Data Mining Techniques | 4 | 4 |
| MS M 21 E25 | Machine Learning & Predictive Modeling | 4 | 4 |
| MS M 21 E26 | Advanced Resampling Techniques | 4 | 4 |
| MS M 21 E27 | Time Series Analysis & Forecasting | 4 | 4 |
| MS M 21 E28 | Bioinformatics and Computational Biology | 4 | 4 |
| MS M 21 E29 | Survival Analysis | 4 | 4 |
| MS M 21 E30 | Biostatistics & Epidemiology | 4 | 4 |
| MS M 21 E31 | Demography & Population Dynamics | 4 | 4 |
| MS M 21 E32 | Categorical & Directional Data Analysis | 4 | 4 |
| MS M 21 E33 | Clinical Trials and Bioassays | 4 | 4 |
| MS M 21 E34 | Statistical Genetics and Ecology | 4 | 4 |
| MS M 21 E35 | Statistical Methods for Micro-Array Analysis | 4 | 4 |
| MS M 21 E36 | Operations Research | 4 | 4 |
| MS M 21 E37 | Industrial Statistics & Quality Control | 4 | 4 |
| MS M 21 E38 | Actuarial Statistics | 4 | 4 |
| MS M 21 E39 | Econometric Methods | 4 | 4 |
| MS M 21 E40 | Stochastic Finance | 4 | 4 |
| MS M 21 E41 | Reliability Modeling and Analysis | 4 | 4 |
| MS M 21 E42 | Advanced Distribution Theory | 4 | 4 |
| MS M 21 E43 | Mixture Regression Analysis | 4 | 4 |
| **Open Course (During Semester III) for students of Schools / Departments / Centres other than the School of Mathematics and Statistics** | | | |
| **MS M 21 O 21** | **Elements on Clinical Trials and Business Analytics** | 4 | 4 |

**SCHEME OF MSc STATISTICS PROGRAMME**

**FIRST SEMESTER SCHEME**

|  |  |  |
| --- | --- | --- |
| **Course code** | **Course Title** | **Credits** |
| MS M 21 C21 | Mathematical Tools for Statistics | 4 |
| MS M 21 C22 | Probability Theory I | 4 |
| MS M 21 C23 | Statistical Distribution Theory | 4 |
| MS M 21 C24 | Statistical Estimation Theory | 4 |
| MS M 21 C25 | Sampling Techniques & Official Statistics | 4 |
| MS M 21 C26 | Statistical Computing I Practical (Using R) | 4 |
|  | Total Credits for the first semester courses | **24** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C21: MATHEMATICAL TOOLS FOR STATISTICS** |

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| --- | --- | --- | --- | --- | --- | --- |
| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **MATHEMATICAL TOOLS FOR STATISTICS** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C21** | | | | | |
| **Course Summary & Justification** | To make students familiar with fundamental concepts in Real Analysis and Linear Algebra, which are essential tools for understanding probability and statistical concepts. | | | | | |
| **Semester** | First | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Prerequisites** | Understanding of fundamental concepts in Real Analysis and Linear Algebra. | | | | | |

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| --- | --- | --- | --- |
| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are capable of applying the concepts in real analysis and linear algebra to understand Probability Theory and Statistics with more clarity. | R/A/E | 1,2,3,5,7 |
| 2 | Students have studied continuity, convergence, integrals, Reimann – Stieltjes integral etc in real analysis and can apply these in probability and statistics. | U/C/I/An | 1,2,3,5,7 |
| 3 | Students understood generalized inverses, advanced theory of eigen values, quadratic forms and their nature, orthogonal reduction, spectral decomposition etc. in linear algebra and can apply these in regression analysis, multivariate analysis, design of experiments | U/A/Ap | 1,2,3,4,5,7 |
| 4 | Students are capable of applying these concepts in research and model building . | A/S/C/I | 6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

|  |  |  |  |
| --- | --- | --- | --- |
| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Open and closed sets, countable and uncountable sets, supremum, infimum. Sequences and series, convergence, limsup, liminf. Bolzano Weierstrass theorem, Heine Borel theorem. Continuity, uniform continuity, differentiability, mean value theorem. Sequences and series of functions, uniform convergence, absolute convergence. | 1,3,4 | 15 |
| 2 | Riemann sums and Riemann integral, Rieman- Stieltjes Integral, condition for integrability, Improper Integrals. Beta and gamma integrals, Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral. Functions of several variables, directional derivative, partial derivative, inverse and implicit function theorems. Metric spaces, compactness, connectedness. | 1,2,3,4, | 15 |
| 3. | Vector space, sub spaces, linear dependence and independence, basis and dimensions, orthogonality of vectors, Gram-Schmidt ortho-normalization process. Row rank, column rank and rank of a matrix, trace, determinant, partitioning of matrices. Inverse of a non-singular matrix and computation. Solving linear equations, consistency, properties of solutions. Generalized Inverse of Matrices, Definition and existence, Moore-Penrose inverse, computation and applications. | 1,2,3,4 | 20 |
| 4 | Eigen values and vectors of a matrix, determination and properties, nature of eigen values. Cayley - Hamilton theorem, characteristic sub-spaces, algebraic and geometric multiplicity Quadratic forms, diagonal reduction in the real field, canonical forms, nature of definiteness of quadratic forms, necessary and sufficient conditions. Orthogonal reductions of quadratic forms, Spectral decomposition of a matrix, extrema of quadratic forms, simultaneous reduction of a pair of quadratic forms.Derivatives with respect to scalar functions of vectors and matrices, quadratic forms, determinant, inverse, Jacobians of matrix transformations Y=AX, Y= AXB; Y= AXAT; X=TTT. | 1,2,3,4 | 20 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Rudin. W. (2013). Principles of Real Analysis (3rd Ed.),McGraw Hill. 2. Bapat, R. B. (2000). Linear Algebra and Linear Models., Springer. 3. Rao A.R. and Bhimasankaram P. (2000) Linear Algebra, Second edition, Hindustan Book Agency. | | | |
| **Further Reading:**   * Rao, C.R. (2009) Linear Statistical Inference and its Applications, Wiley Asia, Second Edition. * Khuri, A.T. (1993) Advanced Calculus with Applications in Statistics, John Wiley and Sons, Inc., New York. * Gilbert Strang (2014) Linear Algebra and its Applications, 15th Re-Printing edition, Cengage Learning. * Searle, S. R. (1982): Matrix Algebra for Statistical Applications, John Wiley and Sons Inc. * Mathai, A. M. (1997) Jacobians of Matrix Transformations and Functions of Matrix Arguments, World Scientific Publishing, New York. * Bartle, R. G. (1976). Elements of Real Analysis, John Wiley * Ghorpade, S. R. and Limaye, B. V. (2006). A Course in Calculus and Real Analysis, Springer * Malik S. C. and Arora, S (2017). Mathematical Analysis, 5th ed. New Age International Publishers. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction):** Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments, Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A.Continuous Internal Assessment (CIA)- 40 marks**  1. Minimum two Internal Tests of 10 marks each-Maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End Examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| MS M 21 C22 :PROBABILITY TEORY - 1 |

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| --- | --- | --- | --- | --- | --- | --- |
| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | PROBABILITY TEORY - 1 | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C22** | | | | | |
| **Course Summary & Justification** | The main objective of this course is to introduce students the inter-link between measure and probability. | | | | | |
| **Semester** | First | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Pre-requisite** | Understanding of fundamental concept of Probability Theory | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Understand the concepts of measure and probability and their properties. | U/I/An | 1,2,3,5,7 |
| 2 | Understand convergence of sequence of sets, sequence of measurable functions and sequence of integrals. | U/R/A/An | 1,2,3,5,7 |
| 3 | Understand convergence of sequence of random variables | A/Ap | 1,2,3,4,5,7 |
| 4 | Understand the inequalities involving moments | U/A/E/S | 6, 7 |
| 5 | Apply these in teaching, research and applications | S/An/Ap/C | 1,2,3,4,5,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

|  |  |  |  |
| --- | --- | --- | --- |
| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | **Measure and Measurable Function:** Class of sets, limits of sequence of sets, fields and *σ*-fields, minimal *σ*-fields and Borel field, monotone class. Measurable space, measure, measure space, Lebesgue measure and counting measure .Measurable functions and their properties. Limit of a sequence of measurable functions, simple functions, non-negative measurable functions as limit of simple functions. | 1 | 20 |
| 2 | **Integral and Convergence of Sequence of Integrals:** Integral of a simple function, integral of a measurable function, properties of integrals. Sequence of integrals and properties, the monotone convergence theorem, Fatou’s lemma. Bounded convergence theorem, Lebesgue dominated convergence theorem. Normed linear spaces, Lp spaces, Holder’s inequality, Minkowski’s inequality. | 2,3,4, | 20 |
| 3. | **Probability Measure and Random Variables:** Axiomatic approach to probability, probability space. Conditional probability space, independence of events and sigma fields, Bayes’ theorem and applications **.** Real and vector valued random variables, distribution function, density function and properties. Expectation of a random variable and properties, probability space induced by a random variable Sequence of random variables and different modes of convergence: in probability, in distribution, in rth mean and almost sure, their mutual implications. | 1,2,3,4,5 | 20 |
| 4 | **Expectation and Inequalities:** Expectation of a function of random variable as Riemann-Stielje’s integral, moments of a random variable. Inequalities involving moments - Cr inequality, Jenson’s inequality. Basic inequality, Markov inequality and their applications. | 1,2,3,4,5 | 10 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Laha, R. G. and Rohatgi, V. K. (2020). Probability Theory, Dover Publications Inc 2. Bhat, B.R.(2004). Modern Probability Theory, New Age Publishers, New Delhi. 3. Robert G. Bartle(1995). The Elements of Integration and Lebesgue Measure. John Wiley & Sons, New York. | | | |
| **Further Reading:**   * Basu, A.K. (1999).Measure Theory and Probability, Prentice-Hall. * Billingsley, P. (1986).Probability and Measure, Second Edition, JohnWiley. * Parthasarathy,K.R. (2005).Introduction to Probability and Measure, Hindustan Book Agency. * Royden, H. L. (1988 ). Real Analysis, Third Edition, McMillain Publishing Company, New-York. * Ash, R.B. (1972) Real Analysis and Probability, Academic press. * Luckas, E. (1970) Characteristic functions, Second Edition, Hafner Publishing Company, NewYork. * Parthasarathy, K.R. (2005) Introduction to Probability and Measure, Hindustan Book Agency. * Loeve, M. (1977) Probability Theory, Fourth edition, Springer Verlag. * Rohatgi, V.K. and Saleh, M. (2015) An Introduction to Probability and Statistics, Third edition, Wiley. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction):** Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment:**  **A.Continuous Internal Assessment (CIA) - 40 marks**  1. Two Internal Tests of 10 marks each- maximum 20 marks  2. Seminar Presentation – a theme is to be discussed/ presented in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C23 : STATISTICAL DISTRIBUTION THEORY** |

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| --- | --- | --- | --- | --- | --- | --- |
| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **STATISTICAL DISTRIBUTION THEORY** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C23** | | | | | |
| **Course Summary & Justification** | To make the students familiar with basic probability models and their properties as well as applications | | | | | |
| **Semester** | First | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Prerequisite** | Understanding of fundamentals of Mathematical Statistics . | | | | | |

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| --- | --- | --- | --- |
| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to model real life data using appropriate probability distributions. | U/I/A/C | 1,2,3,4,5,6,7 |
| 2 | They are capable of computing probabilities and are enabled to make probabilistic conclusions about real life problems using these distributions.  . | U/R/A/An | 1,2,3,45,6,7 |
| 3 | They are able to pursue research in distribution theory. | A/Ap | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

|  |  |  |  |
| --- | --- | --- | --- |
| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Probability Generating functions, Moment generating functions and their properties.Quick review of Discrete Distributions:- ( Degenerate, Bernoulli, Binomial, Uniform, Geometric, Poisson) Negative binomial and Hyper geometric , Logarithmic series. Modified Power series and Generalized Power series and special cases, multinomial distribution and its basic properties. | 1,2,3 | 15 |
| 2 | Continuous Distributions: Rectangular, Triangular, Exponential, Weibull, Normal, Lognormal, Laplace, Beta, Gamma, Pareto, Cauchy, Logistic, Inverse Gaussian, Extreme Value distributions. Pearson family and Exponential family of distributions | 1,2,3, | 20 |
| 3. | Functions of Random variables and their distributions. Jacobian of transformation, Distributions of sums and differences, products and ratios of independent random variables. Compound, Truncated and mixture distributions. Notions of bivariate distributions, Marshall - Olkin, Gumbel’s bivariate exponentials and basic properties. Bivariate normal distribution- marginal and conditional distributions. | 1,2,3 | 20 |
| 4 | Sampling distributions: Chi-square, *t* and *F* distributions (concept of central and non-central forms of , t, F (definition only). Sampling distributions of mean and variance, independence of sample mean and variance.Order statistics and their distributions:- joint and marginal distributions, Distributions of sample median, range and mid-range (Exponential and Uniform cases only). Record Values, Concomitants of order statistics (basic ideas only). | 1,2,3,4 | 15 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Hogg R.V and Craig A.T. (2013) Introduction to Mathematical Statistics, MacMillan Publishing Company. 2. Gupta S.C. and Kapoor V.K. (2000) Fundamentals of Mathematical Statistics, S. Chand & Co, New Delhi. | | | |
| **Further Reading:**   * Johnson N.L, Kotz S. and Kemp A.W. (1992) Univariate Discrete Distributions, Wiley. * Johnson N.L, Kotz S. and Balakrishnan N. (1991) Continuous Univariate Distributions I & II, Wiley * Rohatgi V.K. and Saleh M. (2015) An Introduction to Probability and Statistics, Third edition, Wiley. * Arnold B.C, Balakrishnan N. and Nagaraja H.N. (1992) A First Course in Order Statistics. Wiley * Biswas S. and Srivastava G.L (2008) Mathematical Statistics: A Text Book, Alpha Science International Ltd * Forbes, C., Evans, M., Hastings, N.. and Peacock, B. (2011) Statistical Distributions, 4th Edition, John Wiley & Sons | | | |

|  |  |
| --- | --- |
| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction):** Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, Library work and Group discussion, Presentations |
| **Assessment Types** | **Mode of Assessment**   1. **Continuous Internal Assessment (CIA)- 40 marks**   1.Minimum two Internal Tests of maximum 10 marks marks each- 20  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar - Maximum marks 10  3.Write a detailed report on a given topic based on research findings and literature search – Maximum 10 marks   1. **Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C24 :STATISTICAL ESTIMATION THEORY** |

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| --- | --- | --- | --- | --- | --- | --- |
| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | STATISTICAL ESTIMATION THEORY | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C24** | | | | | |
| **Course Summary & Justification** | Students will be able to understand the desirable properties for good estimators. They will be aware of different estimation methods as well as basics of Bayesian inference. | | | | | |
| **Total Student Learning Time (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Pre-requisite** | Understanding the concept of statistical inference. | | | | | |

**COURSE OUTCOMES**

|  |  |  |  |
| --- | --- | --- | --- |
| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to estimate parameters and compare their efficiencies to find the best estimate among them. | U/R/A/An | 1,2,3,4,5,6,7 |
| 2 | They are aware of different estimation methods like method of mle and method of moments.  . | U/R/A/An | 1,2,3,45,6,7 |
| 3 | They have understood basic theory of Bayesian inference which is an emerging area in research and applications. | U/R/A/An | 1,2,3,4,5,6,7 |
| 4 | They know the idea of interval estimation and how to construct confidence intervals. | S/I/Ap | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

|  |  |  |  |
| --- | --- | --- | --- |
| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Point estimation-properties of estimators – unbiasedness, consistency, sufficient condition for consistency.CAN and BAN estimatorsSufficiency, minimal sufficiency, completeness, bounded completeness, Fisher - Neyman factorization theorem, exponential families, UMVUE estimators and their characterization, **1.4** Rao- Black well theorem, Lehmann -Scheffe theorem, applications. | 1 | 20 |
| 2 | Fisher information measure and its properties, Fisher information matrix . Lower bound to the variance of an unbiased estimator, Cramer - Rao inequality, Bhattacharyya's bounds, Chapman-Robins bound **.** Efficiency , minimum variance bound estimator. ancillary statistics, Basu's theorem. | 1,2 | 15 |
| 3. | Methods of estimation: method of moments, method of maximum likelihood & their properties, asymptotic normality, Cramer - Huzurbazar theorem, Fisher's scoring method. Method of minimum chi-square and method of modified minimum chi-square- .Interval estimation – Pivotal method of construction - shortest confidence intervals and their construction, UMA confidence interval. Construction of shortest confidence intervals in large samples. | 2,4 | 20 |
| 4 | Basic elements of Bayesian Inference, Loss functions and risk functions, Standard forms of loss functions- Squared error, absolute error, 0-1 loss functions. Prior distributions, non-informative, improper, Jeffrey’s prior, Bayes’ rule and applications. Posterior distribution, Bayes risk, Bayes principle. Bayes estimators, Minimax estimators, Credible Intervals | 3,4 | 15 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Rohatgi V.K. and Saleh A.K. (2015) An Introduction to Probability Theory and Mathematical Statistics, Wiley. 2. Berger J.O. (1993) Statistical Decision Theory and Bayesian Analysis, Third Edition, Springer. 3. Casella, G and Berger, R.L (2007) Statistical Inference, Second Edition, Cengage Learning. | | | |
| **Further Reading:**   * Hogg R. V. and Craig A. T. (2013) Introduction to Mathematical Statistics, Pearson * Kale B. K. and Muralidharan, K. (2005) A First Course on Parametric Inference, Alpha Science International * Rajagopalan M. and Dhanavanthan, P. (2012) Statistical Inference, Prentice Hall of India Learning Private Limited, New Delhi * Lehmann E.L. (1983) Theory of Point Estimation – Wiley, New York. * Lindgren B.W (1976) Statistical Decision Theory (3rd Edition), Collier Macmillian, New York. * Rao C.R (2009) Linear Statistical Inference and its Applications, John Wiley, New York. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**   1. **Continuous Internal Assessment (CIA)** 2. Two Internal Tests of 10 marks- maximum 20 marks 3. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10 4. Write a detailed report on a given topic based on research findings and literature search – maxiimum10 marks 5. **Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C25 :SAMPLING TECHNIQUES & OFFICIAL**  **STATISTICS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **SAMPLING TECHNIQUES & OFFICIAL STATISTICS** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C25** | | | | | |
| **Course Summary & Justification** | By the end of this course students are aware of the basic concepts related to sampling techniques, to determine sample size so as the estimator will have a desired precision. | | | | | |
| **Semester** | First | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Pre-requisite** | Basic concepts related to sampling techniques. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to use appropriate sampling methods and determine optimum sample sizes. | U/R/A/An | 1,2,3,4,5,6,7 |
| 2 | They will be able to plan and conduct suitable sample surveys as part of any statistical study to estimate population values. | U/R/A/An/I | 1,2,3,45,6,7 |
| 3 | They are aware of the official statistical system in India and the different agencies. | U/I | 6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Official Statistical Systems in India – Role of MOSPI, NSSO and CSO and their activities, Recent Surveys by NSSO. Census and Sampling methods, Advantages and disadvantages, Principles of sampling theory, Principal steps in a sample survey, preparation of questionnaires, probability sampling and non probability sampling, sampling and non sampling errors, bias, variance and MSE .Simple random sampling with and without replacement - estimation of population mean, total and proportions, estimation of sample size . Properties of the estimators, variance and standard error of the estimators, confidence intervals, determination of the sample size. Randomized response techniques: Warner’s model-related and unrelated questionnaire methods. | 1,3 | 20 |
| 2 | Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, Comparison of the precision of estimators under proportional allocation, optimum allocation and SRS. Systematic sampling – Linear and Circular, estimation of the mean and its variance, intra-class correlation coefficient, Comparison of systematic sampling, SRS and stratified random sampling for a population with a linear trend. | 1,2 | 20 |
| 3. | Ratio method of estimation, estimation of population ratio, mean and total. Bias and relative bias of ratio estimator, comparison with SRS estimation. Unbiased ratio type estimators- Hartley-Ross estimator, Regression method of estimation. Comparison of ratio and regression estimators with mean per unit method, Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error, Multistage and Multi-phase sampling (Basic Concepts), estimation of the population mean and its standard error. | 1,2 | 15 |
| 4 | Varying probability sampling, PPS sampling with and without replacement. Cumulative total method, Lahiris method, Midzuno - Zen method and its inclusion probabilities, 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 **.**  Des-Raj’s ordered estimator, Murthy’s unordered estimator. Indian Population Census, Human Development Index. Estimation of national income, Measuring inequalities in income distribution. | 1,2,3 | 15 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Cochran, W.G (1992): Sampling Techniques, Wiley Eastern, New York. 2. Singh, D. and Chowdhary, F.S. (1999): Theory and Analysis of Sample Survey Designs, Wiley Eastern (New Age International), New Delhi.   . | | | |
| **Further Reading:**   * Mukhopadhyay P. (2009) Theory and Methods of Survey Sampling, Second Edition, PHI Learning (P) Ltd * Arnab, R. (2017). Survey Sampling: Theory and Applications. Academic Press. * Sukhatme P.V. et.al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA. * Murthy, M.N. (1977) Sampling Theory and Methods, Statistical Publishing Society, * Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., * Thomas Lumley (1996) Complex Surveys. A Guide to Analysis Using R, Wiley eastern Ltd. * Des Raj (1967) Sampling Theory. Tata McGraw Hill ,NewDelhi * Chaubey, P. K. (1995). Poverty Measurement Issues, Approaches and Indices. New Age Publication, New Delhi. * Sen, Amartya. (1983). Poverty and Femine. Oxford University Press. * Singh, S. (2003). Advanced Sampling Theory with Applications, Kulwer Academic Publishers, Netherlands. * MOSPI website. www.mospi.gov.in | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**   1. **Continuous Internal Assessment (CIA)- 40 marks** 2. Two Internal Tests of 10 marks each - maximum 20 marks 3. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10 4. Write a detailed report on a given topic based on research findings and literature search – maximum 10 marks 5. **Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C26 :STATISTICAL COMPUTING I PRACTICAL ( USING R )** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | STATISTICAL COMPUTING I PRACTICAL ( USING R ) | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C26** | | | | | |
| **Course Summary & Justification** | To make the student capable to do practical problems and data analysis in more advanced areas of Statistics using R software. | | | | | |
| **Total Student Learning Time (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning  Learning through Practicals | 40 | 10 | 40 | 10 | 100 |
| **Pre-requisite** | Basic knowledge of R programme and necessary statistical theory. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Using R students will be enable to carry out statistical computing and graphics. | U/R/A/An/E/I/C | 1,3,4,5 |
| 2 | Using R students can achieve the basic areas of probability, distributions and sampling. | U/R/A/An/E/C/I | 1,3,4,5 |
| 3. | Students will be enable to carry out practical problems of matrix algebra | U/R/A/An/E/I/C | 1,3,4,5 |
| 4. | Developing skill to do practical problems in the area of sampling techniques and estimation theory through R software | U/R/A/An/S/E/C/Ap | 1,3,4,5 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Introduction to statistical software R, Methods of data input, Data Accessing, Data objects in R, Manipulating vectors, matrices, lists, importing of files, data frame**.**Graphics using R- Diagrammatic representation of data, bar diagrams, pie chart, Graphical representation of data, Histogram, Box-plot, Stem and leaf plot, Scatter plot, Plot options; Multiple plots in a single graphic window, frequency table, descriptive measures of central tendency, dispersion, skewness and kurtosis **.** Controlling Loops- For, repeat, while, if , if else etc. | 1 | 20 |
| 2 | Distribution Theory using R, Plotting of pdf, cdf and computing probability for discrete and continuous distributions. Generation of random variables and random samples, sampling distribution of sample mean from normal population. Plots to check normality, P-P plot, Q-Q Plot, Simulation of random numbers. Fitting of discrete and continuous distributions. Chi Square goodness of fit. | 1,2 | 20 |
| 3. | Analytical tools for Statistics using R, Implementation of numerical problems using R: Writing user defined functions for statistical methods. Use of the apply group of functions. Vector functions. Use of matrix methods in statistical analysis, R for computing rank, inverse, g inverse. Use of R for solving system of equations, computing eigen values and vectors, spectral decomposition etc. | 1,3 | 20 |
| 4 | Use of statistical packages in survey sampling, Sample size determination, selection of representative samples, R- commands to generate random samples, srswr, srswor, stratified sampling, systematic sampling .Use of other related packages in sampling theory. Writing user defined functions for various computations in sampling theory. Applications in estimation of parameters, method of moments, maximum likelihood estimates, UMVUE etc | 1,2,4 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **N.B.** It is expected to teach R Programming with Applications in Statistics in the classroom ( lectures for 3 hours) and then applications for data analysis relating to relevant topics in all courses in this semester in the Statistics Computer Lab ( for 2 hours) in a week.. The basic commands and codes will be explained using the listed books. R Program being an open software, students can study this on their own laptop. Many workshops and training programs will also be conducted. Students have to work out the practical questions using R and submit the Practical Record every week. There will be Continuous Internal Assessment only. | | | |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Heuman, C., Schomaker, M. and Shalab (2016) Introduction to Statistics and Data Analysis with Applications in R, Springer. 2. Purohit, S.G, Gore, S., and Deshmukh, S.R.(2009) Statistics Using R, Narosa Publishers. | | | |
| **Further Reading:**   * Michaeaux, P.L., Droulhet, R and Liquet, B. (2013) The R software- Fundamentals of Programing and Statistical Analysis, Springer * Dalgaard, P.(2008) Introductory Statistics with R, 2 Edition, Springer * Zuur, A.F. ,Ieno, E.N. and Meesters, E.H.(2009) A Beginners Guide to R, Springer | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture on R, Explicit Teaching, E-learning, interactive Instruction, Active co-operative learning, Practicals, Group Assignments, Writing Practical Records |
| **Assessment Types** | **Mode of Assessment**  **Continuous Internal Assessment (CIA)- 100 marks**   1. Two Internal Examinations for testing experimental skills-40 marks 2. Viva - Voce and presentations - 20 marks 3. Lab discipline, punctuality, accuracy etc - 20 marks 4. Write and submit Practical Records in time – 20 marks |

**SECOND SEMESTER COURSES - TOTAL CREDITS 24**

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| **Course code** | **NAME OF THE COURSE** | **Credits** |
| MS M 21 C27 | Probability Theory II | 4 |
| MS M 21 C28 | Testing of Hypotheses | 4 |
| MS M 21 C29 | Design of Experiments | 4 |
|  | Elective 1 | 4 |
|  | Elective 2 | 4 |
| MS M 21 C30 | Statistical Computing II Practical  (using R and Python) | 4 |
|  | **TOTAL CREDITS FOR ALL COURSES** | **24** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| MS M 21 C27 :PROBABILITY THEORY II |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | PROBABILITY THEORY II | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | MS M 21 C27 | | | | | |
| **Course Summary & Justification** | The aim of the course is to make a thorough knowledge about some fundamental theorems in probability such as continuity theorem on characteristic functions, laws of large numbers, central limit theorems and various decomposition theorems of signed measures with their applications. | | | | | |
| **Semester** | Second | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Prerequisite** | Basic knowledge of Probability theory. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Understand the concepts of decomposition of measures. | U/R/A/An | 1,2,3,4,5,6,7 |
| 2 | Understand characteristic function and its properties. | U/R/A/An | 1,2,3,45,6,7 |
| 3 | Understand various laws of large numbers and apply them in practical situations. | U/R/A/An | 1,2,3,4,5,6,7 |
| 4 | Understand different central limit theorems, their mutual implications and applications | U/R/A/An | 1,2,3,4,5,6,7 |
| 5 | Understand the concept of conditional expectation and martingales with applications | U/R/A/An | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Signed Measures and Decompositions: Signed measure space, singular and absolutely continuous measures, Radon-Nikodym theorem (without proof) and its applications. Decomposition of measures, Hahn Decomposition theorem, Hahn- Jordan decomposition, and Lebesgue decomposition theorem. Product space and product measure. Fubini’s theorem (without proof). | 1 | 20 |
| 2 | Characteristic Functions and Properties, Definition, elementary properties. Characteristic functions and moments, Taylor’s series expansion of characteristic functions, Bochner’s theorem (without proof). Inversion theorem, uniqueness theorem, continuity theorem and applications. | 2 | 15 |
| 3. | The Weak laws of large numbers, the strong laws of large numbers and Kolmogorov three series theorem (withot proof), applications. Weak convergence of distributions. Helly’s convergence theorem, Helly-Bray lemma, Scheffe theorem, Independence of class of events and random variables. Borel 0-1 criteria and Borel-Cantelli Lemma, Kolmogorov 0-1 laws. | 3,4 | 20 |
| 4 | The central limit theorems – Lindberg Levy, Liapounov and Lindberg-Feller (without proof) central limit theorems, their mutual implications and applications. Central limit problem, the class of infinitely divisible distributions, Stable laws and examples. Conditional expectation, martingales, simple properties and examples. | 3,4,5 | 15 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Laha, R. G. and Rohatgi, V. K. (2020). *Probability Theory*, Dover Publications Inc. 2. Bhat, B. R. (2004). *Modern Probability Theory*, New Age Publishers, New Delhi. 3. Robert G. Bartle (1995). *The Elements of Integration and Lebesgue Measure*, John Wiley & Sons, NewYork. 4. Rohatgi, V.K. and Saleh, M. (2015) An Introduction to Probability and Statistics, Third edition, Wiley. | | | |
| **Further Reading:**   * Basu, A.K. (1999). *Measure Theory and Probability*, Prentice-Hall. * Billingsley, P. (1986). *Probability and Measure*, Second Edition, John Wiley. * Parthasarathy, K.R. (2005). *Introduction to Probability and Measure*, Hindustan Book Agency. * Royden, H. L. (1988 ). *Real analysis*(3rd edition), McMillain Publishing Company, New York. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**   1. **Continuous Internal Assessment (CIA)** 2. Two Internal Tests of 10 marks each- maximum 20 marks 3. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10 4. Assignments / detailed report on a given topic based on research findings and literature search – maximum 10 marks 5. **Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C28 :TESTING OF HYPOTHESES** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **TESTING OF HYPOTHESES** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | MS M 21 C28 | | | | | |
| **Course Summary & Justification** | To make the student understand the concepts of testing of hypothesis and to develop appropriate tests for testing certain statistical hypotheses. | | | | | |
| **Semester** | Second | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Prerequisite** | Basic knowledge of inferential statistics and statistical testing of hypothesis. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | This will enable the students for formulating hypotheses and to apply suitable test procedures like Neyman-Pearson Most Powerful Tests, UMP Tests,etc. | U/R/A/An | 1,2,3,4,5,6,7 |
| 2 | Helps to understand Likelihood Ratio Tests, Sequential Tests, Non-parametric Tests and their applications in practical situations. | U/R/A/An | 1,2,3,45,6,7 |
| 3 | It will help them to test such hypotheses and interpret the conclusions for making appropriate decisions | U/R/A/An/S | 1,2,3,4,5,6,7 |
| 4 | It will make them aware of the connection between tests and confidence intervals | U/R/A/AnC/S | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Basic concepts in statistical hypotheses testing-simple and composite hypothesis, critical regions, Type-I and Type-II errors, significance level, p-value and power of a test; Neyman-Pearson lemma and its applications; Construction of tests using NP lemma- Most powerful test, uniformly most powerful (UMP) test; Monotone Likelihood ratio and testing with MLR property; Testing in one-parameter exponential families-one sided hypothesis, Unbiased and Uniformly Most Powerful Unbiased tests for different two-sided hypothesis; Extension of these results to Pitman family when only upper or lower end depends on the parameters. | 1 | 20 |
| 2 | Similar regions tests, Neyman structure tests, Likelihood ratio (LR) criterion and its properties, LR tests for testing equality of means and variances of several normal populations. Testing in multi-parameter exponential families . UMP and UMPU similar size-tests; Confidence sets, UMA and UMAU confidence sets, Construction of UMA and UMAU confidence sets. Locally Most Powerful (LMP) tests, LMPU tests. | 2 | 15 |
| 3. | Sequential probability ratio tests (SPRT), Properties of SPRT, Determination of the boundary constants . Construction of sequential probability ratio tests, Wald’s fundamental identity, Operating characteristic (OC) function, derivation, graph and Average sample number (ASN) functions for Binomial, Poisson, Normal and exponential distributions. | 3,4 | 15 |
| 4 | Non-parametric tests-- Sign test, Wilcoxon Signed Rank test, paired sign test, paired signed rank test . Chi-square goodness of fit tests, Kolmogorov-Smirnov one sample and two samples tests, Median test, Mann- Whitney U-test, Wilcoxon sum of ranks test , Test for Randomness, Runs up and runs down test, Wald–Wolfowitz run test for identical distributions, Kruskall–Wallis one-way analysis of variance, Friedman’s two-way analysis of variance, Power and asymptotic relative efficiency | 3,4,5 | 20 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Rohatgi V.K. and Saleh A.K. (2015) An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NewYork. 2. Gibbons, J. D. and Chakraborti, S (2010). Nonparametric Statistical Inference, 5th Ed. Chapman and Hall/CRC. | | | |
| **Further Reading:**   * Casella G. and Berger R.L. (2002) Statistical Inference, Second Edition Duxbury, Australia. * Lehman E.L. (1998) Testing of Statistical Hypothesis. John Wiley, New York. * Wald A. (1947) Sequential Analysis, Wiley, Doves, New York. * Parimal Mukhopadhyay (2006) Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata. * Siegel S. and Castellan Jr. N. J. (1988) Non-parametric Statistics for the Behavioral Sciences, McGraw Hill, New York. * Rao C.R. (1973) Linear Statistical Inference and its Applications, Wiley. * Rohatgi, V. K. and Saleh A. K. Md. E (2015). An Introduction to Probability and Statistics, 3rd Ed. Wiley, New York. * Hogg, R. V. and Craig, A. T. (2012). Introduction to Mathematical Statistics, 7th Ed. Pearson Edward (Indian Print). | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**   1. **Continuous Internal Assessment (CIA)** 2. Two Internal Tests of 10 marks each- maximum 20 marks 3. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10 4. Write a detailed report on a given topic based on research findings and literature search – maximum 10 marks 5. **Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C29 :DESIGN AND ANALYSIS OF EXPERIMENTS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **DESIGN AND ANALYSIS OF EXPERIMENTS** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C29** | | | | | |
| **Course Summary & Justification** | By the end of the course the students will be able to plan and conduct experiments by using appropriate designs, analyse the data, test related hypotheses and estimate the parameters. | | | | | |
| **Semester** | Second | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Prerequisite** | Basic knowledge of inferential statistics. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students will get necessary knowledge in the theory of Linear Estimation | U/R/A/An | 1,2,3,4,5,6,7 |
| 2 | Students are able to compare different treatment effects using appropriate designs | U/R/A/An | 1,2,3,45,6,7 |
| 3 | They will be capable to use the ANOVA and ANCOVA technique when covariates are available | U/R/A/An/S | 1,2,3,4,5,6,7 |
| 4 | They get practical knowledge in planning and executing factorial experiments with appropriate designs. | U/R/A/AnC/S | 1,2,3,4,5,6,7 |
| 5 | Students are equipped with practical knowledge of different designs for application in agricultural fields, industry, bio-statistics, clinical trials etc. | U/R/A/AnC/S | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Linear estimation: Gauss Markov set up, Estimability of parameters, Method of least squares, best linear unbiased Estimators, Gauss-Markov Theorem, Tests of general linear hypotheses , Analysis of variance- one-way, two-way and three-way classification models. | 1 | 20 |
| 2 | Planning of experiments: Basic principles of experimental design, Uniformity trails, 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 and RBD. | 2,3,5 | 20 |
| 3. | Incomplete block design: Balanced incomplete block design (BIBD); Incidence Matrix, C- Matrix, Parametric relations; Intra-block analysis of BIBD, Connectedness, Construction of BIBD by developing initial blocks, Basic ideas of partially balanced incomplete block design (PBIBD), Optimality of designs. | 2,3,5 | 15 |
| 4 | Factorial experiments, 2n and 3n factorial experiments, Analysis of 22, 23 and 32 factorial experiments, Confounding in 2n and 3n factorial experiments, Construction of confounded scheme in 2n  factorial experiments, Split plot experiments (RBD). Introduction to response surfaces and applications. | 3, 5 | 15 |
| **Total Credits of the Course** | | 4 | 70 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Das, M.N. and Giri, N.C. (1994) Design and Analysis of Experiments, Wiley Eastern Ltd 2. Joshi, D.D. (1987) Linear Estimation and Design of Experiments, Wiley Eastern. 3. Montgomery, C.D. (2012) Design and Analysis of Experiments, John Wiley, New York. | | | |
| **Further Reading:**   * Dean, A. and Voss, D. (1999) Design and Analysis of Experiments, Springer Texts in Statistics * Dey, A. (1986) Theory of Block Designs, Wiley Eastern, New Delhi. * Kempthrone, O. (1952) Design and Analysis of Experiments, Wiley Eastern, New York * Rangaswamy, R. (2010) A textbook on Agricultural Statistics, New Age International. * Mathews, P. (2005) Design of Experiments with MINITAB, Pearson Education, Singapore. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**   1. **Continuous Internal Assessment (CIA)** 2. Two Internal Tests of 10 marks each - maximum 20 marks 3. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10 4. Write a detailed report on a given topic based on research findings and literature search – maximum 10 marks 5. **Semester End examination – 60 marks** |

**ELECTIVE 1**

ELECTIVE 2

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C30: STATISTICAL COMPUTING II PRACTICAL (USING R & PYTHON)** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **STATISTICAL COMPUTING II PRACTICAL (USING R & PYTHON)** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C30** | | | | | |
| **Course Summary & Justification** | To make the student capable to do practical problems and data analysis in more advanced areas of Statistics using R and Python software. | | | | | |
| **Semester** | Second | | | | | |
| **Total Student Learning Time (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Pre-requisite** | Basic knowledge of inferential statistics. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Using R and Python students will be enabled to carry out data analysis corresponding to different areas such testing of hypotheses, design of experiments and regression analysis. | A/An/E/S/C/I/Ap | 1,2,3,4,5,6 |
| 2 | Students will be able to chose appropriate design model and analyze data sets from various contexts. | A/An/E/S/C/I/Ap | 1,2,3,45,6 |
| 3 | They will be able to test hypotheses, plan and layout clinical trials and agricultural experiments, forecast future values using linear and non-linear regression models. | A/An/E/S/C/I/Ap | 1,2,3,4,5,6 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| It is expected to teach R Programing and Python with Applications in the classroom ( lectures for 3 hours) and then applications for data analysis relating to relevant topics in all courses in this semester in the computer lab ( for 2 hours) in a week | | |
| **Total Credits of the Course** | 4 |  |
| **Books for Reference** | | |
| 1. Heuman, C., Schomaker, M. and Shalab (2016) Introduction to Statistics and Data Analysis with Applications in R, Springer. 2. Purohit, S.G, Gore, S.,and Deshmukh, S.R.(2009) Statistics Using R, Narosa Publishers. 3. Mark L. and Hernandez, L. (2018) Introduction to Python, Kindle Store e- Edition 4. Haslwanter, T. (2016) An Introduction to Statistics with Python, Springer 5. Michaeaux, P.L., Droulhet, R and Liquet, B. (2013) The R software- Fundamentals of Programing and Statistical Analysis, Springer 6. Dalgaard, P.(2008) Introductory Statistics with R, 2 Edition, Springer 7. Zuur, A.F. ,Ieno, E.N. and Meesters, E.H.(2009) A Beginners Guide to R, Springer | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  The basic commands and codes will be explained using the reference books. R Program and Python being open software, students can start its study in the first semester itself. Many workshops and training programs will also be conducted. Students have to work out the practical questions and submit the Practical Record every week. Evaluation will be fully based on Continuous Internal Assessment. |
| **Assessment Types** | **Mode of Assessment**  **Continuous Internal Assessment (CIA)- 100 marks**   1. Two Internal Examinations for testing experimental skills-40 marks 2. Viva - Voce and presentations - 20 marks 3. Lab discipline, punctuality, accuracy etc - 20 marks 4. Write and submit Practical Records in time – 20 marks |

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**THIRD SEMESTER COURSES - TOTAL CREDITS: 24**

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| **Course code** | **NAME OF THE COURSE** | **Teaching Hours** | **Credits** |
| MS M 21 C31 | Multivariate Statistical Analysis | 4 +0+0 | 4 |
| MS M 21 C32 | Stochastic Processes Modeling | 4 +0+0 | 4 |
|  | Elective 3 | 4 +0+0 | 4 |
|  | Elective 4 | 4 +0+0 | 4 |
| MS M 21 C33 | Advanced Statistical Computing (using R and Python / SPSS & SAS) | 2 +0+2 | 4 |
|  | Open Course | 4 +0+0 | 4 |
|  | **Total Credits** |  | **24** |

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| **School Name** | **School of Mathematics and Statistics** |
| **Programme** | **M.Sc. Statistics** |
| **Course Name** | MULTIVARIATE STATISTICAL ANALYSIS |
| **Type of Course** | Core |
| **Course Code** | **MS M 21 C31** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C31: MULTIVARIATE STATISTICAL ANALYSIS** |

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| **Course Summary & Justification** | To impart basic knowledge and skills to the students in Applied Multivariate Analysis and their applications in Statistics | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Basic knowledge of multivariate analysis. | | | | | |

**COURSE OUTCOMES**

|  |  |  |  |
| --- | --- | --- | --- |
| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have understood multivariate techniques to handle multivariate data and are confident to handle real problems involving various characteristics. | U/R/A/An/E | 1,3,4,5,7 |
| 2 | They will be able to conduct Multivariate testing and Analysis of Variance | U/R/A/An/E | 1,3,4,5,6,7 |
| 3. | They will understand various dimension reduction methods like PCA and Canonical Correlation Analysis. | U/R/A/An/E | 1,3,4,5 |
| 4. | They will get a clear understanding of classification techniques and Cluster Analysis for pattern recognition. | U/R/A/An/S/E/C/Ap | 1,3,4,5 |
| 5 | They will be able to carry out factor analysis of data from different contexts. | U/R/A/An/S/E/C/Ap | 1,2,3,4,5 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| --- | --- | --- | --- |
| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Multivariate normal (singular and non-singular), characteristic function, marginal and conditional distributions, characterizations, Estimation of mean vector and dispersion matrix, independence of sample mean vector and sample dispersion matrix. Quadratic forms and their distributions, Independence of quadratic forms, Cochran’s theorem. Simple, partial and multiple correlation - null distributions and tests of significance. | 1 | 20 |
| 2 | Notion of likelihood ratio tests, Hotellings-T2 and Mahalnobis-D2 statistics-Their properties, interrelationships and uses, Null distributions (one sample and two sample cases). Testing equality of mean vectors,Problem of symmetry, Multivariate Fisher-Behren problem, matrix variate gamma and beta distributions. Wishart distribution and its basic properties, characteristic function, generalized variance and its distribution | 2 | 20 |
| 3. | Classification problems: Discriminant Analysis- Bayes’ procedure, Classification into one of the two populations ( multivariate Normal distribution only), Classification into several populations ( multivariate Normal distribution only), Fishers linear discriminant function and its associated tests, Profile Analysis and the associated tests, Dimension Reduction methods:Principal component Analysis - Method of estimation and computation Canonical variates and canonical correlation analysis, estimation and computation applications. | 3 | 25 |
| 4 | Multivariate General linear models - MANOVA (one way and two way), Wilk’s λ, Rau’s U, Pillai’s trace, Hotelling-Lawley trace, Roy's Maximum Root Statistics (Concepts only), Tests- Independence of sets of variables, Equality of dispersion matrices and Sphericity test.Cluster Analysis: proximity measures, Hierarchical and non-hierarchical methods Agglomerative and divisive techniques., Factor Analysis - Orthogonal Model-, Estimation of factor loadings. | 3,4 | 10 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Anderson T. W. (2010) An Introduction to Multivariate Statistical Analysis (3rd ed.) John Wiley. 2. Rencher, A. C. (2012) Methods of Multivariate Analysis.(3rd ed.) John Wiley. 3. Johnson R.A. and Wichern D.W. (2008) Applied Multivariate Statistical Analysis. 6th Edition, Pearson Education. | | | |
| **Further Reading:**   * Seber G. F. (2004) Multivariate Observations, John Wiley. * Rao C. R. (2009) Linear Statistical Inference and Its Applications (2nd Ed.), Wiley * Johnson, D. E. (1998) : Applied Multivariate methods for Data Analysts, Duxbury Press, USA-An International Thomson Publishing Company. * Morrison, F (2003): Multivariate Statistical Methods, Brooks/Cole, 4thRevisededn. McGraw Hill Book Company. * Graybill, F.A. (1969) Introduction to Matrices with Applications in Statistics, WadsworthPublishing Company, USA. * Kshirsagar A.M. (1972): Multivariate Analysis, Marcel Dekker & Co. * Srivastava M.S.and Khatri C.G.(2002): Methods of Multivariate Statistics, John Wiley & Sons, N.Y. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C32 : STOCHASTIC PROCESSES MODELING** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | STOCHASTIC PROCESSES MODELING | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C32** | | | | | |
| **Course Summary & Justification** | To impart basic knowledge & skills in Stochastic Models and their applications in Statistics. This is helpful in modeling natural phenomenon in everyday life. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Basic knowledge of Mathematical statistics and probability theory. | | | | | |

**COUSE OUTCOMES**

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are familiar with various stochastic process modes | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They can apply these to model various data sets on income, population growth, epidemics, traffic, queues, etc. to derive valuable conclusions. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 3. | They are enabled to develop birth and death models in epidemic modeling, queuing theory etc. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 4. | They are now aquainted with renewal models and branching processes and can apply these in real life situations. | U/R/A/An/S/E/C/Ap | 1,2,3,4,5,6,7 |
| 5 | They can apply different time series models to forecast future values in the context of prices, sales, temperature, rainfall etc. | U/R/A/An/S/E/C/Ap | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Introduction to stochastic processes:- classification of stochastic processes, 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 function relations, criteria for recurrent and transient states Communication of states, Reducible and irreducible Markov chains, mean recurrence time, classification of states. | 1 | 20 |
| 2 | Mean ergodic theorem, basic limit theorem of Markov chains (statement only), stationary distributions, limiting probabilities and absorption probabilities. Random walk, gambler’s ruin problem; ultimate ruin probabilities, random walk approximation of Brownian motion and diffusion process **.** Galton-Watson branching process, generating function relations, mean and variance functions, Extinction probabilities, criteria for extinction, distribution of total progeny size. | 2 | 20 |
| 3. | Continuous time Markov chains, Poisson processes, properties, inter-arrival time distribution , 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 queues - M/M/1, M/M/s, M/M/∞ models. | 2,3 | 25 |
| 4 | Renewal processes - concepts, examples, Poisson process viewed as a renewal process, renewal equation, Elementary renewal theorem, Key renewal theorem (statement only), applications, delayed renewal processes, Time series modeling, Autocorrelation function (ACF), partial auto correlation function (PACF), correlogram, AR, MA, ARMA, ARIMA Models, Yule- Walker equations, Box-Jenkins Model fitting and diagnostics. | 4, 5 | 10 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second Edition, Academic Press, New-York. 2. Medhi J. (2017) Stochastic Processes, Second Edition , Wiley Eastern, New Delhi 3. Ross S.M. (2007) Stochastic Processes. Second Edition, Wiley Eastern, New Delhi | | | |
| **Further Reading:**   * Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting Second edition, Springer-Verlag. * Feller W. (1968) Introduction to Probability Theory and its Applications, Vols. I & II, John Wiley, New York. * Cinlar E. (1975) Introduction to Stochastic Processes, Prentice Hall, New Jersey. * Basu A.K. (2003) Introduction to Stochastic Processes, Narosa, New-Delhi. * Bhat U.N. and Miller G. (2003) Elements of Applied Stochastic Processes. (Third edition), John Wiley, New York. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **Semester End examination – 60 marks** |

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**ELECTIVE 3**

**ELECTIVE 4**

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M2 21 C13 Advanced Statistical Computing I Practical**  **( Using R / Python / SPSS/ SAS)** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **Advanced Statistical Computing I Practical**  **( Using R / Python / SPSS/ SAS)** | | | | | |
| **Type of Course** | Core | | | | | |
| **Course Code** | **MS M 21 C33** | | | | | |
| **Course Summary & Justification** | To make the student capable for advanced statistical computing and data analysis in more advanced area of Statistics using R / Python / SPSS / SAS software. | | | | | |
| **Semester** | Third | | | | | |
| **Total Student Learning Time (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 45 | 10 | 30 | 25 | 120 |
| **Pre-requisite** | .Knowledge of al courses in this semester | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Using R software, students will be able to carry out data analysis corresponding to different areas such testing of hypotheses, design of experiments and regression analysis. This will help them to undertake research projects and execute them successfully. | A/An/E/C/S/Ap | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

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| It is expected to teach R / Python / SPSS / SAS with Applications in the classroom ( lectures for 2 hours) and then applications for data analysis relating to topics in all courses in this semester in the computer lab (for 2 hours) in a week.  The basic commands and codes will be explained using the reference books. Many workshops and training programs in SPSS / SAS will also be conducted. Students have to work out the practical questions and submit the Practical Record every week. The evaluation is fully based for Continuous Internal Assessment. | | |
| **Total Credits of the Course** | 4 |  |
| **Books for Reference** | | |
| **Compulsory Reading:**   1. Heuman, C., Schomaker, M. and Shalab (2016) Introduction to Statistics and Data Analysis with Applications in R, Springer. 2. Haslwanter, T.(2016) An Introduction to Statistics with Python, Springer 3. Der, G. and Everitt, B.S.(2006). A Handbook of Statistical Analysis Using SAS, CRC Press. 4. Littell R.C., Stroup W.W. & Freud R.J. (2002). SAS For Linear Models, SAS Institute Inc. 5. Lora, D. and Susan, S.(2009) The Little SAS, support.sas.com 6. Michaeaux, P.L., Droulhet, R and Liquet, B. (2013)The R software- Fundamentals of Programing and Statistical Analysis, Springer 7. Dalgaard, P.(2008) Introductory Statistics with R, 2 Edition, Springer 8. Zuur, A.F. ,Ieno, E.N. and Meesters, E.H.(2009)A Beginners Guide to R, Springer 9. Purohit, S.G, Gore, S.,and Deshmukh, S.R.(2009) Statistics Using R, Narosa Publishers. 10. Mark L. and Hernandez, L. (2018) Introduction to Python, Kindle Store e- Edition | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **Continuous Internal Assessment (CIA)- 100 marks**   1. Two Internal Examinations for testing experimental skills-40 marks 2. Viva - Voce and presentations - 20 marks 3. Lab discipline, punctuality, accuracy etc - 20 marks 4. Write and submit Practical Records in time – 20 marks |

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**OPEN COURSE**

**FOURTH SEMESTER COURSES - TOTAL CREDITS 16**

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| --- | --- | --- | --- |
| **Course code** | **NAME OF THE COURSE** | **Hours** | **Credits** |
|  | Elective 5 | 4 | 4 |
| MS M 21 C34 | Project Work / Dissertation | 24 | 12 |
|  | Total Credits |  | 16 |

**ELECTIVE 5**

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 C14: Project Work / Dissertation** |

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| **School Name** | **School of Mathematics and Statistics** |
| **Programme** | **M.Sc. Statistics** |
| **Course Name** | **Project Work / Dissertation** |
| **Type of Course** | Core |
| **Course Code** | **MS M 21 C34** |
| **Course Summary & Justification** | It consists of a Project Work; Project Report and Viva Voce |
| **Semester** | Fourth |
| **Pre-requisite** | . |

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| A Project Work / Dissertation shall be carried out by each student in a reputed research institute / department or industry under the joint supervision of an internal faculty and external guide / expert approved by the Director. The students have to submit a bound copy and soft copy of the Project Report (documented in LaTex) of at least 50 pages certified by the supervisors, at least 7 days before the conduct of the Presentation and Viva Voce. The Project/ Dissertation will be valued with respect to various criteria including content and presentation as decided by the University/ School/Department as per CSS Rules & Regulations. | |
| **Total Credits of the Course** | 12 |

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| **Assessment Types** | **Mode of Assessment**  The student has to present a brief summary of the Project Report/ Dissertation as part of Viva Voce. The viva-voce is meant for examining the student’s understanding and ability to explain the ideas orally and will be based on all courses studied during the entire program as well as the project report/ dissertation. The viva voce board will consist of at least two internal examiners and an external examiner appointed by the university. The marks for Project work will be allotted in the Ratio 30:40:30 for Continuous Internal Assessment, Project Report and Viva Voce based on various criteria like style, originality, relevance, clarity, explanation, contents, knowledge of the subject, applications, references, publications etc. |

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**LIST OF ELECTIVE COURSES**

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E21: APPLIED REGRESSION ANALYSIS** |

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| --- | --- | --- | --- | --- | --- | --- |
| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **APPLIED REGRESSION ANALYSIS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E21** | | | | | |
| **Course Summary & Justification** | By the end of this course students are expected to understand the basics of regression analysis and various regression models as well as model diagnostics. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 70 | 10 | 10 | 10 | 100 |
| **Pre-requisite** | Basic knowledge of regression analysis. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students will be able to apply the results in linear regression using simple or multiple models, polynomial models, Logistic and Poisson models etc. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They know how to predict the future values and compute the risk involved. | U/R/A/An/E/S | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| --- | --- | --- | --- |
| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Simple linear regression, assumptions, principle of least squares Ordinary,partial and multiple correlation coefficients and their tests . Multiple regression, least square estimators, MLEs of parameters, coefficients of determination **.** Tests for regression coefficients, model adequacy checking **.** Residual analysis and residual plots | 1 | 20 |
| 2 | Tests for departure from assumptions, fitness of the model, normality homogeneity of variances **. D**etection of outliers and remedies **.**  Diagnostics for Leverage and influence. **T**ransformations for variance stabilization, Linearization. Power transformations, Transformation on regressor, Generalized least squares and Weighted least squares. | 1,2 | 20 |
| 3. | Polynomial regression models, Nonparametric regression, Kernel regression, Loess Orthogonal polynomials, indicator variables Subset regression, stepwise regression, variable selection Robust regression **.** Non-Linear Regression, Parameter estimation**.** Random and mixed effect models, Multi-collinearity, sources, effects, tests, ridge regression. | 1,2 | 25 |
| 4 | Generalized linear models, Analysis of binary and grouped data, Logistic Regression, Poisson regression, link functions **,**  log-linear models, large sample tests about parameters **,**  goodness of fit, analysis of deviance **,** Auto correlation of errors, Effect of measurement errors, Inverse regression, calibration problem and bootstrapping. | 1,2 | 10 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Montgomery, D.C ; Peck, E.A, Vining, G.G (2003). Introduction to Linear Regression Analysis, John Wiley & Sons 2. John O. Rawlings, Sastry G. Pantula, David A. Dickey (1998) Applied Regression Analysis, Second Edition, Springer. 3. Draper, N. and Smith, H. (1986) Applied Regression Analysis – John Wiley & Sons. 4. Seber, A.F. and Lee, A.J. (2003) Linear Regression Analysis, John Wiley, | | | |
| **Further Reading:**   * Searle, S.R. (1971) Linear Models, John Wiley & Sons, Inc. * Fox, J. (1984) Linear Statistical Models and Related methods, John Wiley, * Christensen, R. (2001) Advanced Linear Modeling,. * Bovas Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley & Sons. * Bapat R.B. (1999) Linear Algebra and Linear Models, Edition 2, Hindustan Book Agency | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)-40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E22: BAYESIAN INFERENCE AND COMPUTING** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **BAYESIAN INFERENCE AND COMPUTING** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E22** | | | | | |
| **Course Summary & Justification** | To introduce the basics of Bayesian Inference and computational methods using computer packages. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding Bayes Theorem and Fundemental concepts of Bayes analysis. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are equipped with various Bayesian Inference techniques and computing. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They will be able to apply Bayesian computing methods to analyze data sets for advanced level research as well as for Data Science and Data Analytics works. | U/R/A/An/E/S | 1,2,3,4,5,6,7 |
| 3 | They are enabled to apply MCMC Methods, Monte Carlo methods, Gibbs sampling, EM algorithm, Jackniffe and Bootstrapping techniques in real data analysis and estimation. | U/R/A/An/E/S | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Parametric family and likelihood, exponential family, Bayes’ theorem for inference, prior and posterior densities, conjugate priors, non-informative prior, beta prior for binomial proportion, uniform prior, discrete prior, Jeffrey’s prior **,** single parameter models, normal distribution with known variance and unknown mean, normal with known mean and unknown variance, Poisson model, Natural Conjugate family of priors for a model, Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension. Introduction to LearnBayes package and examples. | 1 | 20 |
| 2 | Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0-1 loss functions, LINEX loss functions, Evaluation of the estimate in terms of the posterior risk Multi-parameter Models, normal distribution with both parameters unknown, multinomial model, Dirichlet prior, Comparing two proportions, predictive distribution, beta-binomial distribution, multivariate normal distribution, examples using LearnBayes package. | 1,2 | 20 |
| 3. | Bayesian Testing and Model Selection: Bayesian interval estimation, Credible intervals, Highest posterior density regions **,** Bayesian testing of hypothesis problem, Prior odds Posterior odds, Bayes factor for various types of testing of hypothesis problems. Hierarchical models, comparison of hypotheses, one sided test for normal mean, two sided test for normal mean, normal linear regression model, shrinkage estimators, posterior predictive model checking, prediction of future observations, examples and R codes, Introduction to WinBUGS package. | 1,2 | 20 |
| 4 | Bayesian Computation: Simulation Techniques : Random number generation-Inverse Method: Acceptance-rejection method, Computing integrals using Monte-Carlo simulation, approximation based on posterior mode, importance sampling, multivariate- t distribution, Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, Gibbs sampling, EM algorithm, Jackknife method, Bootstrapping. | 1,2,3 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Albert, J. (2007). *Bayesian Computation with R,* Springer Verlag New York. 2. Berger, J. (2000).*Statistical Decision Theory and Bayesian Analysis*, Springer-Verlag New York. 3. Ghosh, J.K., Delampady, M. and Samanta, T. (2011) An Introduction to Bayesian Analysis- Theory and Methods, Springer India, New Dellhi | | | |
| **Further Reading:**   * Bolstad, W. (2004). *Introduction to Bayesian Statistics*, Hoboken, NJ: John Wiley * Gelman, A., Carlin, J., Stern, H. and Rubin, D. (2003). *Bayesian Data Analysis*, New York: Chapman and Hall * Gilks, W.R., Richardson, S and Spiegelhalter, D.J. (1996). Markov Chain Monte Carlo in Practice. Chapman & Hall/CRC, New York * Robert, C. and Casella, G. (2004).*Monte Carlo Statistical Methods*, New York: Springer * Bansal A.K. (2007) Bayesian Parametric Inference, Narosa Publishers, New Delhi. * Spiegelhalter, D., Thomas, A., Best, N. and Lunn, D. (2003), WinBUGS 1.4 Manual. * Rao. C.R. and Day. D. (2006). Bayesian Thinking, Modeling & Computation, Handbook of Statistics, Vol. 25. Elsevier * Carlin, B.P. and Louis, T.A. (2000) Bayes and Empirical Bayes Methods for Data Analysis, Second Edition * Congdon P. (2006) Bayesian Statistical Modelling, Second Edition, John Wiley & Sons. * Ntzoufras I. (2009) Bayesian Modeling using WinBUGS. John Wiley & Sons Inc. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)-40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E23 : DATA SCIENCE AND BIG DATA ANALYTICS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **DATA SCIENCE AND BIG DATA ANALYTICS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E23** | | | | | |
| **Course Summary & Justification** | To make students aware of basics of of big data analytics and various statistical methods used for analyzing big data. They are to be trained in fundamentals of data warehousing and data mining for big data analysis. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding of various computational statistical methods | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have understood basics of big data analytics and can pursue big data analysis using different softwares and statistical techniques. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They are able to use Hadoop and MapReduce for processing big data sets | U/R/A/An/E/S | 1,2,3,4,5,6,7 |
| 3 | They can use these for machine earning, clustering and classification and can apply these in real data sets. | U/R/A/An/E/S | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Origins of Data Science: Development, Popularization, Definition of Data Science, Professional Organizations, Case Study, Data Engineering, Acquiring, Ingesting, Transforming , Metadata, Storing and Retrieving . Big Data – Introduction, Data structures, Structuring Big Data, Elements of Big data, Big Data analytics, Big Data applications. Big Data in business context.Technologies for handling big data – Distributed and Parallel computing for Big Data. | 1 | 20 |
| 2 | Understanding Analytics, Drivers of Big data, Discovering Data, Data preparation, Data Conditioning, Data Models, Computing Models, Model Building, Comparison of Reporting and Analysis, Types of Analytics, Analytical approaches, Data Analytics Life Cycle, Basic Data Analytic Methods using R, Descriptive Statistics, Exploratory Data Analysis, Visualization. | 1,2 | 20 |
| 3. | Introducing Hadoop – HDFS and MapReduce., Hadoop EcoSystem, Hadoop Distributed file system, HDFS architecture. Hadoop YARN, Introducing HBase, Hive and Pig, MapReduce framework, Techniques to Optimize MapReduce, Uses of MapReduce, Role of HBase in Big data processing, Processing Data with MapReduce , Framework, Developing simple MapReduce Application. MapReduce execution and implementing MapReduce Programs. | 1,2 | 20 |
| 4 | YARN Architecture – Limitations of MapReduce, Advantages of YARN, Working of YARN, YARN Schedulers, Configurations, Commands, Containers, Introduction to Mahout – Machine Learning, Clustering, Classification, Mahout Algorithms, Environment for Mahout. Introduction to NoSQL | 1,2,3 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Berson, A. and Smith, S.J. (1997): Data Warehousing, Data Mining, and OLAP. McGraw Hill Publishers. 2. Pujari, A.K. (2001) Data Mining Techniques, Universities Press. 3. Breiman, L. Friedman, J.H. Olshen, R.A. and Stone, C.J. (1984): Classification and Regression Trees. Wadsworth and Brooks/Cole. | | | |
| **Further Reading:**   * EMC Services (2015) Data Science and Big Data Analytics:: Discovering, Analyzing, Visualizing and Presenting Data, Wiley, EMC Education Services * Davy Cielen, Arno D. B. Meysman, Mohamed Ali (2016) Introducing Data Science, , Manning Publications Co. * Han, J. and Kamber, M. (2012): Data Mining; Concepts and Techniques. 3rrd Edition Morgan Kaufmann Publishers. * Mitchell, T.M. (1997): Machine Learning. McGraw-Hill. * Ripley, B.D. (1996): Pattern Recognition and Neural Networks. Cambridge   University Press.   * Chuck Lam ( 2011) Hadoop in Action, Wiley India Pvt Ltd. * Jimmy Lin and Chris Dyer (2010) Data Intensive Text Processing with Map Reduce:, Morgan & Claypool Publishers. * Berry,M. and Linoff, G. (2000) Mastering Data Mining, John Wiley & Sons. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E24 : DATA MINING TECHHNIQUES** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **DATA MINING TECHHNIQUES** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E24** | | | | | |
| **Course Summary & Justification** | To enable the students to handle data mining and the related methodologies and problems. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Basic knowledge of Data Mining | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | The students are now aware of the data mining and ANN methods and are able to understand data in deep manner and draw conclusions using data mining techniques. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Introduction to Data Mining**,** Data Mining for Business Intelligence, Business Understanding. Data Mining Concepts and Definitions, Characteristics, and Benefits, How Data Mining Works, Data Mining Applications, Data Mining and Society. | 1 | 20 |
| 2 | Data Mining Process, Data Understanding, Data objects and Attribute types, Basic statistical descriptions of data, Data Visualization, Measuring Data Similarity and dissimilarity, Data Preparation, pre-processing, data cleaning, data integration, data reduction, data transformation and discretization**.**. Other Data Mining Standardized Processes and Methodologies. | 1 | 20 |
| 3. | Data Warehousing, Data Warehouse modelling, Data Cube and OLAP, Data Mining Methods, Classification, Estimating the True Accuracy of Classification Models**,** Cluster Analysis for Data Mining. Partitioning methods, Hierarchical methods, Density based methods, Grid based methods, Advanced cluster analysis, Outlier detection, Statistical approaches Text Mining and Web Mining. | 1 | 20 |
| 4 | Artificial Neural Networks**,**  Association Rule in Mining, Artificial Neural Networks for Data Mining, Elements of ANN, Applications of ANN, Modelling Building, Testing and Evaluation, Deployment of Data, Mining trends and research frontiers, mining complex data sets. Data Mining Software Tools | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Turban, Sharda Efraim, Ramesh, Dursun Delen and King, David. (2011). Business Intelligence: A Managerial Approach, 2nd Edition., Prentice Hall. 2. Han, Jiawei and Kamber, Micheline. (2012). Data Mining: Concepts and Techniques, 3rd Edition. Morgan Kaufman Publishers. 3. Du, H. (2010). Data Mining Techniques and Applications. Cenage Learning. 4. Gorunescu, F. (2011) Data Mining: Concepts, Models and Techniques. Springer. | | | |
| **Further Reading:**   * Govindaraju, V. and Rao, C. R. (2013). Machine Learning: Theory and Applications. Handbook of Statistics, Vol. 31(Edited by Govindaraju and Rao). Elsevier. * Tang, P.N., Steinbackm, M. And Kumar, V. (2006). Introduction to Data Mining. Addison Wesley. * Myatt, Glenn and Johnson, Wayne. (2009). Making Sense of Data II. John Wiley & Sons. * Rajaraman, Anand. (2011). Mining of Massive Datasets. Cambridge, University Press. * Witten, I. H., Frank, E. and Hall, M. A. (2011). Data Mining: Practical Machine Learning Tools and Techniques. Elsevier Publishers. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E25: MACHINE LEARNING & PREDICTIVE MODELING** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **MACHINE LEARNING & PREDICTIVE MODELING** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E25** | | | | | |
| **Course Summary & Justification** | To enable the students familiar with machine learning techniques for deep learning and pattern recognition. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding of basics knowledge of machine learning techniques. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | The students are now aware of the machine learning methodology and are able to predict models and assess model accuracy | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They are clear about classification models and trees to draw conclusions using such techniques. | U/R/A/An/E/S | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Introduction, Prediction Versus Interpretation, Key Ingredients of Predicting Models. Statistical Learning, Supervised Versus Unsupervised Learning, Regression Versus Classification Problem. | 1 | 20 |
| 2 | Machine Learning, Assessing Model Accuracy, Basics of Decision Trees, Support Vector Machines, etc. Predictive Modeling Process, Data Pre-processing, Over Fitting, etc. | 1,2 | 20 |
| 3 | Regression Models: Linear Regression, Nonlinear Regression Models. Regression Trees and Rule-Based Models. Classification Models: Measuring Performance in Classification Models. | 1,2 | 25 |
| 4 | Discriminant Analysis and Other Linear Classification Models, Nonlinear Classification Models. Classification Trees and Rule-based Models. Measuring Predictor Importance, Feature Selection. | 1,2 | 10 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Bishop, C. (2010). Pattern Recognition and Machine Learning. Springer. 2. Hastie, T., Tibshirani, R., and Friedman, J. (2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer, Second Edition. 3. Kuhn, M. and Johnson, K. (2013). Applied Predictive Modeling. Springer. | | | |
| **Further Reading:**   * Izenman, A. J. (2013). Modern Multivariate Statistical Techniques: Regression, Classification, and Manifold Learning, 2nd ed. Springer. * James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013). An Introduction to Statistical Learning with Applications in R. Springer. * Harrington, P. (2012). Machine Learning in Action. Dreamtech Press. * Silver, N. (2012). The Signal and the Noise: The Art and Science of Prediction. Allen Lane, Penguin Books Ltd. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. **Continuous Internal Assessment (CIA)- 40 Marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E26 : ADVANCED RESAMPLING TECHNIQUES** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **ADVANCED RESAMPLING TECHNIQUES** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E26** | | | | | |
| **Course Summary & Justification** | To enable the students to understand advanced resampling methodologies and techniques such as Jackknife and bootstrapping. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding of basics knowledge of resampling techniques such as Jackknife and bootstrapping | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | The students are now aware of the resampling techniques and are able to apply Jackknifing and bootstrapping techniques and compare their performance. These are useful in advanced research like micro-array analysis, gene sequencing, etc. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Normal approximation and its limitations. Shortcomings of analytic derivations, with examples. Estimates of the distribution function: parametric and non-parametric MLE. U-Statistics, Mm-Estimators, Resampling - Purpose of resampling, Examples, estimating the estimating variance, the sampling distribution and other features of a statistic. | 1 | 20 |
| 2 | Jackknife. Bias reduction. Estimation of variance. Delete 1 and delete d jackknives. Examples. Bootstrap. Parametric and non-parametric bootstrap. Estimation of variance, estimation of distribution function. Examples. Comparison between bootstrap approximation and normal approximation. Examples. | 1,2 | 20 |
| 3 | Notions of variance consistency and distributional consistency. Jackknife distributional inconsistency. Bootstrap distributional consistency. Comparisons between bootstrap and jackknife. Examples. | 1,2 | 20 |
| 4 | Resampling in non-i.i.d. models: need for other resampling schemes. Examples. Resampling in linear models: special emphasis on residual bootstrap and weighted bootstrap, Concept of robust and efficient resampling schemes. Introduction to estimating equation and generalized bootstrap. Examples. | 1,2 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Bose, Arup and Chatterjee, Snigdhansu (2018). U-Statistics, Mm-Estimators and Resampling, Hindusthan Book Agency, June 2018. 2. Davidson, A. C. and Hinkley D. V. (1997). Bootstrap methods and their applications. 3. Efron, B. (1982). The Jackknife, the Bootstrap and other Resampling Plans. CBMS-NSF Regional Conference Series in Applied Mathematics,No 38. 4. Efron, B. and Tibshirani, R. J. (1993). An Introduction to the Bootstrap. Chapman & Hall/CRC. 5. Shao, J. and Tu, D. (1995). The Jackknife and Bootstrap. Springer. | | | |
| **Further Reading:**   * Barbe, P.. and Bertail, P. (1995). *The Weighted Bootstrap*. Lecture Notes in Statistics, Vol 98. * Gine, E. (1997). *Lectures on Some Aspects of the Bootstrap*. Lecture Notes in Mathematics,Vol 1665. Springer * Hall, P. (1992). *The Bootstrap and Edgeworth Expansion*. Springer.   .   * Politis, D. N., Romano J. P. and Wolf, M. (1999). *Subsampling*. Springer. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E27 : TIME SERIES ANALYSIS & FORECASTING** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **TIME SERIES ANALYSIS & FORECASTING** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E27** | | | | | |
| **Course Summary & Justification** | By the end of this course the student will be able to analyse time series data and identify and interpret various types of behaviour of the time series. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding of basics knowledge of Time series and stochastic process. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Now students are aware of various aspects of time series analysis and modeling. | U/R/A/An/E/Ap | 1,2,3,4,5,6,7 |
| 2 | They are able to analyze a given time series data and fit suitable ARIMA model using Box-Jenkins method. | U/R/A/An/E/S/C | 1,2,3,4,5,6,7 |
| 3 | Students are aware of spectral density, periodogram etc as well as various non-linear models like ARCH, GARH, Bilinear, Multivariate and Vector Autoregression. | U/R/A/An/E/S/C | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Time series, Components of time series, Additive and multiplicative models, Estimation and elimination of trend and seasonality, Moving averages , Simple Exponential Smoothing, Holt’s exponential smoothing, Holt-Winter’s exponential smoothing, Forecasting based on smoothing. | 1,2,3 | 20 |
| 2 | Time series as a discrete parameter stochastic process, Auto-covariance and auto-correlation functions, Partial Auto-correlation function and their properties, Stationary processes, Wold representation of linear stationary processes, Detailed study of the Box - Jenkins linear time series models: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average models. | 1,3,6 | 20 |
| 3 | Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes. Choice of AR and MA periods, Forecasting using ARIMA models, Residual analysis and diagnostic checking. Forecasting of future values. Non-Gaussian Time Series Modeling- exponential, gamma and Laplace stationary marginal distributions. | 1,4,5 | 20 |
| 4 | Spectral density of a stationary time series and its elementary properties, Periodogram, Spectral density of AR, MA, ARMA processs. Seasonal ARIMA models Introduction to ARCH and GARCH models and their applications; non-linear time series models, bilinear models; Multivariate Time Series Analysis and Vector Auto-regression. | 1, 4,7 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting Second Edition, Springer-Verlag. 2. Box G.E.P, Jenkins G.M. and Reinsel G.C. (2008) Time Series Analysis: Forecasting and Control, Fourth Edition, Wiley. 3. Abraham B. and Ledolter J.C. (2005) Statistical Methods for Forecasting, Second Edition Wiley. | | | |
| **Further Reading:**   * Cryer, J. D. and Chan, K. (2008). Time Series Analysis with Applications in R, Second Edition, Springer-Verlag. * Shumway, R. H. and Stoffer, D. S. (2011) Time Series Analysis and Its Applications with R Examples, Third Edition, Springer-Verlag. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)-40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E28 : BIOINFORMATICS AND COMPUTATIONAL BIOLOGY** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **BIOINFORMATICS AND COMPUTATIONAL BIOLOGY** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E28** | | | | | |
| **Course Summary & Justification** | To make students aware of basics of bioinformatics and computational biology and make them familiar with data bases like NCBI-GENBANK. It is also expected to give them training in RASMOL software and computer aided drug design. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding the basics of bioinformatics. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have understood basics of bioinformatics and computational biology. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They are aware of different data bases like NCBI- GENBANK and can use RASMOL for drug development. | U/R/A/An/E/C/S/Ap | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Basics of Bioinformatics, Definition, importance and role of bioinformatics in life sciences. Computational Biology Biological sequences, Biological databases: Nucleotide sequence databases (NCBI- GENBANK, DDBJ and EMBL). Protein databases - structure and sequence databases (PDB, SWISSPROT and UNIPROT). | 1 | 20 |
| 2 | Introduction to Sequence alignment: Local alignment and Global alignment, Pair wise alignment (BLAST and FASTA) and multiple sequence alignment. Phylogenetic Tree construction and Analysis, Molecular visualization software - RASMOL. Basic concepts of Drug discovery pipe line, computer aided drug discovery and its applications. Human Genome Project and genome analysis. | 1 | 20 |
| 3 | Applications of HMM to biological sequence analysis, Markov chain as a classifier, use of Markov chain Model for demarcation of a region in Biological sequence analysis, Applications in genetic sequence analysis such as detection of CPG Island. Testing whether given stretch of sequence is coming from CPG Island (use of Markov model for discrimination) **,**  Markov model based classification & cluster analysis, testing order of a Markov model, testing homogeneity of two Markov models, Use of these tests to design clustering algorithm. | 1 | 20 |
| 4 | Hidden Markov/chains, Difference between these and simple Markov chains, Analysis of Hidden Markov Models/chains, Verterbi’s algorithm, Forward and backward algorithm for hidden Markov model, Parameter estimation in hidden Markov model when path is known as well as unknown, Baum – Welch algorithm | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Alexander Isaac: (2006). Introduction to Mathematical Methods in Bioinformatics. Springer. 2. Durbin R., Eddy S., Krogh A., Michelson G. (1998). Biological Sequence Analysis, Cambridge University Press. | | | |
| **Further Reading:**   1. Rajan S S and Balaji R, (2002), Introduction to Bioinformatics, Himalaya Publishing House 2. Waterman, M.S. (2000). Introduction to Computational Biology, CRC Pres | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. **Continuous Internal Assessment (CIA) -40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E29: SURVIVAL ANALYSIS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **SURVIVAL ANALYSIS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E29** | | | | | |
| **Course Summary & Justification** | Survival Analysis is highly applied in clinical data for life time modeling. This course will help them in handling clinical data and lifetime data and related analysis. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding the basics of probability and statistics | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are equipped with various parametric and non-parametric methods for survival analysis of clinical data including censored and truncated data. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | 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 | 1 | 20 |
| 2 | 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. | 1 | 20 |
| 3 | 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 | 1 | 20 |
| 4 | 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 | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for Censored and Truncated Data, Second Edition, Springer-Verlag , New York, | | | |
| **Further Reading:**   * Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons * Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc. * 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. * Miller, R.G. (1981) Survival Analysis, John Wiley. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. **Continuous Internal Assessment (CIA)- 40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E30 : BIOSTATISTICS & EPIDEMIOLOGY** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **BIOSTATISTICS & EPIDEMIOLOGY** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E30** | | | | | |
| **Course Summary & Justification** | To make aware of various biostatistical and epidemiological measures and methods for studying about incidence of diseases. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding the basics of probability and statistics | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to plan and conduct epidemiological studies using appropriate methods | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | Now they can conduct cohort studies, case control studies etc and can calculate incidence rate, case fatality rate etc. to assess and validate the situation. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Basic concepts in epidemiology; Measures of Exposures, Types of exposures, Sources of exposures, Measures of outcome; Disease registries, Classification of diseases, Measures of disease frequency: Prevalence, Incidence, Risk, Odds of disease, Incidence time, Incidence rate, Relationship between prevalence, rate and risk, Routine data to measure disease occurrence, cumulative rate, cumulative risk, proportional incidence, Case fatality; Standardization - direct method of Standardization, indirect method of standardization. | 1 | 20 |
| 2 | Type of study design- Intervention studies, Cohort studies, case-control studies, cross-sectional studies, ecological studies; Relative and absolute measures of effect, Confidence intervals and significance tests for measures of occurrence and effect; Validity and reliability of measures of exposure and outcome: Sensitivity, Specificity, Predictive value method for selecting a positivity criterion, Receiver Operator Characteristic (ROC) curve, Intra and Inter-observer reliability, Kappa measure of agreement. | 1,2 | 20 |
| 3 | Case-control studies: Definition of cases, and controls, methods of selecting cases and controls, matching, sample size, power calculations, Basic methods of analysis of grouped data, Basic methods of analysis of matched data. Logistic regression for case-control studies, estimation and interpretation of logistic parameters, matched analysis- estimation of logistic parameters, Categorical data analysis. Cohort studies: Prospective cohort studies: planning and execution, retrospective cohort, nested case-control, case-cohort studies: planning and execution, matching and efficiency in cohort studies, cohort studies –statistical analysis. Longitudinal studies: Design, execution and analysis of longitudinal studies, repeated measurement analysis. | 1,2 | 20 |
| 4 | Sources of bias, Selection bias, measurement bias, misclassification of exposure and outcome, Differential and non-differential exposure and outcome classification, Confounding, Assessment of confounding, Mantel-Haenszel summary measures of effect, Interaction, Mantel-Haenszel method to adjust for several confounders, Confidence intervals and statistical tests for adjusted relative measures of effect; Excess risk and Attributable risk; Causation and Hill’s criteria. | 1,2 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Leon Gordis (2008) Epidemiology, Elsevier Publishers 2. Rothman K.J and Greenland S (1998). Modem Epidemiology, Third edition, Lippincott 3. Isabel dos Santos Silva (1999) Cancer Epidemiology: Principles and Methods, International Agency for Research on Cancer. | | | |
| **Further Reading:**   * Penny Web ,Chiris Bain & Sandi Pirozzo (2005).Essential Epidemiology - An Introduction for students & Health Professionals, Cambridge University Press * R Bonita, R Beaglehole. T Kjellström, (2006): Basic Epidemiology 2nd Edition. * Clayton, D. and Hills, M. (2013). Statistical Methods in Epidemiology, OUP * Ahrens W. and Pigcot I.(2005). Handbook of Epidemiology, Springer. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)-40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E31: DEMOGRAPHY & POPULATION DYNAMICS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **DEMOGRAPHY & POPULATION DYNAMICS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E31** | | | | | |
| **Course Summary & Justification** | 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. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding the basics of Indian population census and statistical models etc. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Now students have understood various mortality and morbidity measures | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | They are equipped to develop life tables, fertility indices etc using different methods. Also they can construct population growth indices and develop population growth models. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Sources of mortality data-mortality measures-ratios and proportions, crude mortality rates, specific rates- measures Mortality trends, levels and determinants in India with special reference to infant mortality and maternal mortality, Cause of death statistics standardization of mortality rates, direct and indirect methods, gradation of mortality data, fitting Gompertz and Makeham curves, Concepts and definitions of health and morbidity, morbidity rates, Sources of data on mortality and morbidity. | 1,2 | 20 |
| 2 | 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. | 2 | 20 |
| 3 | Fertility models, fertility indices relation between CBR,GFR,TFR and NRR, stochastic models on fertility and human reproductive process, Dandekar’s modified binomial and Poisson models, Brass, Singh models, models for waiting time distributions, Sheps and Perrin model. | 2 | 20 |
| 4 | 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. | 2 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Biswas, S. (2007) Applied Stochastic Processes-A Biostatistical and Population Oriented Approach, Second Edition, New Central Book Agency. 2. Pollard, J. H. (1975) Mathematical Models for the Growth of Human Population, Cambridge University Press. 3. Shrivastava OS, 1998, Demography and Population Studies, Vikas Publishing House Pvt Ltd , 2nd Edition. | | | |
| **Further Reading:**   * Biswas, S. (1988) Stochastic Processes in Demography and Applications, Wiley Eastern. * Keyfitz, N. (1977) Applied Mathematical Demography A Wiley Interscience publication. * Ramkumar, R. (1986) Technical Demography, Wiley Eastern. * Srinivasan, K. (1970) Basic Demographic Techniques and Applications. * Keyfitz, Nathan. (1977). Introduction to the Mathematics of Population, Addision-Wesley Publishing Company, Massachusetts. * Pathak, K. B. and Ram, F. (2015). Techniques of Demographic Analysis, 2nd Revised ed. Himalaya Publishing House, New Delhi. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)—40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E32 : CATEGORICAL & DIRECTIONAL DATA ANALYSIS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **CATEGORICAL & DIRECTIONAL DATA ANALYSI** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E32** | | | | | |
| **Course Summary & Justification** | To enable the students familiar with categorical data and various probability models associated with it. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Understanding the basics of probability and statistical models | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are now able to analyze categorical and directional data and fit suitable models. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Categorical variables, Introduction to Binary data, The linear probability models, The logit model, The Probit model, the latent variable approach, the odds ratio, Relarive risks, Sensitivity and specificity, McNemar's test,Binomial response models, log-log models, Likelihood ration Chi-squared statistic, Log-rate models, Time Hazard models, Semi-parametric rate models | 1 | 20 |
| 2 | Logistic Regression Analysis: Log-linear models, Logit Models with Categorical Predictors Logistic Regression models, regression diagnostics, Predictions, Interpreting parameters in logistic Regression. Inference for logistic Regression, Multiple logistic regression. | 1 | 20 |
| 3 | Poisson regression: interpretations, regression diagnostics, Predictions, negative binomial regression, Proportional hazards regression. Classical treatments of 2 and 3-way contingency tables, measures of association and nonparametric methods, 2 × 2 and r × c tables - tests for independence and homogeneity of proportions, Fishers exact test, Modeling repeated Measurements, generalized estimating equations. | 1 | 20 |
| 4 | Directional Data Analysis: Circular data, examples and differences with linear data; Data representations and Summary measures. Probability models on the circle- Circular Normal (CN) and Wrapped Stable distributions . Inference for the CN model - one, two and k-samples; Goodness-of-Fit tests | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Agresti, A. (1990) Categorical Data Analysis. New York: John Wiley 2. Mardia, K.V. (1972). Statistics of Directional Data. Academic Press. | | | |
| **Further Reading:**   * Powers D.A. (1999) Statistical methods for Categorical Data Analysis. Academic press Inc. * Jammalamadaka, S. R. and SenGupta, A. (2001). Topics in Circular Statistics, World Scientific. * SenGupta, A. (2005). DDSTAP 1.1 – Statistical Analysis Package for Directional Data. Indian Statistical Institute. Kolkata | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E33 : CLINICAL TRIALS AND BIOASSAYS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **CLINICAL TRIALS AND BIOASSAYS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E33** | | | | | |
| **Course Summary & Justification** | To impart basic knowledge about Controlled Clinical Trials & Bioassays and their applications in Biostatistics and Drug development. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Statistical sampling methods for application in clinical trials. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to plan and execute the necessary statistical steps for conducting Clinical Trials. They are well equipped to prepare the protocol and analyze all types of data and interpret the conclusions. They can estimate the parameters in a bioassay experiment and determine safe doses using various statistical techniques. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Introduction to clinical trials**,** participants and sponsors of a trial, informed consent, benefits and risk of participating in a trial , blinding, placebo, controlled and uncontrolled trials, need and ethics of clinical trials **,** objectives and end-points of a clinical trial, single center and multi-center trials, ICH and GCP, FDA and EMEA guidelines **,**  Drug Development Process**,** overview of Phase I to IV trials (Design and analysis) | 1 | 20 |
| 2 | Clinical trial study designs, bioequivalence trials, adaptive trials, sample size determination, randomization methods, handling of missing data, handling multiplicity Clinical Data Management (CDM), understanding protocol**,** clinical study report, statistical analysis plan(SAP) data visualization methods, Data Comprehension, Data Interpretation, Clinical Data Analysis :Analysis methods/models for continuous data, categorical data, binary data, survival data **,** parametric and non-parametric methods, sub-group Analysis, sensitivity analysis, interim analysis, Quality of life data analysis. | 1 | 20 |
| 3 | **Bioassays,** Types of biological assay, direct assays and indirect assays ratio estimators**,** asymptotic distributions regression approaches for estimating dose response relationships | 1 | 20 |
| 4 | Quantal responses methods of estimation of parameters **,** dose allocation schemes, median dose **,** estimation of points on the quantal response function **,** Estimation of safe doses. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Friedman L.M., Furberg C.D. & Demets D.L.(1998). Fundamentals of clinical trials, Springer 2. Govindarajulu Z., (2001) Statistical Techniques in Bioassays. Karger publication | | | |
| **Further Reading:**   * Shein-Chung Chow and Jen-Pei Liu(2004).  Design and Analysis of Clinical Trials: Concepts and Methodologies (2nd edition) Wiley-Interscience * M. Iqbal Choudhary and William J. Thomson (2001) Bioassay techniques for drug development. Harvard Academic Publishers * Stuart J. Pocock (2010) Clinical Trials – A practical approach (Reprint), John Wiley Stephen Senn (2009) Statistical Issues in Drug Development (2nd edition), John Wiley * Dmitrienko, A. ,Molenberghs, G., Stein,C.C.,, Offen, W. (2005). Analysis of Clinical Trials Using SAS – A Practical Guide ,SAS Publishing | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)-40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 E34 : STATISTICAL GENETICS AND ECOLOGY** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **STATISTICAL GENETICS AND ECOLOGY** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M 21 E34** | | | | | |
| **Course Summary & Justification** | To provide basic knowledge & skills in Statistical Genetics and Ecology for solving the emerging issues in biological modeling, ecological studies, bio-diversity assessment etc. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Basic knowledge of statistical models and probability theory. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have understood biological concepts in genetics and can explain these using probability. They are able to test and detect linkage using a data. They have understood ecological issues and population growth as well as abundance. They are able to compute diversity indices as well as apply game theory to explain evolutionary strategy. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Basic biological concepts in genetics , Mendel’s law **,** The law of natural selection, mutation and genetic drift **,**  Hardy-Weinberg equilibrium, estimation of allele frequency (dominant/co-dominant cases) **,**  Approach to equilibrium for X-linked gene. **,** Non-random mating and inbreeding phenotypic assortative mating | 1 | 20 |
| 2 | Pedigree data: Elston-Stewart algorithm for calculation of likelihood Linkage, Genetic mapping Linkage equilibrium Partitioning of Chi-square Detection of linkage and estimation of re-combination fraction inheritance of quantitative traits. | 1 | 20 |
| 3 | Introduction to ecology and evolution , population dynamics: single species-Exponential, Logistic and Gompertz models , Leslie matrix model for age and stage Structured population , survivorship curves-Constant, monotone and bath tub shaped hazard rates , Two species: Lotka-Volterra equations 3**.6** isoclines | 1 | 20 |
| 4 | Abundance estimation: Capture–recapture **,** Nearest Neighbour **,**  line transect sampling **,** indirect methods**. ,**  Ecological Diversity: Species abundance curve, indices of diversity (Simpson’s index, Shannon-Wiener index) **,** Game theory in ecology – **,**Evolutionarily stable strategy, its properties**, ,**  simple games such as Hawk-Dove game, Prisoner’s dilemma. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Anil Gore & Sharayu Paranjpe (2001). A Course in Mathematical and Statistical Ecology, Kluwer academic Publishers. 2. Lange, K (2002). A Course in Mathematical and Statistical Methods for Genetic Analysis, Springer. 3. Falconer D.S.(1991) Introduction to Quantitative Genetics, ELBS Logman group. | | | |
| **Further Reading:**   * Gardner E.J. & Simmons D. P.(2007) Principles of Genetics, John Wiley & Sons Inc. * Lange, K (2002). Mathematical and Statistical Methods for Genetic Analysis, Springer. * Robert J Booker (2009) Genetics: Analysis & Principles, McGraw-Hill. * Robert H Tamarin, (2001) Principles of Genetics, McGraw-Hill. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E35 :STATISTICAL METHODS FOR MICRO-ARRAY ANALYSIS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **STATISTICAL METHODS FOR MICRO-ARRAY ANALYSIS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E35** | | | | | |
| **Course Summary & Justification** | To make students aware of basics of micro-array analysis, and the statistical methods for their analysis and modeling. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Basic knowledge of statistical models and probability theory. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have understood micro-array analysis and modeling. They can involve in gene sequence micro array analysis and research. They are to carry out multiple hypothesis testing using appropriate statistical methods. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Microarrays and Normalization techniques, Introduction to Biology relevant to microarray experiment, Microarray experimental set up and quantification of information, Data cleaning, transformation of data. Between array & within array normalization, quantile and LOWESS normalization, stage wise normalization, Concordance coefficient and its role in normalization. | 1 | 20 |
| 2 | Statistical Inference procedures in comparative experiments, Inference procedures for single channel microarray data, application of two sample t –test, Tests for validating assumptions of two sample t-test. Application of Welch test and Wilcoxon rank sum test, Inference procedures for two channel microarray data. Paired t –test, Tests for validating assumptions of paired t-test. Wilcoxon signed rank test, Comparison of more than two types of mRNA samples. | 1 | 20 |
| 3 | Multiple hypotheses testing and Principal component analysis Multiple hypotheses testing, Adjustments for multiple hypotheses testing, adjusted p-values, false discovery rate and its application to microarray data analysis. Principal component analysis for microarray data, scree plot, application to microarray data. | 1 | 20 |
| 4 | Cluster analysis and Logistic regression, Hierarchical cluster analysis of microarray data, K - means cluster analysis of microarray data, Application of logistic regression for microarray data, Concept of AIC and BIC and its role to identify marker genes, Application of Bayesian methods in micro-array analysis. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Amartunga, D. and Cabrera J. (2004). Exploration and Analysis of DNA Microarray and Protein Array Data. Wiley. 2. Deshmukh S.R. and Purohit S.G. (2007). Microarray Data: Statistical Analysis Using R, Narosa Publishers. | | | |
| **Further Reading:**   * Draghici, S. (2003). Data Analysis Tools for DNA Microarrays, Chapman and Hall/CRC. * Dov, S. (2003). Microarray Bioinformatics, Cambridge University Press, * McLachlan, G.J.; Do, K.A. and Ambroise, C. (2004). Analyzing Microarray Gene Expression Data, Wiley. * Simon, R.M ; Korn, E.L. ; McShane, L.M. ; Radmacher, M.D. ; Wright, G.W. and Zhao, y. (2003). Design and Analysis of DNA Microarray Investigations. Springer. * Speed, T. (2003). Statistical Analysis of Gene Expression Microarray Data, Chapman and Hall/CRC | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E36: OPERATIONS RESEARCH** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **OPERATIONS RESEARCH** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E36** | | | | | |
| **Course Summary & Justification** | To make the students able to deal with optimization problems and the mathematical theory involved in them. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of operations research. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to make use of various OR techniques such as LPP, Transportation problems, Assignment and Sequencing, Dynamic and Quadratic Programing, NLPP, Inventory Management, Game Theory etc for the efficient functioning of the firm or industry. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Linear programming: convex sets and associated theorems, Simplex method, Artificial variables technique-Big M method, Two phase method; Dual simplex method. Concept and theorems of duality, Transportation problems, Assignment problems, Sequencing, Traveling sales man problems. | 1 | 20 |
| 2 | Dynamic and Quadratic programming: Bellman’s principle of optimality, single additive constraint- additively separable return, single multiplicative constraint- additively separable return, single additive constraint-multiplicatively separable return, General non-linear programming problem, Constrained optimization with equality constraints -necessary conditions for a general NLPP, sufficient conditions for a general NLPP with one constraint, sufficient conditions for a general problem with *m*(<*n*)constraints, Constrained optimization with inequality constraints, Kuhn-Tucker conditions for general NLPP with *m*(<*n*) constraints, Wolfe’s modified simplex method and Beale’s method. | 1 | 20 |
| 3 | Inventory models:-Deterministic inventory models - general inventory model, Economic-order quantity (EOQ) models -classic EOQ model, EOQ with price breaks, multi-item EOQ with storage limitation, Probabilistic inventory models:- Single period stochastic models without setup cost, General single period models. | 1 | 20 |
| 4 | Theory of Games, Two person zero sum games, fundamental theorem of matrix games, Rectangular games as a Linear programming problem, Dominance property, Graphical Method of solution 2 x n and m x2 games. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Kanti Swarup, Gupta, P.K. and Man Mohan (2001) Operations Research, Ninth edition, Sultan Chand & Sons 2. Sharma J.K. (2013) Operations Research: Theory and Applications, Fifth edition,Laxmi Publications-New Delhi. 3. Ravindran A, Philips D.T and Soleberg J.J. (1997) Operation Research-Principles and Practice, John Wiley & Sons. | | | |
| **Further Reading:**   * Taha H.A. (2007) Operations Research -An introduction, Eighth edition, Prentice-Hall of India Ltd. * Gass S.I. (1985) Linear Programming -methods and applications, Fifth edition, McGraw Hill, USA, * Sinha, S.M. (2006) Mathematical programming theory and methods, Elsevier, a division of Reed Elsevier India Pvt. Ltd., New Delhi. * Paneerselvam, R. (2008) Operations Research, Second edition, Prentice Hall of India Pvt. Ltd., New Delhi. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E37: INDUSTRIAL STATISTICS & QUALITY CONTROL** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **INDUSTRIAL STATISTICS & QUALITY CONTROL** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E37** | | | | | |
| **Course Summary & Justification** | To make the students aware of the modern quality assurance techniques and methods. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of statistical methods and probability | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are able to carry out quality assessment in variouscontexts using contro charts. They are aware of process capability indices for efficient process control. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Meaning of quality, and need for quality control. Meaning and scope of statistical process control, General theory of control charts, Shewhart control charts for variables- mean charts, R-charts, and S-charts, Moving-average control charts. Attribute control charts - p, np, c, u charts. OC and ARL curves of control charts. | 1 | 20 |
| 2 | Modified control charts. Control charts with memory - EWMA charts, CUSUM charts. Economic design of mean charts Process capability analysis, process capability indices – Cp Cpk, Cpm. Statistical aspect of six sigma philosophy, The Taguchi Method: The Taguchi philosophy of Quality, Quality in the service sector and TQM. | 1 | 20 |
| 3 | Statistical product control- basic ideas. Acceptance sampling for attributes - single sampling, double sampling, multiple sampling and sequential sampling plans. ASN curves. Measuring performance of sampling plans through OC curves. Rectifying inspection plans.AOQ and ATI curves, | 1 | 20 |
| 4 | Acceptance sampling by variables. Sampling plan for a single specification limit with known and unknown variance. Performance evaluation through OC curves. Designing a variable sampling plan with a specified OC curve. Multivariate statistical process control, Hotelling’s T2control chart. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Montgomery, D.C. (2012). Introduction to Statistical Quality Control, Seventh edition, Wiley. 2. Duncan, A.J. (1986) Quality Control and Industrial Statistics, Irwin, Homewood 3. Grant E.L. and Leaven Worth, R.S. (1980) Statistical Quality Control, McGraw Hill. | | | |
| **Further Reading:**   * Amitava Mitra. (2016). Fundamentals of Quality Control and Improvement, 4th edition Pearson Education Asia. * Mittag, H.J. and Rinne, H. (1993) Statistical Methods for Quality Assurance, Chapman & Hall. * David Hoyle.(2017). ISO 9000 Quality Systems Handbook, Routledge; 6 Edition. * Rabbit, J T and Bergle, P.A. The ISO 9000 Book, Quality Resources, Second Edition, * Schilling, E.G. (1982) Acceptance Sampling in Quality Control, Marcel Dekker. * Wetherill, G. B. and Brown, D.W (1991). Statistical Process Control: Theory and Practice. 3rd Ed. Chapman and Hall, USA. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E38 : ACTUARIAL STATISTICS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **ACTUARIAL STATISTICS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E38** | | | | | |
| **Course Summary & Justification** | 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. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of probability and random variables. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | The students have understood various aspects of insurance and actuarial statistics and are capable of computing interest, discount factor , annuities, premium etc. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Insurance Business – Introduction, Insurance Companies as Business Organizations, Concept of Risk; Future Lifetime Distribution and Life Tables, Future Lifetime Random Variable, Curate Future Lifetime, Life Tables, Assumptions for Fractional Ages, Select and Ultimate Life Tables. | 1 | 20 |
| 2 | **1**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 . | 1 | 20 |
| 3 | Statistical product control- basic ideas. Acceptance sampling for attributes - single sampling, double sampling, multiple sampling and sequential sampling plans. ASN curves. Measuring performance of sampling plans through OC curves. Rectifying inspection plans.AOQ and ATI curves, | 1 | 20 |
| 4 | Reserves - Fully Continuous Reserves, Fully Discrete Reserves; **4.2** Multiple Life Contracts – Joint Life Status, **4.3** Last Survivor Status. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   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. | | | |
| **Further Reading:**   * Daykin, C.D, Pentikainen,T. et al, Practical Risk Theory of Actuaries, Chapman and Hill . * Promislow, S.D (2006) Fundamentals of Actuarial Mathematics, John Wiley. * Neill, A (1977) Life Contingencies, Heinemann , London. * King,G. Institute of Actuaries Text Book. Part 11, Second Edition, Charles and Edwin Layton, London. * Donald D.W.A.(1970) Compound Interest and Annuities, Heinemann, London. * Jordan, C.W.Jr.(1967) Life Contigencies, Second Edition, Chicago Society of Actuaries. * Spurgeen, E.T. Life Contigencies, 3rd Edition, Cambridge University Press. * Benjamin, B. and Pollard, J.H.(1980) Analysis of Mortality and other Actuarial Statistics, Second Edition, Heinemann, London. * Freeman,H.(1960) Finite Differences for Actuarial Students, Cambridge University Press. * Biandt-Johnson, R. C. and Johnson, N.L(1980) Survival Models and Data Analysis, John Wiley | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)- 40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E39 : ECONOMETRIC METHODS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **ECONOMETRIC METHODS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E39** | | | | | |
| **Course Summary & Justification** | To enable the students to handle models of Econometrics and Mathematical Economics. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of econometrics . | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students are capable to apply and use the basic concepts related to the economy of a nation and to interpret various parameters used to measure economic status of a nation. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Demand and supply functions, Cobweb model, elasticity of demand, equilibrium of market, indifference curves, Cost Function, Utility, Firms, Marginal analysis of firms,production functions- elasticity of production, homogeneous functions, Cobb-Douglas Production function, constraint maximization of Profit, Revenue, output, Input- Output analysis- open and closed system. | 1 | 20 |
| 2 | Econometric and Economic models, Simple linear regression models, Multiple linear regression models, estimation of the model parameters, tests concerning the parameters, confidence intervals, prediction, use of Dummy variables in regression, Multicollinearity- consequences, Detection, Farrar-Glauber test, remedial measures. Heteroscedasticity- consequences, Detection, tests, remedial measures. | 1 | 20 |
| 3 | Autocorrelation, consequences, Durbin-Watson test, and estimation procedures, Errors in variables - consequences, detection, remedial measures, Stochastic regressors. Outliers, Influential Observations, Leverage Aitken’s generalized least square method, Non parametric regression. | 1 | 20 |
| 4 | Simultaneous equation models, instrumental variables, recursive models, distributed- lag models, identification problems, rank and order condition, methods of estimation- indirect least squares, least variance ratio and two-stage least squares, FIML- methods. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. [Damodar N Gujrati](http://www.madbooks.com/authors?artist_id=3023), [Sangeeth](http://www.madbooks.com/authors?artist_id=13319) (2007) Basic Econometrics 5th Ed., McGraw Hill Education Private Ltd. 2. Johnston J. (1984) Econometric Methods (Third edition), McGraw Hill, New York. | | | |
| **Further Reading:** Allen, [R.G.D.](http://www.amazon.com/R.-G.-D.-Allen/e/B001JS0LVU/ref=sr_ntt_srch_lnk_1?qid=1427304085&sr=1-1) ( 2008) Mathematical Analysis For Economists, Aldine Transaction  * Montgomery D.C., Peck E.A. and Vining G.G. (2007) Introduction to Linear Regression Analysis, John Wiley, India. * Apte P.G. (1990) Text book of Econometrics, Tata Me Graw Hill. * Jeffrey M*.*Wooldridge (2012)Introductory Econometrics: A Modern Approach 5th Edition, South-Western College Pub. * Koutsoyiannis A. (2008) Modern Microeconomics, Second Edition, Macmillan Press Ltd * Kutner M. H, Nachtsheim C.J, Neter J and Li W. (2005), Applied Linear Statistical Model, Fifth edition. McGraw Hill * Theil H. (1982) Introduction to the Theory and Practice of Econometrics, John Wiley. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E40 : STOCHASTIC FINANCE** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **STOCHASTIC FINANCE** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21E40** | | | | | |
| **Course Summary & Justification** | To make students aware of basic ideas of derivatives, option markets and stock prices, common standard models etc. They are aware of the statistical theory behind stochastic finance. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of statistical methods and stochastic process. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have understood the working of option markets and risk involved. They are well trained in portfolio theory and security markets, volatility, option pricing, stocks and bonds etc and can work as stock market advisors and risk analysts. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Derivatives, hedging, forward and future contracts, Markets, prices, arbitrage and hedging Complete market, market risk and credit risks in the use of derivatives. Options markets, properties of stock option prices, American and European options, Binomial model: One-step and two-step models, Binomial trees, Risk neutral valuation | 1 | 20 |
| 2 | Behavior of stock price, Conditional expectation, martingales, Markov property, Random Walk model, Brownian motion and Geometric Brownian motion, Ito integral, Ito/diffusion and mean reverting processes process, Ito Lemma, Black-Scholes formula for option pricing, Put-call option parity formula, Implied volatility. | 1 | 20 |
| 3 | Portfolio Theory: One risky asset and one risk free asset, Two risky assets, Two risky assets and a risk free asset, N-risky assets. Capital Asset pricing Model: Capital market line, Security market line, Security characteristic line. | 1 | 20 |
| 4 | Value-At-Risk: Parametric and Nonparametric estimation of VaR, VaR and risk management. Stochastic differential equation, Stochastic interest rate modes Stochastic High-volatility Models for Stocks and Bonds, Stable and geometric stable distributions. | 1 | 20 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Joshi, M. S.: (2008). The Concepts and Practices of Mathematical Finance. 2nd. ed. Cambridge University Press. 2. Hull, J. (2008). Options, futures and other derivatives, International 7th Edn, Pearson Prentice Hall. 3. Ross, S. (2012). An Elementary Introduction to Mathematical Finance. 2nd. ed. Cambridge University Press. | | | |
| **Further Reading:**   * Leonard, T. and Hsu, J. S. J. (2001). Bayesian Methods, Cambridge University Press * Rachev, S. T. Probability Models in Finance. Wiley. * Ruppert, D. (2004). Statistics and Finance: An Introduction, Springer (India). | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A**. Continuous Internal Assessment (CIA)-40 Marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E41 : RELIABILITY MODELING AND ANALYSIS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **RELIABILITY MODELING AND ANALYSIS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E41** | | | | | |
| **Course Summary & Justification** | To make students aware of basic reliability concepts, reliability models as well as to estimate reliability using probability models and data sets. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of probability theory and reliability. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | The students have understood various notions of aging and different types of failure rates. Now they are able to estimate reliability and develop reliability models for real life contexts in industry. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Basic concepts in reliability: Reliability system, Failure rate, mean, variance and percentile residual life, identities connecting them, Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc and their mutual implications. | 1 | 20 |
| 2 | Non monotonic failure rates and mean residual life functions, Study of life time models - exponential, Weibull, lognormal, generalized Pareto, gamma with reference to basic concepts and ageing characteristics; Bath tub and upside down bath tub failure rate distributions. | 1 | 20 |
| 3 | Reliability systems with dependents components:-Parallel and series systems, k out of n systems, ageing properties with dependent and independents components, concepts and measures of dependence in reliability Stress-strength reliability analysis, simple illustrations. | 1 | 20 |
| 4 | Reliability estimation using MLE - exponential, Weibull and gamma distributions based on censored and non censored samples; UMVUE estimation of reliability function; Bayesian reliability estimation of exponential and Weibull models. | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability, Springer. 2. Deshpande, J. V. and Purohit, S. G. (2016). Lifetime Data: Statistical Models and   Methods, World Scientific.   1. Tobias, T. A. and Trindade, D. C. (2012). Applied Reliability, 3rd Edn. C R C Press. | | | |
| **Further Reading:**   * Barlow, R.E. and Proschan, F. (1975) Statisical Theory of Reliability and Life Testing, Holt, Reinhart and Winston. * Sinha S K and Kale, B.K. (1986) Reliability and Life Testing, Wiley Eastern. * Marshall, A.W. and Olkin, I. (2007) Life Distributions, Springer * Galambos, J. and Kotz, S. (1978) Characterization of Probability distributions, Springer * Lawless, J.F. (2003) Statistical Models and Methods for Life Data, Wiley | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E42 : ADVANCED DISTRIBUTION THEORY** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **ADVANCED DISTRIBUTION THEORY** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E42** | | | | | |
| **Course Summary & Justification** | To make students aware of advanced topics in distribution theory like various generalized families of distributions, characterizations, mixture distributions etc to pursue research. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of distribution theory . | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have become familiar with various families of distributions and characterizations. They can apply these for modeling real data sets. Now they hhave received advanced level knowledge in distribution theory and can pursue research in this area. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Systems of Distributions:Pearson system of frequency curves, determination of parameters, the kappa criterion, properties and extensions, estimation of parameters. The Johnson’s system, Burr’s system, distributions based on series expansion, Edgeworth series, Gram Charlier series. | 1 | 20 |
| 2 | Characterization of probability distribution, Exponential and Geometric law, lack of memory property, normal law - characterization based on independence of linear forms and quadratic forms and regression. | 1 | 20 |
| 3 | Generalized Power Series Distributions**:** power series and compound distributions, Generalized Poisson distribution, Hyper Poisson family, distributions derived from Poisson and other generalization. | 1 | 20 |
| 4 | Mixture Distributions and Non - parametric density estimation: Finite and infinite mixtures, identifiability of mixtures, examples of non-identifiable mixtures, finite normal mixtures and estimation, normal mixture regression models. Density estimation, histogram and naive estimate, Kernel density estimate and properties. | 1 | 20 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1995).Continuous Univariate Distributions, Vol. I &Vol. II, John Wiley and Sons, New-York. 2. MacLachlan, P. and Peel,D.(2000).Finite Mixture Models. John Wiley& Sons, New York 3. Silverman, B. (1986). Density Estimation for Statistics and Data Analysis. Chapman & Hall. | | | |
| **Further Reading:**   * Johnson, N.L., Kotz. S. and Kemp. A.W.(1992). Univarite Discrete Distributions, John Wiley and Sons, New York. * Stuart, A. Ord, A. (1994). Kendall’s Advanced Theory of Statistics, Distribution Theory, 6thEdition. Wiley-Blackwell. * 3. Kagan A.M., Linnik, Y.V. and Rao C.R. (1975). Characterization Problems in Mathematical Statistics. John Wiley | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. Continuous Internal Assessment (CIA)  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M21 E43: MIXTURE REGRESSION MODELS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **MIXTURE REGRESSION MODELS** | | | | | |
| **Type of Course** | Elective | | | | | |
| **Course Code** | **MS M21 E43** | | | | | |
| **Course Summary & Justification** | To make students aware of mixture distributions and mixed regression models and their applications. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Eg.  Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of distribution theory and regression analysis. | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | Students have become familiar with mixture distributions and mixed regression models. Now they are able to apply these techniques in advanced research in many areas like economics, management, health etc for modeling real data sets. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Mixture Distributions**:** Finite and infinite mixtures, location and scale mixtures, non-identifiable mixtures, examples of non-identifiable mixtures, condition for identifiable when the components belong to power series family. | 1 | 20 |
| 2 | Simulation and Estimation:Finite normal, Poisson and negative binomial mixtures, simulation of random samples from mixtures, applications of mixture models. Estimation of parameters of mixture models, method of moments, maximum likelihood estimation, EM algorithm. | 1 | 20 |
| 3 | Mixture Regression:Normal mixture regression, Poisson mixture regression, estimation of parameters, examples using real and simulated data, R packages, FlexMix, Mixtools and CAMAN. | 1 | 20 |
| 4 | Generalized Linear Mixture Models:Exponential family, generalized linear models, examples, generalized linear mixture models, logistic and mixture logistic models, concomitant variables and varying parameter cases.. | 1 | 20 |
| **Total Credits of the Course** | | 4 |  |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. McLachlan, G.J. and Peel, D. (2000). *Finite Mixture Models*. John Wiley & Sons, INC, New York. 2. Schlattmann, P. (2009). *Medical Applications of Finite Mixture Models.* Springer Verlag Berlin Heidelberg. 3. Titterington, D. M., Smith, A. and Makov, U. (1985). *Statistical Analysis of Finite Mixture Distributions.* New York: Wiley | | | |
| **Further Reading:**   * Leisch, F. (2004). Flex Mix: A general framework for finite mixture models and latent class regression in R. *Journal of Statistical Software,*11(8), 1-18. http://www.jstatsoft.org/ * Wang, P. et.al. (1996). Mixed Poisson regression models with covariate dependent rates*. Biometrics*, 52, 381-400. * Sapatinas, T. (1995). Identifiability of mixtures of power-series distributions and related characterizations. *Ann. Inst. Statist. Math.,* 47 (3), 447-459. * McLachlan, G. J. and Krishnan, T. (1997). *The EM algorithm and Extensions*. New York: | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  A. **Continuous Internal Assessment (CIA)**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

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|  | **MAHATMA GANDHI UNIVERSITY** |
| **MS M 21 O 21: ELEMENTS ON CLINICAL TRIALS AND BUSINESS ANALYTICS** |

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| **School Name** | **School of Mathematics and Statistics** | | | | | |
| **Programme** | **M.Sc. Statistics** | | | | | |
| **Course Name** | **ELEMENTS ON CLINICAL TRIALS AND BUSINESS ANALYTICS** | | | | | |
| **Type of Course** | Open Course (for students of other Schools) | | | | | |
| **Course Code** | **MS M21 O21** | | | | | |
| **Course Summary & Justification** | To make students aware of basic concepts in Clinical Trials and Business Analytics in order that they can apply these in practical situations. | | | | | |
| **Total StudentLearningTime (SLT)** | Learning Approach | Lecture | Tutorial | Practical | Others | Total LearningHours |
|  | Authentic learning  Collaborative learning  Independent learning | 75 | 10 | 10 | 25 | 120 |
| **Pre-requisite** | Elementary knowledge of Statistics as well as Economics, Banking, Stock Markets etc | | | | | |

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| **O No.** | **Expected Course Outcome** | **Learning Domains** | **PSO No.** |
| 1 | The students have understood various notions of clinical trials in pharmaceutical research. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 2 | Students have understood basic concepts in Business Analytics | U/R/A/An/E | 1,2,3,4,5,6,7 |
| 3 | Now students can plan and execute clinical trials as well as apply in business analytics for making optimal financial decisions and policy formulation. | U/R/A/An/E | 1,2,3,4,5,6,7 |
| **\**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*** | | | |

**COURSE CONTENT**

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| **Module No** | **Module Content** | **C O** | **Hr** |
| 1 | Introduction to clinical trials**,** participants and sponsors of a trial, informed consent, benefits and risk of participating in a trial, blinding, placebo, controlled and uncontrolled trials, need and ethics of clinical trials, objectives and endpoints of a clinical trial, single center and multi-center trials, ICH and GCP, FDA and EMEA guidelines, Drug Development Process**,** overview of Phase I to IV trials (Design and analysis). | 1 | 20 |
| 2 | Clinical trial study designs, bioequivalence trials, adaptive trials, sample size determination, randomization methods, handling of missing data, handling multiplicity, Clinical Data Management (CDM), understanding protocol**,** clinical study report, statistical analysis Plan (SAP) data visualization methods, Data Comprehension**,** Data Interpretation, Clinical Data Analysis: Analysis methods/models for continuous data, categorical data, binary data, survival data, parametric and non-parametric methods, sub-group Analysis, sensitivity analysis, interim analysis, Quality of life data analysis. | 1 | 20 |
| 3 | Business Intelligence (BI): Introduction, Definition, Business Intelligence Segments, Difference between Information and Intelligence, Defining Business Intelligence Value Chain, Factors of Business Intelligence System, Real time Business Intelligence, Business Intelligence Applications, Creating Business Intelligence Environment, Business Intelligence Landscape, Types of Business Intelligence, Business Intelligence Platform, Dynamic roles in Business Intelligence, Roles of Business Intelligence in Modern Business- Challenges of BI. | 1 | 20 |
| 4 | Business Intelligence Types: Introduction, Multiplicity of Business Intelligence Tools, Types of Business Intelligence Tools, Modern Business Intelligence, the Enterprise Business Intelligence, Information Workers. Architecting the Data: Types of Data, Enterprise Data Model, Enterprise Subject Area Model, Enterprise Conceptual Model, Enterprise Conceptual Entity Model, Granularity of the Data, Data Reporting and Query Tools, Data Partitioning, Meta data, Total Data Quality Management (TDQM). | 1 | 20 |
| **Total Credits of the Course** | | 4 | 80 |
| **Books for Reference** | | | |
| **Compulsory Reading:**   1. Friedman L.M., Furberg C.D. & Demets D.L. (1998). Fundamentals of clinical trials. 2. Shein - Chung Chow and Jen-Pei Liu (2004). Design and Analysis of Clinical Trials: Concepts and Methodologies (2nd edition) Wiley-Inter science. 3. Business Intelligence Roadmap (2003). The Complete Project Lifecycle for Decision-Support Applications by Larissa T. Moss and Shaku Atre. 4. . | | | |
| **Further Reading:**   1. Stuart J. Pocock (2010). Clinical Trials – A practical approach (Reprint), John Wiley. 2. Business Intelligence Guidebook (2014). From Data Integration to Analytics by Rick Sherman. | | | |

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| **TeachingandLearning Approach** | **Classroom Procedure (Mode of transaction)**  Direct Instruction: Brain storming lecture, Explicit Teaching, E-learning, interactive Instruction:, Active co-operative learning, Seminar, Group Assignments Authentic learning, , Library work and Group discussion, Presentation by individual student/ Group representative |
| **Assessment Types** | **Mode of Assessment**  **A. Continuous Internal Assessment (CIA)- 40 marks**  1. Internal Tests of maximum 20 marks  2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar Maximum marks 10  3. Write a detailed report on a given topic based on research findings and literature search – 10 marks  **B. Semester End examination – 60 marks** |

**Rubrics selected for OBE implementation**

**1 .Overall performance** in each course of the semester on a continuous basis

**2.** Response to **critical theoretical questions** in each course

**3.** Procedural approach adopted towards **lab oriented critical questions** in each

practical course.

**4.** Response to **socially relevant issues and recent trends** in each course

**5. Aptitude to research** and **specific research problem**  in each course

**PART 1Task Description**

1. Written Examination
2. Assignment
3. Seminar
4. Practical Exam
5. Viva voce

**PART II Scale- Continuous mode**

Excellent, Satisfactory, Needs improvement (Remedial practices recommended)

**PART III Dimensions**

**Written Examination**-Content, Communicating

**Assignment** -Content, level of Comprehension

**Seminar**-Content, Performance

**Practical exam**- Conduct of practical, Observation and recording

**Viva voice** -Response to questions, Attitude

**PART IV Description of the dimensions**

**Content**-Brief and meaningful

**Comprehension-** Precise and effective

**Communicating-**Direct and orderly

**Procedure adopted-** Scientific Suitability and easiness

**Conduct of practical-**Accuracy and reproducibility

**Observation and recording-** Sharp and systematic

**Response to questions-** Analytical approach and level of accuracy

**Attitude-** Positive and self-inspiring

**MODEL QUESTION PAPER**

**Mahatma Gandhi University, Kottayam**

**School of Mathematics & Statistics**

**M.Sc. Statistics Semester 1 Examination**

**MS M21 C05 SAMPLING TECHNIQUE & OFFICIAL STATISTICS**

**Time: 3 hours Max. marks: 60**

**PART-A (Answer all questions. Each question carries 1 mark )**

1. Which division of CSO releases the Consumer Price Index?
   1. Social StatisticsDivision (b) Economic StatisticDivision
   2. National AccountsDivision (d) Coordination and PublicationDivision
2. If we have a sample of size 15 from a population of 150 units, the finite population correction is:

(a) 1.1 (b) 0.1 (c) 0.9 (d) 9

1. In population with linear trend, consider the following variances under SRS, stratified sampling and systematic sampling and respectively. Then which of the following is true?

a) (b)

(c) (d)

1. It is given that Then the ratio estimator of population total, is :
   1. 525. b) 550. c) 575 d) 625.
2. Who compute National Income in India?
   1. Ministry of Finance (b) RBI (c) National Statistical Office(NSO) (d) None of these

**PART B (Answer any 5 questions. Each question carries 2 marks.)**

1. What are the activities of NSSTA?
2. In a SRSWOR scheme prove that ?
3. If a stratified sample of size 45 is to be selected by Neyman allocation from a population with

, then find the number of units to be selected from the first stratum?

1. Explain Circular systematic sampling?
2. Prove that ratio estimators are consistent?
3. What is multistage cluster sampling?
4. Describe the Lahiris’s method of selection under PPSsampling?
5. ExplainMurthy’sunorderedestimators?

**PART C ( Answer any 5 questions. Each question carries 5 marks.)**

1. Explain the functions and activities of NSSO?
2. Explain Warner’s Model?
3. In case of stratified sampling, explain the proportionalallocation?
4. Explain interpenetratingsubsampling?
5. Explain cluster sampling? When do you prefer this over SRS?
6. In a field of barli, the grain and the grain plus straw were weighted for each of a sampling units located at random over the field. The total (grain+ straw) of the whole field was weighted. The following data were obtained. . Compute the gain in precision obtained by estimating the grain yield of the field from the ratio of grain to total produced instead of the mean yield of grain/unit.?
7. What is Hurwit’s- Thompson estimator? Show that it is unbiased for any sampling design and find itsvariance?
8. DefineDes Raj’sordered estimator for the population total using a sample of size 2 and show that it is unbiased?

**PART D ( Answer any 2 questions. Each question carries 10 marks.)**

1. (a) Write a note on MOSPI and functions of MOSPI?

(b) Show that the sample mean square error is unbiased estimate of the population variance?

1. (a) Show that linear systematic sample mean is an unbiased estimator of population mean and derive its variance.

(b) Compare the estimators of population mean under systematic sampling andSRS

1. (a) Compare the separate and combined ratio estimates?

(b) Show that in SRS, the regression estimate with a pre assigned regression coefficient is unbiased for the population mean?

(c) Explain cluster sampling with clusters in unequal size?

1. (a) What is Probability proportional to size sampling?

(b) DistinguishbetweenorderedandunorderedestimatorsinPPSWOR.

(c) Explain Human Development Index.

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