HSNC UNIVERSITY, MUMBAI

Board of Studies

In the subject of Statistics and Data Science & Business Analytics

Faculty of Science & Technology

Board of Studies in the Subjects of Statistics and Data Science & Business Analytics

1) **Name of Chairperson/Co-Chairperson/Coordinator:-**

Dr Asha Jindal, Professor and Head, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai –400 020. Email ID- asha.jindal@kccollege.edu.in Mobile no- 9821235627

2) **Two to five teachers each having minimum five years teaching experience amongst the full time teachers of the Departments, in the relevant subject.**
   a) **Dr. S. B. Muley,** Assistant Professor, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID sakharam.muley@kccollege.edu.in , Mobile No- 9323817918
   b) **Mrs. Pratiksha Kadam,** Assistant Professor, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID pratiksha.kadam@kccollege.edu.in , Mobile No- 7507162816
   c) **Ms. Shailaja Rane,** Assistant Professor, Department of Statistics, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID shailaja.rane@kccollege.edu.in, Mobile No- 7506986359

3) **One Professor / Associate Professor from other Universities or professor / Associate Professor from colleges managed by Parent Body;**
   a) **Dr Anjum Ara Ahmed;** I/C Principal, Rizvi College, Mumbai. Email ID **anjumahmed8@gmail.com, Mobile No-** 8451046220

4) **Four external experts from Industry / Research / eminent scholar in the field relevant to the subject nominated by the Parent Body;**

a. **Prof. Suresh Kumar Sharma,** Professor, Department of Statistics, Panjab University, Chandigarh. Email ID ssharma643@yahoo.co.in, **Mobile No**-9815911381

b. **Mr Mukesh Jain,** Chief Technological Officer, Capgemini. Email ID mdjain@hotmail.com, **Mobile No**-7972637347.

c. **Dr Santosh Gite,** Professor, Dept. of Statistics, University of Mumbai, Mumbai. Email ID santgite@yahoo.com, **Mobile No**- 9167157717.

d. Mr Prashant Kumar Nair, Director, Geo Spatial Analytics Global Lead, Intelligent Analytics, Nielsen Connect, Email ID prashantkumar.nair@nielsen.com , **Mobile No**-9833747057.

5. Top rankers of the Final Year Graduate and Final Year Post Graduate examination of previous year of the concerned subject as invitee members for discussions on framing or revision of syllabus of that subject or group of subjects for one year.

a) **Ms. Nishna Paria** (undergraduate student -2021-22) Email Id- parianishna@gmail.com; Mobile no- 9987468545

b) **Ms. Madhu Yadav** (Postgraduate student-2021-22) Email ID-dharanmadhu00@gmail.com; Mobile no- 7208658042

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(Dr. Asha Jindal)

BOS Chairperson - Statistics and Data Science & Business Analytics

Part –I

Outline of Choice Based Credit System as outlined by University Grants Commission:

R. ** : The Definitions Of The Key Terms Used In The Choice Based Credit System And Grading System Introduced From TheAcademicYear2020-2021AreAs Under:**

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a core course.

2. **Elective Course:** Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

   2.1 **Discipline Specific Elective (DSE) Course:** Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

   2.2 **Dissertation/Project:** An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of adiscipline specific elective paper.

   2.3 **Generic Elective (GE) Course:** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
   P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. **Choice Base Credit System :** CBCS allows students to choose inter- disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students.

4. **Honours Program :** To enhance employability and entrepreneurship abilities among the learners, through aligning Inter Disciplinary / Intra Disciplinary courses with Degree Program. Honours Program will have
40 additional credits to be undertaken by the learner across three years essentially in Inter / Intra Disciplinary course.

   A learner who joins Regular Undergraduate Program will have to opt for Honours Program in the first year of the Program. However, the credits for honours, though divided across three years can be completed within three years to become eligible for award of honours Degree.

5. **Program:** A Program is a set of course that are linked together in an academically meaningful way and generally ends with the award of a Degree Certificate depending on the level of knowledge attained and the total duration of study, B.Sc. Programs.

6. **Course:** A 'course' is essentially a constituent of a 'program' and may be conceived of as a composite of several learning topics taken from a certain knowledge domain, at a certain level. All the learning topics included in a course must necessarily have academic coherence, i.e. there must be a common thread linking the various components of a course. A number of linked courses considered together are in practice, a 'program'.

7. **Bridge Course:** Bridge course is visualized as Pre semester preparation by the learner before commencement of regular lectures. For each semester the topics, whose knowledge is considered as essential for effective and seamless learning of topics of the Semester, will be specified. The Bridge Course can be conducted in online mode. The Online content can be created for the Bridge Course Topics.

8. **Module and Unit:** A course which is generally an independent entity having its own separate identity, is also often referred to as a 'Module' in today's parlance, especially when we refer to a 'modular curricular structure'. A module may be studied in conjunction with other learning modules or studied independently. A topic within a course is treated as a Unit. Each course should have exactly 3 Units.

9. **Self-Learning: 20% of the topics will be marked for Self-Learning.** Topics for Self-Learning are to be learned independently by the student, in a time- bound manner, using online and offline resources including online lectures, videos, library, discussion forums, fieldwork, internships etc.

   Evaluative sessions (physical/online), equivalent to the credit allocation of the Self Learning topics, shall be conducted, preferably, every week for each course. Learners are to be evaluated real time during evaluative sessions. The purpose of evaluative sessions is to assess the level of the students' learning achieved

in the topics earmarked for Self-Learning.

The teacher's role in these evaluative sessions will be that of a Moderator and Mentor, who will guide and navigate the discussions in the sessions, and offer concluding remarks, with proper reasoning on the aspects which may have been missed by the students, in the course of the Self-Learning process.

The modes to evaluate self-learning can be a combination of the various methods such as written reports, handouts with gaps and MCQs, objective tests, case studies and Peer learning. Groups can be formed to present self- learning topics to peer groups, followed by Question and Answer sessions and open discussion. The marking scheme for Self Learning will be defined under Examination and Teaching.

The topics stipulated for self-learning can be increased or reduced as per the recommendations of the Board of Studies and Academic Council from time to time. All decisions regarding evaluation need to be taken and communicated to the stakeholders preferably before the commencement of a semester. Some exceptions may be made inexigencies, like the current situation arising from the lockdown, but such ad hoc decisions are tobe kept to the minimum possible.

10. **Credit Point:** Credit Point refers to the 'Workload' of a learner and is an index of the number of learning hours deemed for a certain segment of learning. These learning hours may include a variety of learning activities like reading, reflecting, discussing, attending lectures / counseling sessions, watching especially prepared videos, writing assignments, preparing for examinations, etc. Credits assigned for a single course always pay attention to how many hours it would take for a learner to complete a single course successfully. A single course should have, by and large a course may be assigned anywhere between
2 to 8 credit points wherein 1 credit is construed as corresponding to approximately 30 to 40 learning hours.

11. **Credit Completion and Credit Accumulation:** Credit completion or Credit acquisition shall be considered to take place after the learner has successfully cleared all the evaluation criteria with respect to a single course. Thus, a learner who successfully completes a 4 CP (Credit Point) course may be considered to have collected or acquired 4 credits. learner level of performance above the minimum prescribed level (viz. grades / marks obtained) has no bearing on the number of credits collected or acquired. A learner keeps on adding more and more credits as he completes successfully more and more courses. Thus the learner 'accumulates' course wise credits.

12. **Credit Bank:** A Credit Bank in simple terms refers to stored and dynamically updated information regarding the number of Credits obtained by any given learner along with details regarding the course/s for which Credit has been given, the course-level, nature, etc. In addition, all the information regarding the number of Credits transferred to different programs or credit exemptions given may also be stored with the individual's history.

13. **Credit Transfer:** (performance transfer)When a learner successfully completes a program, he/she is allowed to transfer his/her past performance to another academic program having some common courses and Performance transfer is said to have taken place.

14. **Course Exemption:** Occasionally, when two academic programs offered by a single university or by more than one university, may have some common or equivalent course-content, the learner who has already completed one of these academic programs is allowed to skip these 'equivalent' courses while registering for the new program. The Learner is 'exempted' from 'relearning' the common or equivalent content area and from re-appearing for the concerned examinations. It is thus taken for granted that the learner has already collected in the past the credits corresponding to the exempted courses.

Part-II

O*** The fees for transfer of credits or performance will be based on number of credits that a learner has to complete for award of the degree.**

The Scheme of Teaching and Examination:

The performance of the learners shall be evaluated in two components: Internal Assessment with 40% marks by way of continuous evaluation and by Semester End Examination with 60% marks by conducting the theory examination.

INTERNAL ASSESSMENT:- It is defined as the assessment of the learners on the basis of continuous evaluation as envisaged in the credit based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

A). Internal Assessment – 40% **40 marks**

Practical's (internal Components of the Practical Course)

1. For Theory Courses

Sr. No.	Particulars	Marks
1	ONE class test / online examination to be conducted in the given semester	15 Marks
2	One assignment based on curriculum (to be assessed by the teacher Concerned	10 Marks
3	Self-Learning Evaluation	10 Marks
4	Active participation in routine class instructional deliveries	05 Marks

2. For Courses with Practicals

Semester End Examination Practicals : At the end of the semester, Practical examination of 3 hours duration and 100 marks (80+10*+10**) shall be held for each course as shown below:

Practical Course	Part A	Part B	Duration	Marks out of
USSTP01	Questions from US-TST-501	Questions from US-TST-502	3 hours	80
USSTP02	Questions from US-TST-503	Questions from US-TST-504	3 hours	80
USSTP03	Applied Component from US-TST-505		3 hours	80
USSTP04	Questions from US-TST-601	Questions from US-TST-602	3 hours	80
USSTP05	Questions from US-TST-603	Questions from US-TST-604	3 hours	80
USSTP06	Applied Component from US-TST-605		3 hours	80

Pattern of practical question paper at the end of the semester for each course:

1. Every paper of Statistics will consist of two parts A and B. Every part will consist of two

questions of 40 marks each for main papers. Students to attempt one question from each part.

2. Every paper of Applied Component will consist of four questions based on each unit. Every question will be of 20 marks each.
3. *Practical journal will carry 10 marks and **Viva 10 marks in each paper.
4. One internal examiner and one external examiner will be appointed for this examination.

SEMESTER END EXAMINATION: - It is defined as the examination of the learners on the basis of performance in the semester end theory / written examinations.

B. Semester End Examination- 60 % *60 Marks*

The semester end examination (external component) of 60 % for each course will be as follows:

Semester End Examination:

Theory: At the end of the semester, Theory examination of two hours duration and 60 marks based on the four units shall be held for each course.

Pattern of Theory question paper at the end of the semester for each course:

There shall be four compulsory questions of fifteen marks each with internal option.
Question 1 based on Unit I.
Question 2 based on Unit II.
Question 3 based on Unit III.
Question 4 based on Unit IV.

The marks will be given for all examinations and they will be converted into grade (quality) points. The semester-end, final grade sheets and transcripts will have only credits, grades, grade points, SGPA and CGPA.

Guidelines for conducting University examination of Papers based on Statistical software at T.Y. B.Sc.

a. The examination will be conducted in Statistics laboratory on computers.
b. Provision of at least 25 computers with necessary R / SPSS / SPSS AMOS/MS Excel/TORA software installed should be made available by the center. Battery backup in case of power failure is essential.
c. The examination will be conducted batch wise. A batch will consist of at most 25 candidates.
d. The batches examined simultaneously will have same question paper. However there will be separate question paper for each batch in case more (than one) batches are required to be formed.
e. A candidate will solve the question paper given to him/ her on computer and the output of work done by him/her will be evaluated by the examiner.
f. In case of partial power failure proportionate additional time may be given to the concerned batch.

Workload Theory: 4 lectures per week per course.
Practicals: 4 lecture periods per course per week per batch. All four periods of the practicals shall be conducted in succession together on a single day.

3. Project and Assignment:

- Project or Assignment, which can in the following forms
  - Case Studies
  - Videos
  - Blogs
  - Research paper (Presented in Seminar/Conference)
  - Field Visit Report
  - Presentations related to the subject (Moot Court, Youth Parliament, etc.)
  - Internships (Exposition of theory into practice)
  - Open Book Test
  - Any other innovative methods adopted with the prior approval of Director Board of Examination and Evaluation.

4. Self-Learning Evaluation

- **20% OF THE TOPICS OF CURRICULUM ARE LEARNED BY THE STUDENT THROUGH SELF LEARNING USING ONLINE / OFFLINE ACADEMIC RESOURSE SPECIFIED IN THE CURRICULUM.**

- **HENCE 20% OF THE LECTURES SHALL BE ALLOCATED FOR EVALUATION OF STUDENTS ON SELF LEARNING TOPICS**

- The identified topics in the syllabus shall be learnt independently by the students in a time bound manner preferably from online resources. Evaluative sessions shall be conducted by the teachers and will carry 10 Marks.

  CLUB The self-learning topics into 3-4 GROUPS OF TOPICS ONLY FOR EVALUATION.

- **PRESCRIBE TIME DURATION (IN DAYS) FOR COMPLETION OF EACH GROUP OF TOPIC AND EARMARK SELF LEARNING EVALUATION LECTURES IN THE TIMETABLE. HENCE EACH GROUP OF TOPIC CAN BE ASSIGNED 3 REGULAR LECTURES FOR THIS EVALUATION FOR ENTIRE CLASS**

  3 Sub Topics

  Each evaluative session shall carry 3 Marks (3 x 3 Units = 9 Marks). Students who participate in all evaluative sessions shall be awarded 1 additional Mark.

  4 Sub Topics

  Each evaluative session shall carry 2.5 Marks (2.5 x 4 Units = 10 Marks)

- **EVALUATION OF SELF LEARNING TOPICS CAN COMMENCE IN REGULAR LECTURES ASSIGNED FOR SELF LEARNING EVALUATION IN THE TIMETABLE**

3 Evaluative sessions

Each evaluative session shall carry 3 Marks (3 x 3 = 9 Marks). Students who participate in all evaluative sessions shall be awarded 1 additional Mark.

4 Evaluative sessions

Each evaluative session shall carry 2.5 Marks (2.5 x 4 = 10 Marks).

Methods for Evaluation of Self-learning topics:

- Seminars/presentation (PPT or poster), followed by Q&A − Objective questions /Quiz / Framing of MCQ questions.
- Debates
- Group discussion
- You-Tube videos (Marks shall be based on the quality and viewership)
- Improvisation of videos
- Role Play followed by question-answers

HSNC University Mumbai

(2022-2023)

Ordinances and Regulations With

Respect to

Choice Based Credit System

(CBCS)

For the Programmes Under

The Faculty of Science and Technology

For the Course

Statistics

Curriculum – Third Year Undergraduate Programmes

Semester-V and Semester -VI

2022-2023

STATISTICS
Part 1-Preamble

T. Y. B. Sc. Statistics program is of minimum 40 credits cover two semesters. Statistics is the language of the uncertainties riddled modern information age. Statistics facilitates the choice making process by quantifying the element of chance or uncertainties. It's descriptive and inferential roles not only formulate the basis of the expansion of almost all the disciplines of the modern world, but also provide an array of non-traditional employment avenues starting from that of sport analysts to business analysts to actuaries.

This course has Applied Component program which carries 8 credits out of 40 credits over two semesters. Operations Research, also called Decision Science or Operations Analysis, is the study of applying mathematical and statistical techniques to address business problems. As a sub-field of Applied Statistics, it has a very interesting position alongside other fields as Data Science and Machine Learning.

The thrust of the course is to prepare students to enter into a promising career even after graduation. It also provide them a platform for pursuing higher studies resulting in post-graduate or doctorate degrees in the subject of Statistics. The program has some unique features like applying analytical methods to help make better management decisions. Students will get extensive computer training of statistical computations including standard software packages like R, IBM-SPSS Statistics, SPSS AMOS, MS-Excel and TORA on real life data.

1. **Course objective:** The main objectives of the course are-

- Make students realize about understanding and importance of the data.
- Acquaint students in understanding behavior and identification of pattern present in the data.
- Make students realize measuring certainty involved into uncertainty in happening of events with accuracy and precision.
- Acquaint students in understanding behaviour of the data using discrete probability distributions and continuous probability distributions.
- Make students realize about understanding and importance of the estimation theory and framing appropriate null hypothesis and alternative hypothesis of different tests and their interpretations with application in various domains of education and industry.
- To develop an understanding and application of theoretical statistics and analytical skills required in the industry and for research in the subject of statistics.

Semester 5

Course Code: US-TST-501

Objective:

1. Concept based understanding of probability and its applications in detail.
2. Understanding Laws of 'Large Number, Inequalities and its use.
3. To learn Reliability knowledge and specialist techniques to identify the likelihood or frequency of failures. To identify and correct the causes of failures that occur despite the efforts to prevent them.
4. To learn Joint Moment Generating Function, Trinomial and Multinomial Distribution with applications.
5. Understanding the concept of order statistics and its use in distribution theory.

Course Code: US-TST-502

Objective:

1. Gain knowledge in the concepts of Theory of estimation and distinguish various types of estimation. Know the properties of estimators and construction of point and interval estimators.
2. Gain knowledge on Point estimation. Properties of estimators and mean square error. Minimum variance unbiased estimators.
3. Understand different methods of estimations. Estimating point estimators using different methods. Construction of confidence interval for parameters of different distributions.
4. Gain knowledge of Bayes estimation and Linear Models.

Course Code: US-TST-503

Objective:

1. Understanding of the concepts of epidemics
2. Applying basic stochastic and deterministic models of epidemic analysis to estimate different parameters of epidemic.
3. Understanding of basic bioassay and its types.
4. Understanding and application of different methods to estimate potency of drugs and related statistic under different conditions.

5. Understanding of concepts and application of analysis procedure of Clinical Trails.
6. Understanding of concepts and application of analysis procedure of Bioequivalence trial.

Course Code: US-TST-504

Objective:

1. Students will learn how Demography is useful for governments and private businesses as a means of analyzing and predicting social, cultural, and economic trends related to population.
2. To achieve knowledge about the size, composition, structure of a population, growth or decline depends upon fertility, mortality and migration.

Course Code: US-TST-505

Objective:

1) To Learn Statistical Software R in detail along with menu driven softwares MS Excel/ToRA.
2) To learn Data Entry, Data Manipulation to processing, Data Analysis for large data sets.
3) To learn mathematical formulation of real-life situations using LPP, Transportation. , Assignment Problems and Simulation Models and to study methods to solve the formulated problems.
4) To learn the application of Operations research in industry.

Semester 6

Course Code: US-TST-601

Objective:

1. Understanding the concept of Bivariate Normal Distribution and its use.
2. Derivation of 'Probability Generating functions' of the standard discrete distributions.
3. Understanding the concept of Stochastic Process and its use, application.

Course Code: US-TST-602

Objective:

1. Gain knowledge on testing of hypothesis. Different types of hypothesis. Statistical tests, types of error, size and power of a test, Most powerful (MP), Uniformly most powerful (UMP) and unbiased test.
2. Understanding of Neymann- Pearson Lemma and its applications in testing of hypothesis regarding different distributions. Power functions of UMP test. Likelihood Ratio test.
3. Students will learn the fundamental concepts Sequential test Wald SPRT.
4. Difference of parametric and non- parametric test. Area of applications. Testing of hypothesis using Non-Parametric tests like sign test, Wilcoxon rank test, Mann- Whitney test, etc. and ability to use them judiciously for the testing of given data.

Course Code: US-TST-603

Objective:

1. Understanding of the concept to derivation of estimation of parameters and ANOVA of linear regression with one, two and k independent variables, ordinal regression, weighted least square and Quadratic Regression .
2. Grasp the concept of normality, linearity, autocorrelation, heteroscedasticity and multi-collinearity and learn methods to detect the presence of these using SPSS.

3. Understanding concept of dummy variables and its inclusion in analysis of regression models, Moderated Regression Analysis, Factor Analysis, and Confirmatory Factor Analysis, Structural Equation Modeling on real life data using IBM SPSS Statistics and SPSS AMOS.
4. To impart working knowledge of these models by simplifying the treatment of statistical inference to focus on how to specify models in the context of testing causal relationships.
5. To give emphasis on interpreting and understanding of the results obtained from statistical models/ computer outputs.

Course Code: US-TST-604

Objective:

1. Understand the concept of vital statistics and mortality tables.
2. Understand and calculate several quantities pertaining to the field of actuarial science
3. Understand and calculate amount to be or to be received under different conditions of annuities like certain, life, Variable etc.
4. Understanding the concept of Assurance and calculation of different quantities with respect to benefits under different assurance plans.

Course Code: US-TST-605

Objective:

1) To learn the application of Operations research in industry.
2) To plan and schedule projects.
3) To focuses on providing a thorough knowledge of importance of Inventory and Replacement
4) To familiarize with statistical tools and exposed to specially designed software like MS EXCEL, R and TORA.

2. Process adopted for curriculum designing.

The members of Department of Statistics initially drafted the syllabus. The draft syllabus was shown to Industry Partners, Academic Partners and Research Institute Partners through mail and in person invited to college. They suggested some changes. These changes were incorporated.

3. Salient features, how it has been made more relevant.

Statistics deals with collection, organization, analysis and interpretation of data. Statistical knowledge is very important as it helps to use appropriate methodologies for collecting data, tools for employing analysis and interpretation of results. It also provides us with techniques which are important in designing and planning of experiments.

A lot of data is generated at each and every moment. Data literacy has become crucial and indispensable to the society. Statistics has the quality of quantifying and measuring uncertainty which helps in assessing risk. It helps in extracting the meaningful information from the data, making predictions and taking decisions. Study of data has become an integral part of education, business, and overall human progress. This has put Statistics on the center stage of teaching, research, policy making and development all over the globe.

The T.Y.B.Sc Statistics syllabus is a Choice based credit system comprising of four main papers and one applied component paper having four units each in both the semesters.

The current course is designed to enhance the knowledge of the subject. While designing of the syllabus care has been taken to balance the fundamental techniques of Statistics with analytical skills like analysis using **Statistical Softwares** MS-Excel, R and IBM SPSS Statistics, SPSS AMOS and TORA. The course would give the students option to develop skills in areas which have direct relevance to employability in Insurance and Finance Industries, Banks, Econometrics, Quality Control, Pharmaceutical, Medical/Bio-statistics, Agricultural Statistics, Weather Forecasting, Indian Statistical Services, Stock Market, Machine Learning and Artificial Intelligence related job opportunities in Statistics.

4. Learning Outcomes

Our curriculum is designed to educate the learner about various applications of Statistics and Operations Research in various fields like Genetics, Medical Sciences, Pharmaceutical Industry, Environmental, Biotechnology, etc. The course would help students to apply their statistical concepts to summarize, analyze, and inculcate problem solving approach in the newer developments and innovations in the future. The curriculum design and the teaching and the evaluation patterns would help students to develop skills and competencies to build a progressive and successful career in the field of Statistics, Data Science and Research & Development.

- The learner will understand the importance of use of statistics and analytical skill for all types of data.
- The learner will learn measuring certainty involved into uncertainty in happening of events with accuracy and precision
- The learner will understand behaviour of the data using discrete and continuous probability distributions.
- The learner will learn methods to frame complex problem into a mathematical models and its solutions, interpretations and thereby its application in decision making process.
- Understand variety of problems such as linear programming problem, assignment, transportation, travelling salesman etc. and solve the problems using linear programming approach with software and analyze any real-life system with limited constraints and depict it in a model form.
- Simulate different real life probabilistic situations using Monte Carlo simulation technique.
- Understand different Inventory /Stocking/ Replacement situations and find the optimal solutions using models for different situations.
- The learner will learn the handling of various softwares which will help them to acquaint with requisite skill which in turn will prepare them to secure high paid job in the industries.
- Solve the mathematical model manually as well as using soft resources such as R, MS-Excel add-in Solver, TORA software etc.

Part 2- The Scheme of Teaching and Examination is as under: Second Year Semester – V Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Statistics**)			US-TST-501, US-TST-502, US-TSTP-1	
2	Elective Course	Discipline Specific Elective (DSE) Course		US-TST-505, US-TSTP-3	
		2.1	Interdisciplinary Specific Elective (IDSE) Course		
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)			US-TST-503, US-TST-504, US-TSTP-2	
	Skill Enhancement Courses (SEC)				

Detail Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme		Total Marks		
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	US-TST-501	Probability and Distribution Theory	4	20% *	4	0	0	2.5	10	20	10	60	100
2	US-TST-502	Theory of Estimation	4	20% *	4	0	0	2.5	10	20	10	60	100
3	US-TST-503	Biostatistics	4	20% *	4	0	0	2.5	10	20	10	60	100
4	US-TST-504	Demography	4	20% *	4	0	0	2.5	10	20	10	60	100
5	US-TST-505	Operations Research T	4	20% *	4	0	0	2	10	20	10	60	100
6	US-TSTP-1	**Practical based on** US-TST-501					4	3			100		
		Practical based on US-TST-502					4						
7	US-TSTP-2	**Practical based on** US-TST-503					4	3			100		
		Practical based on US-TST-504					4						
8	US-TSTP-3	**Practical based on** US-TST-505					4	2			100		
	Total Hours / Credit							20	Total Marks		800		

***One to two lectures to be taken for CONTINUOUS self -learning evaluation.**

Third Year Semester – V Units – Topics – Teaching Hours

S. No.	Subject Code	Subject Unit Title		Hours/ Lectures	Total No. of hours/ lectures	Credit	Tot al Marks
1	US-TST-501	I	Probability	15	60L	2.5	100 (60+40)
		II	Inequalities and Law of Large Numbers and Reliability	15			
		III	Joint Moment Generating Function, Trinomial and Multinomial Distribution	15			
		IV	Order Statistics	15			
2	US-TST-502	I	Point Estimation and Properties of Estimators	15	60L	2.5	100 (60+40)
		II	Methods of Point Estimation	15			
		III	Bayesian Estimation Method & Interval Estimation	15			
		IV	Introduction to Linear Models	15			
3	US-TST-503	I	Epidemic Models	15	60 L	2.5	100 (60+40)
		II	Bioassays	15			
		III	Clinical Trials	15			
		IV	Bioequivalence and Introduction to Survival Analysis.	15			
4	US-TST-504	I	Population Theories	15	60 L	2.5	100 (60+40)
		II	Measurement of Fertility and Measurement of Growth	15			
		III	Measurement of Mortality	15			
		IV	Construction of Life Tables	15			
5	US-TST-505	I	Fundamentals of R	15	60 L	2.0	100 (60+40)
		II	Linear Programming Problem -I	15			
		III	Transportation Problem	15			
		IV	Assignment Problem and Simulation	15			
6	US-TSTP-1	I	Practical based on US-TST-501	60	120 L	3	100
		II	Practical based on US-TST-502	60			
7	US-TSTP-2	III	Practical based on US-TST-503	60	120 L	3	100
		IV	Practical based on US-TST-504	60			
8	US-TSTP-3		Practical based on US-TST-505	60	60L	2	100
			TOTAL			20	800

- **Lecture Duration – 48 Minutes**
- **One Credit =15 Classroom hours**
- *First Batch Size of 25 students *** Second Batch of 20 Students * Last Batch of 20 Students**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT- Commutative Test, SEE- Semester End Examination , PA- Project Assessment, AT- Attendance

Part -3 - Detailed Scheme Theory

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

Course Code: US-TST-501

Title of paper: PROBABILITY AND DISTRIBUTION THEORY

Unit	Content	No. of Lectures
I	**PROBABILITY** 1.1 Review of Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. 1.2 Mathematical, Statistical, Axiomatic and Subjective probability. 1.3 Review of Addition Theorem for (a) two events (b) three events 1.4 Review of Conditional Probability: Multiplication Theorem for two events, three events. 1.5 Review of Bayes' theorem. 1.6 Theorems on Probability of realization of : (a) At least one (b) Exactly m (c) At least m of N events A_1, A_2, $A_3 \ldots A_N$. 1.7 Matching and Guessing problems. 1.8 Problems based on all above of them.	15
II	**INEQUALITIES AND LAW OF LARGE NUMBERS** 2.1 Markov Inequality 2.2 Tchebyshev's Inequality 2.3 Boole's Inequality 2.4 Cauchy Schwartz's Inequality 2.5 Weak law of large numbers. (Ref.9,10) **RELIABILITY:** 2.6 Concept of reliability, Hazard-rate. Bath tub curve. 2.7 Failure time distributions: (i) Exponential, (ii) Gamma, (iii) Weibull, (iv) Gumbel, Definitions of increasing (decreasing) failure rate. 2.8 System Reliability. Reliability of (i) series (ii) parallel system of independent components having exponential life distributions. 2.9 Mean Time to Failure of a system (MTTF). 2.10 Application of Reliability	15
III	**JOINT MOMENT GENERATING FUNCTION, TRINOMAIL DISTRIBUTION AND MULTINOMIAL DISTRIBUTION** 4.1 Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. 3.1.1 Necessary and Sufficient condition for independence of two random variables. 3.1.2 Concept and definition of Bivariate MGF. Marginal & Conditional	15

	distributions. Their Means & Variances. Correlation coefficient between (X, Y). 4.2 **Trinomial distribution** 5.2.1 Definition of joint probability distribution of (X, Y). 5.2.2 Joint moment generating function, moments μ_{rs} where r=0, 1, 2 and s=0, 1, 2. 5.2.3 Marginal & Conditional distributions. Their Means & Variances. 5.2.4 Correlation coefficient between (X, Y). Distribution of the Sum X+Y 5.3 Extension **to Multinomial distribution** with parameters (n, p1, p2,…pk-1) where p1+ p2,+…pk-1+ pk = 1. 5.3.1 Expression for joint MGF. Derivation of: joint probability distribution of (Xi, Xj). 5.3.2 Marginal & Conditional probability distribution of Xi. 5.3.3 Correlation coefficient	
IV	**ORDER STATISTICS** 4.1 Definition of Order Statistics based on a random sample. 4.2 Derivation of: 4.1.1 Cumulative distribution function of r^{th} order statistic. 4.2.1 Probability density functions of the r^{th} order statistic. 4.3.1 Joint Probability density function of the r^{th} and the s^{th} order statistic (r<s) 4.4.1 Joint Probability density function of all n ordered statistics. 4.5.1 Distribution of Maximum observation (n^{th} order statistic) and Minimum observation (first order statistic) in case of uniform and Exponential distribution. 4.6.1 Probability density function of the difference between r^{th} and s^{th} order statistic (r<s) and computation of correlation coefficient in case of uniform and Exponential distribution (Ref.2,3,4)	15

Self-Learning topics (Unit wise)

Unit	Topics
I	Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. Mathematical, Statistical, Axiomatic and Subjective probability Review of Addition Theorem for (a) two Review of Conditional Probability: Multiplication Theorem for two. Review of Bayes' theorem.
II	Markov Inequality, Cauchy Schwartz's Inequality System Reliability
IV	(i) Definition of Order Statistics based on a random sample. (ii) Derivation of: (d) Joint Probability density function of all n ordered statistics.

Online Resources

'Probability Theory and Applications' by Prof. Prabha Sharma, Department of Mathematics, IIT Kanpur Link: https://nptel.ac.in/courses/111104079 for US-TST- 501 for unit I., unit2
'Introduction to Probability and Statistics' by Prof. G. Srinivasan from IIT Madras available on the Swayam portal, https://nptel.ac.in/courses/111/106/111106112/ for US-TST- 501 for unit I.

Course Code: US-TST-502

Title of paper: THEORY OF ESTIMATION

Unit	Content	No. of Lectures
I	**POINT ESTIMATION AND PROPERTIES OF ESTIMATORS** 1.1.Notion of a Parameter and Parameter Space. 1.2.Problem of Point estimation. 1.3.Review of terms : Statistic, Estimator and Estimate. 1.4.Properties of a good estimator:	15

	1.5.Unbiasedness**:** Definition of an unbiased estimator, Illustrations and examples. Proofs of the following results: 1.6.(i) Two distinct unbiased estimators of U(θ) give rise to infinitely many unbiased estimators. (ii) If T is an unbiased estimator of θ then U(T) is an unbiased estimator of U(θ) provided U(·) is a linear function. **1.7.**Consistency**:** Definition of Consistency. Sufficient condition for consistency, proof & Illustrations 1.8.Sufficiency **:** Concept. Definition of sufficient statistic. Neyman's Factorization theorem (without proof). 1.9.Relative efficiency of an estimator & illustrative examples. **Minimum variance unbiased estimator (MVUE) and Cramer Rao Inequality:** 1. Definition of MVUE 2. Uniqueness property of MVUE (proof). 3. Fisher's information function 4.Regularity conditions. 5.Statement and proof of Cramer-Rao inequality. 6. Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. 7. Condition when equality is attained in Cramer Rao Inequality and its use in finding MVUE.	
II	**METHODS OF POINT ESTIMATION** 2.1.Method of Maximum Likelihood Estimation (M.L.E.): **1.** Definition of likelihood as a function of unknown parameter for a random sample from: Discrete distribution & Continuous distribution. **2.** Derivation of Maximum likelihood estimator (M.L.E.) for parameters of Standard distributions (case of one and two unknown parameters). **3**. Properties of MLE (without proof). **2.2. Method of Moments:** 1. Derivation of Moment estimators for standard distributions (case of one and two unknown parameters) • Illustrations of situations where MLE and Moment Estimators are distinct and their comparison using Mean Square error. 2.3.Method of Minimum Chi-square and Modified Minimum Chi-Square	15
III	**BAYESIAN ESTIMATION METHOD & INTERVAL ESTIMATION** 3.1.**Bayes Estimation:** 1. Prior distribution, Posterior distribution 2. Loss function, Risk function 3. Types of Loss function: Squared error Loss function	15

	(SELF), Absolute error Loss function (AELF) 4. Bayes' risk. 5.Bayes' method of finding Point estimator (assuming SELF) 3.2.**Examples** :(i) Binomial- Beta (ii) Poisson- Gamma (iii) Gamma-Gamma (iv) Normal-Normal **3.3.Interval Estimation:** 1. Concept of confidence interval & confidence limits. 2. Definition of Pivotal quantity and its use in obtaining confidence limits. 3. Derivation of 100(1-∝) % equal tailed confidence interval for : (a)The population mean : $\mu, \mu_1 - \mu_2$ (population variance known/ unknown) (b) the population variance: $\sigma^2, \frac{\sigma_1^2}{\sigma_2^2}$(Normal distribution)	
IV	**INTRODUCTION TO LINEAR MODELS** 4.1.Explanation of General Linear Model of full rank with assumptions. Model: $Y = X\beta + \underline{e}$ where $\underline{e} \sim N(0, \sigma^2 I)$ 4.2.Derivation of : 1) Least squares estimator of $\underline{\beta}$ 2) $E(\hat{\beta})$ 3) $V(\hat{\beta})$ 4.3.Guass Markoff theorem for full rank Model: $Y = X\beta + e$. 4.4.Derivation of : 1) $E(l'\hat{\beta})$ 2) $V(l'\hat{\beta})$. 4.5.Confidence interval for $l'\beta$ when $\sigma^2$is known. 4.6.Confidence interval of $\hat{\beta}$ when σ^2 is known.	15

Self-Learning topics (Unit wise)

Unit	Topics
1	Review of terms: Statistic, Estimator and Estimate. Properties of a good estimator, Definition of Consistency & Illustrations
2	Method of Maximum Likelihood Estimation (M.L.E.)
3	**Interval Estimation:** 1. Concept of confidence interval & confidence limits. 2. Derivation of 100(1-∝) % equal tailed confidence interval for : (a)The population mean : $\mu, \mu_1 - \mu_2$ (population variance known/ unknown) (b) the population variance: $\sigma^2, \frac{\sigma_1^2}{\sigma_2^2}$(Normal distribution)

Online Resources

"Statistical Inference", Prof. Somesh Kumar, IIT Kharagpur available at NPTEL LINK: https://nptel.ac.in/courses/111105043

Course Code: US-TST-503

Title of paper: Biostatistics

Unit	Content	No. of Lectures
I	**EPIDEMIC MODELS** 1.1. The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals (for 'a' introductions), Carrier model. 1.2. Chain binomial models. Reed-Frost and Greenwood models. Distribution of individual chains and total number of cases. Maximum likelihood estimator of `p' and its asymptotic variance for households of sizes up to 4. (Ref. 1)	15
II	**BIOASSAYS** 2.1. Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. 2.2. Indirect assays. Dose-response relationship. Conditions of similarity and Monotony. Linearizing transformations. Parallel line assays. Symmetrical (2, 2) and (3, 3) parallel line assays. Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency. 2.3. Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit and Logit analysis. (Ref.2, 3)	15
III	**CLINICAL TRIALS :** 3.1 Brief History of Clinical Research: Brief history of clinical trial in India and world-wide 3.2 Ethics of clinical trials, Ethics Committee and their responsibilities and Need and highlights on 1. Nuremberg code 2. Declaration of Helsinki. 3. Belmont Report 3.3 International Conference on Harmonization (ICH), Guidelines for Good Clinical Practice, ICMR guidelines for Biomedical Research on Human Subjects. 3.4 Introduction to clinical trials: Common terminology used in clinical trials. Over view of phases like Pre clinical phase, phase-0-phase-IV. 3.5 Study Designs (Parallel, Cross Over their advantages &), Study Protocol, Case record/Report form, Blinding (Single/Double), Randomized controlled (Placebo/Active controlled) 3.6 Types of Trials (Inferiority, Superiority and Equivalence, Multi-centric trial), Inclusion/Exclusion Criteria. 3.7 Use of two sample tests (parametric and non-parametric test), Analysis of Variance (One way, Two way and repeated measure). Chi square test, odds ratio for clinical trial data analysis. (problems calculation with respect only),	15

	(Ref. 4, 5, 6, 7, 8)	
IV	**BIOEQUIVALENCE AND INTRODUCTION TO SURVIVAL ANALYSIS:** 4.1. Bioequivalence trial: Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (PK) parameters C_{max}, AUC_t ,$AUC_{0-\infty}$, T_{max}, K_{el}, T_{half}. 4.2 Estimation of PK parameters using `time vs. concentration' profiles. Analysis of Parallel design using logarithmic transformation (Summary statistics, ANOVA and 90% confidence interval). Confidence Interval approach to establish bioequivalence (80/125 rule). 4.3 Introduction to survival analysis; concepts and definitions; concept of time to event data and censoring, type of censoring. 4.4 Survival function, hazard function; relationship between the three types of function; survival curve; estimating medium survival time. 4.5. Survival distributions- Weibull distribution; exponential distribution; lognormal distribution; gamma distribution. 4.6. Nonparametric methods of estimating survival function-introduction; Kaplan-Meier estimates; life table vs. Kaplan-Meier estimates; The Mantel-Haenszel test. (Ref. 4, 5, 6, 7, 8, 9)	15

Self-Learning topics (Unit wise)

Unit	Topics
1	Maximum likelihood estimator of `p' and its asymptotic variance for households of sizes up to 4.
2	Linearizing transformations, Symmetrical (3, 3) parallel line assays. (Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency).
3	3.2 Ethics of clinical trials, Ethics Committee and their responsibilities and Need and highlights on 1. Nuremberg code 2. Declaration of Helsinki. 3. Belmont Report 3.3 ICMR guidelines for Biomedical Research on Human Subjects. 3.4 Types of Trials (Non-Inferiority, Superiority and Equivalence, Multi-centric trial), Inclusion/Exclusion Criteria.
4	3.3.2. Bioequivalence trial: Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (PK) parameters C_{max}, AUC_t ,$AUC_{0-\infty}$, T_{max}, K_{el}, T_{half}. Survival distributions- Weibull distribution; exponential distribution; lognormal distribution; gamma distribution.

Online Resources

Unit-1: Content is continuation of previous topic. So needs to be read by students from book only.
Unit-2, Unit-3 and Unit-4: NOC:Current regulatory requirements for conducting clinical trials in India for investigational new drugs/new drug (Version 2.0), IIT Madras, Prof. Vishnu Rao, Prof. Rubina Bose, Prof. D. K. Sable, Prof. Y. K. Gupta, Prof. Arun B. Ramteke, Prof. Sucheta Banerjee Kurundkar, Prof. Nandini K Kumar. (https://nptel.ac.in/courses/127106137)
Unit-4: Survival Analysis by Ani Katchova, econometricsacademy,: https://www.youtube.com/watch?v=fTX8GghbBPc

Course Code: US-TST-504

Title of paper: DEMOGRAPHY

Unit	Content	No. of Lectures
I	Population Theories: 1.1 Introduction and sources of collecting data on vital statistics, error in census and registration data. Coverage and content error in demographic data 1.2 Evaluation and adjustment of age-sex data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. 1.3 Measurement of population, rate and ratio of vital events. Population composition, dependency ratio, 1.4 Adjustment of age data- use of Whipple, Myer and UN indices	15
II	Measurement of Fertility: 2.1 Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). 2.2 Measurement of Population Growth: 2.3 Gross Reproduction Rate (GFR) and Net Reproductive Rate (NRR). Models of population growth and their filling to population data.	15
III	Life (Mortality) Tables: Assumption, description, 3.1 Construction of Life Tables: Case studies on construction of Life Tables based on various Socio- demographic Characteristics and Uses of Life Tables. 3.2 Measure of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. 3.3 Stationary and Stable population, Central Mortality Rates.	15
IV	Abridged Life Table; 4.1 Concept and construction of abridge life tables by Reed-Merrell method and King's method. 4.2 Internal migration and its measurement, migration models, concept of international migration. 4.3 Methods for population projection, component method of population projection, 4.4 Nuptiality and its measurements.	15

Self-Learning topics (Unit wise)

Unit	Topics
I	Coverage and content error in demographic data, Introduction and sources of collecting data on vital statistics, error in census and registration data
III	Construction of Life Tables: Case studies on construction of Life Tables based on various Socio- demographic Characteristics
IV	Internal migration and its measurement, concept of international migration.

Online Resources

Method of Construction of Complete Life Tables by Dr. Nick Negovetich on Completing a life table for Dall Sheep Link: https://www.youtube.com/watch?v=hCZveJwP9Rg
Internal migration and its measurement, concept of international migration. https://www.youtube.com/watch?v=_9Ep_79xTpI
Introduction and sources of collecting data on vital statistics, error in census and registration data. Coverage and content error in demographic data https://www.youtube.com/watch?v=JYQzUavh97g

Course Code: US-TST-505

Title of paper: Operations Research Techniques

Unit	Content	No. of Lectures
I	**Fundamentals of R** 1.1 Introduction to R features of R, installation of R, Starting and ending R session, getting help in R , Value assigning to variables 1.2 Basic Operations : +, -, *, ÷, ^, sqrt 1.3 Numerical functions : log 10, log , sort, max, unique, range, length, a. var, prod, sum, summary, dim, sort, five num etc 1.4 Data Types : Vector, list, matrices, array and data frame 1.5 Variable Type and factor : logical, numeric, integer, complex, character 1.6 Data Manipulation : Selecting random N rows, removing a. duplicate row(s), dropping a variable(s), b. Renaming variable(s), sub setting data, c. creating a new variable(s), selecting of d. random fraction of row(s), appending of e. row(s) and column(s), simulation of f. variables. 1.7 Data Processing : Data import and export, setting working a. directory, checking structure of Data b. :Str(), Class(), Changing type of variable i. (for eg as.factor, as.numeric) 1.8 Data Visualisation using ggplot2 and ggstatplot: a. Basics of GGplot2, Aesthetics, lines, Annotation, Titles and Themes, b. Simple bar diagram, subdivided bar diagram, multiple bar diagram, pie Chart, Box plot for one and more variables, histogram, frequency polygon, Quantile plot, scatter plot. c. pdf and cdf plots of standard distributions. d. Facet wrap and Facet Grid, Arranging Plots using patchwork package. e. GGStatplot (Ref.6, 7, 8, 9,10)	15
II	**Linear Programming Problem (L.P.P)** 2.1 Mathematical Formulation : Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal Solution. 2.2 Graphical Solution for problems with two variables. and various cases 2.3 Simplex Method :Simplex method of solving problem with two or more variables and solutions to various cases. 2.4 Big M method. 2.5 Concept of duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and dual. Economic interpretation of Dual, 2.6 application of LP model to product mix and production scheduling problems.	15
III	**Transportation Problem** 3.1 Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution.	15

	3.2 Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. 3.3 Optimal Solution by MODI Method. 3.4 Optimality test, 3.5 Improvement procedure. 3.6 Variants in Transportation Problem: 3.7 Unbalanced, Maximization type. Formulation of TP as LPP and computer aided solution. 3.8 Extension to Transhipment Problem	
IV	**Assignment Problem** 4.1 Concept. Mathematical Formulation. 4.2 Solution by: Complete Enumeration Method and Hungarian method. 4.3 Variants in Assignment Problem: 4.4 Unbalanced, Maximization type. 4.5 Travelling Salesman Problem. Formulation of AP as LPP and computer aided solution. **Simulation** 4.6 Concept and Scope of simulation. Monte Carlo Technique of Simulation 4.7 Generation of random numbers using (i) Mid. Square Method and (ii) Multiplicative Congruential Method. 4.8 Inverse method of generation of random observations from (i) Uniform distribution, (ii) Exponential distribution, (iii) Gamma distribution, (iv) Normal distribution. 4.9 Applications of Simulation techniques in inventory and queueing model, computer-aided simulation.	15

Self-Learning topics (Unit wise)

Unit	Topics
1	Introduction to R features of R, installation of R, Starting and ending R session, getting help in R , Value assigning to variables Data Processing :Data import and export, setting working directory, checking structure of Data :Str(), Class(), Changing type of variable
2	Mathematical Formulation of LPP, Graphical Solution for problems with two variables. and various cases . Big M method. Concept of duality, Economic interpretation of Dual.
3	Formulation of TP as LPP
4	Formulation of AP as LPP

Online Resources

"INTRODUCTION TO R SOFTWARE" by PROF. Shalabh, Department of Mathematics IIT Kanpur https://archive.nptel.ac.in/courses/111/104/111104146/
"Linear programming and Extensions" by Prof Prabha Sharma, IIT Kanpur https://archive.nptel.ac.in/courses/111/104/111104027/
"Optimization", by Prof. A. Goswami, Dr. Debjani Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/111105039
"Operations Research" by Prof. Kusumdeep ,IT Roorkee https://nptel.ac.in/courses/111107128

Part – 4- Detailed Scheme Practical

Practical of Semester-V **Total Credit: 08**

COURSE CODE US-TSTP-1

Sr. No.	Practical topics from US-TST-501		Sr. No.	Practical topics from US-TST-502
5.1.1	Probability-I		5.2.1	MVUE and MVBUE
5.1.2	Probability-II		5.2.2	Methods of Estimation
5.1.3	Inequalities and WLLN		5.2.3	Baye's Estimaion
5.1.4	Reliability		5.2.4	Confidence Interval
5.1.5	Joint MGF, Trinomial and Multinomial Distribution		5.2.5	Linear model
5.1.6	Order statistics-I		5.2.6	Use of R software
5.1.7	Order statistics-II			

COURSE CODE US-TSTP-2:

Sr. No.	Practical topics from US-TST-503		Sr. No.	Practical topics from US-TST-504
5.3.1	Epidemic Models		5.4.1	Measurements of Mortality
5.3.2	Direct Assays		5.4.2	Measurements of Fertility
5.3.3	Parallel Line Assays		5.4.3	Measurement of Population Growth
5.3.4	Quantal Response Assays		5.4.4	Construction of Complete Life Table
5.3.5	Clinical Trials		5.4.5	Construction of Abridge Life Table
5.3.6	Bioequivalence		5.4.6	Migration
5.3.7	Survival Analysis			

COURSE CODE US-TSTP-3

Sr. No.	Practical topics from US-TST-505
5.5.1	Fundamentals of R
5.5.2	Graphs, Diagram and Probability Distributions
5.5.3	LPP- Graphical Method
5.5.4	LPP- Simplex Method and Big M Method
5.5.5	LPP- Duality
5.5.6	Transportation Problems
5.5.7	Assignment Problems
5.5.8	Simulations
5.5.9	Practical from 3-8 using Softwares

*** Each practical will be based on 4 lectures per paper per week.**

***All practical will be based on the real life/ raw online website data as well as finished data which are analysed using Calculator, R/ IBM SPSS Statistics / SPSS AMOS/ Excel/TORA.**

References:

Course Code: US-TST-501

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R V. & Craig Allen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.
3. Mood A. M., Graybill F. A., Boes D. C.: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
4. Hogg R. V. and Tanis E.A. : Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Biswas S.: Topics in Statistical Methodology, First edition, Wiley Eastern Ltd.
7. Kapur J. N. & Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
8. Chandra T.K. & Chatterjee D.: A First Course in Probability, Second Edition, Narosa Publishing House.
9. S.C. Gupta and V.K.Kapoor : Fundamental of Mathematical Statistics,Sultan Chand and Sons
10. V K Rohatgi: An Introduction to probability and Mathematical Statistics,
11. Barlow R. E. and ProchanFrank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston.
12. Mann N. R., Schafer R. e., Singapurwalla N. D. : Methods for Statistical Analysis of Reliability and Life Data. First edition, John Wiley & Sons.

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1. Hogg R.V., CraigA.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
2. Hogg R.V., TannisE. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
3. Rohatgi, V. K, EhsanesSaleh A.K. Md.: An introduction to Probability Theory and Mathematical Statistics, Second Edition, Wiley series in Probability and Statistics.
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8. AroraSanjay and BansiLal : New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi,5(1989)
9. A.M.Kshirsagar; Linear Models
10. F.A. Graybill; An Introduction to Linear Models
11. Asha Jindal (Ed.)(2018), Analysing and Visualising Data with R software- A Practical Manual, Shailja Prakashan, K.C.College.
12. Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London
13. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R, second edition. Narosa Publishing House, New Delhi.
14. Shahababa , B. (2011). Biostatistics with R, Springer, New York
15. Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall /CRC Press, New York.
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1. Bailey N.TJ. : The Mathematical theory of infectious diseases, Second edition, Charles Griffin and Co. London.
2. Das M.N. and Giri N.C. : Design and Analysis of Experiments, Second edition, Wiley Eastern.
3. Finney D.J. : Statistical Methods in Biological Assays, First edition, Charles Griffin and Co. London.
4. Sanford Boltan and Charles Bon : Pharmaceutical Statistics, Fourth edition, Marcel Dekker Inc.
5. Zar Jerrold H. :Biostatistical Analysis, Fourth edition, Pearson's education.
6. Daniel Wayne W. : Biostatistics . A Foundation for Analysis in the Health Sciences, 7th Edition, Wiley Series in Probability and Statistics.
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Course Code: US-TST-504

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2. Gupta S.C. and Kapoor, V.K. (2008), Fundamentals of Applied Statistics, 4 th Ediction (Reprint), Sultan Chand & Sons
3. M.L. Jhingan ,B.K. Bhatt and J.N. Desai, Demography ,
4. Asha A. Bhende (Author), Tara Kanitkar (Author), Principles of Population Studies
5. Kumar, R. (1986), Technical Demography, Wiley Eastern Ltd.
6. Benjamin, B. (1969), Demographic Analysis, George, Allen and Unwin.
7. Chiang, C.L. (1968), Introduction to Stochastic Progression.
8. Spiegelman, M. (1969), Introduction to Demographic Analysis, Harvard University Press.
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2. Schaum Series book in O.R. Richard Broson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.
3. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and
4. Lawrence Friedman, (1959), John Wiley & Sons.
5. Mathematical Models in Operations Research : J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
6. Principles of Operations Research with Applications to Management Decisions: Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.
7. Operations Research: S.D.Sharma.11th edition
8. Operations Research: H. A.Taha.6 edition, Kedar Nath Ram Nath & Company. th edition, Prentice Hall of India.
9. Quantitative Techniques For Managerial Decisions: J.K.Sharma , (2001), MacMillan India Ltd.
10. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
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13. Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall /CRC Press, New York
14. GGSTATSPLOT Presentation by Dr Indrajeet Patil, https://indrajeetpatil.github.io/ggstatsplot_slides/slides/ggstatsplot_presentation.html#1

Part 5- The Scheme of Teaching and Examination is as under: Third Year Semester

– VI Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Statistics**)			US-TST-601, US-TST-602, US-TST-603, US-SSTP-4, US-SSTP-5	
2	Elective Course	Discipline Specific Elective (DSE) Course		US-TST-605, US-SSTP-6	
		2.1	Interdisciplinary Specific Elective (IDSE) Course		
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
	Skill Enhancement Courses (SEC)			US-TST-604	

Detail Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Total Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	US-TST-601	Distribution Theory and Stochastic Processes	4	20% *	4	0	0	2.5	10	20	10	60	100
2	US-TST-602	Testing of Hypothesis	4	20% *	4	0	0	2.5	10	20	10	60	100
3	US-TST-603	Multivariate Techniques	4	20% *	4	0	0	2.5	10	20	10	60	100
4	US-TST-604	Actuarial Science	4	20% *	4	0	0	2.5	10	20	10	60	100
5	US-TST-605	Advance Operations Research Techniques	4	20% *	4	0	0	2	10	20	10	60	100
6	US-TSTP-4	**Practical based on** US-TST-601					4	3			100		
		Practical based on US-TST-602					4						
7	US-TSTP-5	**Practical based on** US-TST-603					4	3			100		
		Practical based on US-TST-604					4						
8	US-TSTP-6	**Practical based on** US-TST-605					4	2			100		
	Total Hours / Credit							20	Total Marks				800

***One to two lectures to be taken for CONTINUOUS self -learning evaluation.**

Third Year Semester – VI Units – Topics – Teaching Hours

S. N	Subject Code	Subject Unit Title		Hours/ Lectures	Total No. of hours/ lectures	Credit	Tot al Marks
1	US-TST-601	I	Bivariate Normal Distribution	15	60L	2.5	100 (60+40)
		II	Generating Functions	15			
		III	Stochastic Processes	15			
		IV	Queuing Theory	15			
2	US-TST-602	I	Most Powerful Tests	15	60L	2.5	100 (60+40)
		II	Uniformly Most Powerful & Likelihood Ratio Tests	15			
		III	Sequential Probability Ratio Tests	15			
		IV	Non-Parametric Tests	15			
3	US-TST-603	I	Simple linear regression model	15	60 L	2.5	100 (60+40)
		II	Multiple linear regression model	15			
		III	Weighted Least Square, Quadratic and Ordinal Regressions	15			
		IV	Structural Equation Modelling	15			
4	US-TST-604	I	Mortality Tables	15	60 L	2.5	100 (60+40)
		II	Compound Interest and Annuities Certain	15			
		III	Life Annuities	15			
		IV	Assurance Benefits	15			
5	US-TST-605	I	Linear Programming Problem -II	15	60 L	2	100 (60+40)
		II	Inventory Control-I	15			
		III	Inventory Control-II and Replacement	15			
		IV	PERT-CPM	15			
6	US-TSTP-4	I	Practical based on US-TST-601	60	120 L	3	100
		II	Practical based on US-TST-602	60			
7	US-TSTP-5	III	Practical based on US-TST-603	60	120 L	3	100
		IV	Practical based on US-TST-604	60			
8	US-TSTP-6		Practical based on US-TST-605	60	60L	2	100
			TOTAL			20	800

- **Lecture Duration – 48 Minutes**
- **One Credit =15 Classroom hours**
- *First Batch Size of 25 students *** Second Batch of 20 Students * Last Batch of 20 Students**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA- Project Assessment, AT- Attendance

Part -6 - Detailed Scheme Theory

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

Course Code: US-TST-601

Title of paper: DISTRIBUTION THEORY AND STOCHASTIC PROCESSES

Unit	Content	No. of Lectures
I	**BIVARIATE NORMAL DISTRIBUTION** 1.1 Definition of joint probability distribution (X, Y). Joint Moment Generating function, moments μ_{rs} where r=0, 1, 2 and s=0, 1, 2. 1.2 Marginal & Conditional distributions. Their Means & Variances 1.3 Correlation coefficient between the random variables. 1.4 Necessary and sufficient condition for the independence of X and Y. 1.5 Distribution of aX + bY, where 'a' and 'b' are constants. 1.6 Distribution of sample correlation coefficient when $\rho = 0$. Testing the significance of a correlation coefficient. Fisher's z – transformation. 1.7 Tests for i) H_0: $\rho = \rho_0$ ii) H_0: $\rho_1 = \rho_2$, Confidence interval for ρ. (Ref. 2,3,5,9)	15
II	**GENERATING FUNCTIONS** 2.1 Definitions of generating function and probability generating function. 2.2 Expression for mean and variance in terms of generating functions. 2.3 Definition of a convolution of two or more sequences. Generating function of a convolution. 2.4 Generating functions of the standard discrete distributions. Relation between: i) Bernoulli and Binomial distributions ii) Geometric and Negative Binomial distributions in terms of convolutions. (Ref.1,5)	15
III	**STOCHASTIC PROCESSES** 3.1 Definition of stochastic process. Examples of Stochastic Process, 3.2 Postulates and difference differential equations for : (i)Pure birth process, (ii)Poisson process with initially 'a' members, for a =0 and a >0, (iii)Yule Furry process, (iv)Pure death process, (v)Death process with $\mu_n=\mu$, (vi) Death process with $\mu_n= n\mu$, (vii)Birth and death process, (viii)Linear growth model. 3.3 Derivation of P_n (t), mean and variance where ever applicable. (Ref.1,7,9)	15
IV	**QUEUING THEORY** 4.1 Basic elements of the Queuing model. Roles of the Poisson and Exponential distributions,Characteristics of queuing Model, Kendall Notation. 4.2 Derivation of Steady state probabilities for birth and death process. Steady state probabilities and various average characteristics for the following models:	15

	(i) (M/M/1) : (GD/ ∞ /∞) (ii) (M/M/1) : (GD/ N /∞) (iii) (M/M/c) : (GD/∞/∞) (iv) (M/M/c) : (GD/ N /∞) (v) (M/M/∞) : (GD/ ∞ /∞) , industrial applications of queuing theory. (Ref.6)	

Self-Learning topics (Unit wise)

Unit	Topics
III	Definition of stochastic process. Examples of Stochastic Process Postulates and difference differential equations for: Poisson process with initially 'a' members, for a =0 and a >0, Derivation of P_n (t), mean and variance of above process
IV	Basic elements of the Queuing model. Roles of the Poisson and Exponential distributions. Derivation of Steady state probabilities for birth and death process. Steady state probabilities and various average characteristics for the following models: (i) (M/M/c) : (GD/ ∞ /∞)

Online Resources

For Unit III, "Introduction to Probability Theory and Stochastic Processes", Dr. S. Dharmaraja, Department of Mathematics, IIT Delhi Link: https://nptel.ac.in/courses/111102111
For Unit IV, 'Introduction to Queueing Theory' by Prof. N. Selvaraju , Department of Mathematics, IIT Guwahati LinK: https://nptel.ac.in/courses/111103159

Course Code: US-TST-602

Title of paper: TESTING OF HYPOTHESIS

Unit	Content	No. of Lectures
I	**MOST POWERFUL TESTS** 1.1.Problem of testing of hypothesis. **1.2.**Review of Definitions and illustrations of i) Simple hypothesis ii) Composite hypothesis iii) Null Hypothesis iv) Alternative Hypothesis v) Test of hypothesis vi) Critical region vii) Type I and Type II errors viii) Level of significance ix) p-value x) Size of the test xi) Power of the test xii) Power function of a test xiii) Power curve. 1.3.Definition of most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma. Randomised test (Ref. 1,2,10)	15
II	**UNIFORMLY MOST POWERFUL& LIKELIHOOD RATIO TESTS** 2.1.Definition, Existence and Construction of Uniformly most powerful (UMP) test (Ref. 1,2,10)	15

	2.2. Likelihood ratio principle: Definition of test statistic and its asymptotic distribution (statement only). Construction of LRT for the mean of Normal distribution for (i) Known σ^2 (ii) Unknown σ^2(two sided alternatives). LRT for variance of normal distribution for (i) known μ (ii) unknown μ (two sided alternatives hypothesis) (Ref. 1,2,3,4)	
III	**SEQUENTIAL PROBABILITY RATIO TESTS** 3.1. Sequential Procedure 3.2. Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size (Neyman-Pearson) test procedure. 3.3. Definition of Wald's SPRT of strength (α, β). Graphical/Tabular procedure for carrying out SPRT. Problems based on Bernoulli, Binomial. Poisson, Normal & Exponential distributions. (Ref. 1,6,7,8)	15
IV	**NON-PARAMETRIC TESTS** 4.1. Need for non parametric tests. 4.2. Distinction between a parametric and a non parametric test. 4.3. Concept of a distribution free statistic. Single sample and two sample Nonparametric tests. (i) Sign test (ii) Wilcoxon's signed rank test (iii) Median test (iv) Mann–Whitney test (v) Run test (vi) Fisher exact test (vii) Kruskal -Wallis test (viii) Friedman test 4.4. Assumptions, justification of the test procedure for small & large samples . (Ref.5,9)	15

Self-Learning topics (Unit wise)

Unit	Topics
I	Problem of testing of hypothesis. Review of Definitions and illustrations of i) Simple hypothesis ii) Composite hypothesis iii)Null Hypothesis iv) Alternative Hypothesis v)Test of hypothesis vi) Critical region vii) Type I and Type II errors viii) Level of significance ix) p-value x) Size of the test xi) Power of the test
II	Likelihood ratio principle: Definition of test statistic and its asymptotic distribution (statement only)
III	Sequential Procedure Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size (Neyman-Pearson) test procedure.

Online Resources

'Business Statistics' by Dr Mukesh Kumar Barua from IIT Roorkee available on the Swayam portal, https://nptel.ac.in/courses/110/107/110107114/ for unit 1
"Statistical Inference", Prof. Somesh Kumar, IIT Kharagpur available on the Swayam NPTEL portal LINK: https://nptel.ac.in/courses/111105043

Course Code: US-TST-603

Title of paper: Multivariate Techniques

Unit	Content	No. of Lectures
I	**1.1** Basic Fundamental Concepts of Modelling, Regression Model - A Statistical Tool, **1.2** Simple Linear Regression Analysis **Simple linear regression model** :Assumptions of the model, Derivation of ordinary least square (OLS) estimators of regression coefficients for simple with one & two independent variable(s) and for quadratic form, 1.3 Properties of least square estimators (without proof), 1.4 Coefficient of determination R^2 and adjusted R^2 , 1.5 Procedure of testing and interpretations a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients 1.6 Data Pre-processing: Detection and treatment of missing value(s)and outliers, Variable selection and Model building, 1.7 Moderated Regression Analysis: Concept and Case Study (Ref. 1,2,3,4,5):	15
II	**Multiple linear regression model** 2.1 Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models, Coefficient of determination R^2 and adjusted R^2 , 2.2 Procedure of testing and interpretations a) Overall significance of the models	15

	b) Significance of individual coefficients c) Confidence intervals for the regression coefficients 2.3 Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building. 2.4 Estimation of parameters for Weighted Least Square Method, Polynomial Regression Models (Ref. 1,2,3,4,5)	
III	**Unit IV : Validity of Assumptions** 3.1 Residual, Diagnostics in Multiple Linear Regression Model: Standardized residuals, Studentized residuals, residual plots, Interpretation of four plots and corrective measures such as transformation of response variable, 3.2 Autocorrelation: Concept and detection using Durbin Watson Test, 3.3 Heteroscedasticity: Concept and detection using Breusch – Pagan-Godfrey Test 3.4 Multicollinearity: Concept and detection using i) R^2 and t-ratios ii) pairwise correlation between repressors iii) Variance Inflation Factor(VIF), 3.5 Interpretations of all of above 3.6 Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures, 3.7 Dummy Variables and 3.8 Moderated Multiple Regression Analysis: Concept and Case Studies (Ref. 1,2,3,4,5)	15
IV	**Basics of Structural Equation Modelling (SEM):** 4.1 Introduction: measurement and structure models, variables and constructs, modelling strategies, conceptualization 4.2 Structural Equation Modelling: Six stages in Model Development, 1) Identification 2) Specification 3) Research design and related issues 4.3 SEM Model Estimation Measurement: Model Structure, Different Estimation Techniques, Issues of Identification 4.4 Model Validity Measurement Model: GOFs and interpretations 4.5 Specifying Structural Models: incorporating theoretical models 4.6 Model validity: Structural models GoFs, Competitive fit, Comparing Models. 4.7 Exploratory and Confirmatory Factor Analysis: Conceptualization Difference between exploratory & confirmatory factor analysis, Objective of CFA, CFA model & assessing measurements, Model validity and interpretations	15

Self-Learning topics (Unit wise)

Unit	Topics
I	Basic Fundamental Concepts of Modelling, Regression Model - A Statistical Tool, Simple Linear Regression Analysis Derivation of ordinary least square (OLS) estimators of regression coefficients for Simple Linear Regression
II	Variable selection and Model building
III	Diagnostics in Multiple Linear Regression Model: Standardized residuals, Studentized residuals, residual plots,
III	Polynomial Regression Models
IV	Exploratory and Confirmatory Factor Analysis: conceptualization Difference between exploratory & confirmatory factor analysis, Objective of CFA,

Online Resources

'Linear Regression Analysis and Forecasting' by Prof. Shalabh, Department of Mathematics, IIT Kanpur Link: https://nptel.ac.in/courses/111104098 and https://nptel.ac.in/courses/111104147
Structural Equation Modelling (SEM) **by Dr. Suresh Sharma** Link: **https://youtu.be/2wniJL8M1ZQ**

Course Code: US-TST-604

Title of paper: ACTURIAL SCIENCE

Unit	Content	No. of Lectures
I	**MORTALITY TABLES** 1.1 Introduction to Life Insurance. Concept of Life tables, Various mortality functions. Important functions lx,qx,dx,px,	15

	1.2 Construction of Mortality table for actuarial, relationship of various mortality functions, Probabilities of living and dying. force of mortality. Estimation of μx from the mortality table. 1.3 Laws of mortality: Gompertz's and Makeham's first law (statement and problems). 1.4 Select, Ultimate and Aggregate mortality tables. Stationary population. Central Mortality Rate, Expectation of life and Average life at death. (Ref.2,3)	
II	**COMPOUND INTEREST AND ANNUITIES CERTAIN** 2.1.Concept of interest, simple interest and compound interest, difference between simple and compound interest, Nominal and Effective rates of interest, relationship of Nominal and Effective rate of interest, Varying rates of interest, Discount and discounted rates, Time value of money, Accumulated value and present value, Equation of value. Equated time of payment. Comparison of all compounding methods. 2.2.Concept of Annuity, Types of annuities. 2.3.Derivation for Present and accumulated values of annuity certain (immediate and due) without deferment period. Derivation for Present and accumulated values of annuity certain (immediate and due) with deferment period. (i) (Ref.2)	15
III	**General Annuties and Life Annuities** Derivation for 3.1.Present and accumulated values of (i) increasing annuity (ii) increasing annuity when successive installments form arithmetic progression (iii) increasing annuity when successive installments form geometric progression (iv) Annuities payable less frequently than interest convertible (v)Annuities payable more frequently than interest convertible 3.2.Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) without deferment period. Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) with deferment period. 3.3.Present values of Variable, increasing life annuities and increasing Temporary life annuities (immediate and due). 3.4.Concept of Continuous annuity.	15
IV	**ASSURANCE BENEFITS** 4.1.Concept of Assurance, Benefit, Types of premiums: Single, Level Annual, Natural and Office premiums. Concept of Perpetuity, difference between annuity and Perpetuity. Derivation for 4.2.Present value for perpetuity (immediate and due) with and without deferment Period. 4.3.Present value of Assurance benefits in terms of commutation functions of: (i) pure endowment assurance (ii) temporary assurance (iii) endowment assurance (iv) whole life assurance (v) double endowment assurance (vi) special endowment assurance (vii) deferred temporary assurance. **4.4.**Net premiums: Net level annual premiums (including limited period	15

	of payment) for various assurance plans. Redemption of loan concept and case study	

Self-Learning topics (Unit wise)

Unit	Topics
1	Important functions lx,qx,dx,px
2	Concept of interest, simple interest and compound interest, difference between simple and compound interest, Discount and discounted rates, Time value of money, Comparison of all compounding methods. Derivation for Present and accumulated values of annuity certain (immediate and due) with deferment period.
3	Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) with deferment period.
4	Present value for perpetuity (immediate and due) with and without deferment Period.

Online Resources

Unit-1, 2,3 & 4

1. NOC: Financial Mathematics coordinated by IIT, Roorkee. https://archive.nptel.ac.in/courses/112/107/112107260/#

2. NOC: Time value of money-Concepts and Calculations, IIT Roorkee, Dr.Bikash Mohanty . https://nptel.ac.in/courses/109107115

3. NOC: Financial Management For Managers, By Prof. Anil K. Sharma | IIT Roorkee https://onlinecourses.nptel.ac.in/noc22_mg08/preview

4. NOC:Financial Mathematics, IIT Roorkee by Dr. Pradeep K. Jha https://nptel.ac.in/courses/112107260

Course Code: US-TST-605

Title of paper: Advance Operations Research Techniques

Unit	Content	No. of Lectures
I	**LINEAR PROGRAMMING PROBLEM -II** 1.1 Two-Phase Simplex Method, Algorithm. 1.2 Dual Simplex Method, Algorithm. Post Optimality Sensitivity Analysis. 1.3 Effect on optimal solution to the LPP and improvement in the solution due to	15

	(i) Change in cost coefficient, (ii)Change in the element of requirement vector, (iii) Addition/deletion of a variable, (iv) Addition/deletion of a constraint. (All expressions without proof)	
II	**INVENTORY CONTROL** -I 2.1 Introduction to Inventory Problem, Inventory Planning and control 2.2 **Deterministic Models :** Single item static EOQ models using simplified approach for (i)Constant rate of demand with instantaneous replenishment, with and without shortages. (ii) Constant rate of demand with uniform rate of replenishment, with and without shortages. (iii) Examples of Safety Stock Calculation 2.3 **Probabilistic models :** Single period with (i)Instantaneous demand (discrete and continuous) without setup cost. (ii) Uniform demand (discrete and continuous) without set up cost.	15
III	**INVENTORY CONTROL** -II **3.1 Deterministic Models :** Single item static EOQ models using Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks. ABC Analysis. **REPLACEMENT** 3.2 Replacement of items that deteriorate with time and value of money (i) remains constant, (ii) changes with time. 3.3 Replacement of items that fail completely: Individual replacement and Group replacement policies.	15
IV	**Project Scheduling**: 4.1 Network representation of project, Project scheduling: Critical Path Method and PERT, 4.2 Types of Floats, 4.3 Crashing: Time and cost trade-off. 4.4 Resource Allocation, 4.5 Updating 4.6 Extension to minimal spanning Tree 4.7 Data Envelopment Analysis	15

Self-Learning topics (Unit wise)

Unit	Topics
1	Two-Phase Simplex Method, Algorithm. Dual Simplex Method, Algorithm, Sensitivity Analysis
2	Inventory Planning and control Examples of Safety Stock Calculation
3	Critical Path Method and PERT

Online Resources

"Linear programming and Extensions" by Prof Prabha Sharma, IIT Kanpur Link: https://archive.nptel.ac.in/courses/111/104/111104027/
"Optimization", by Prof. A. Goswami, Dr. Debjani Chakraborty, IIT Kharagpur Link::https://nptel.ac.in/courses/111105039
"Operations Research" by Prof. Kusumdeep ,IT Roorkee Link:https://nptel.ac.in/courses/111107128
"Production and Operation Management" by Prof. Rajat Agarwal, IIT Roorkee available on NPTEL Link: https://nptel.ac.in/courses/110107141

Part – 7- Detailed Scheme Practical

Practical of Semester-VI Total Credit: 08

COURSE CODE US-TSTP-4 :

Sr. No.	Practical topics from US-TST-601		Sr. No.	Practical topics from US-TST-602
6.1.1	Bivariate Normal Disribution		6.2.1	Testing of Hypothesis - I
6.1.2	Tests for correlation and Interval estimation		6.2.2	Testing of Hypothesis - II

6.1.3	Generating Function		6.2.3	SPRT
6.1.4	Stochastic Process		6.2.4	Non-parametric Test - I
6.1.5	Queuing Theory - I		6.2.5	Non-parametric Test - II
6.1.6	Queuing Theory - II		6.2.6	Use of R software

COURSE CODE US-TSTP-5:

Sr. No.	Practical topics from US-TST- 603 with IBM SPSS Statistics and SPSS AMOS		Sr. No.	Practical topics from US-TST-604
6.3.1	Simple Linear Regression using SPSS		6.4.1	Mortality table I
6.3.2	Weighted Least Square using SPSS		6.4.2	Mortality table II
6.3.3	Multiple Linear Regression using SPSS		6.4.3	Annuities I
6.3.4	Moderated Regression Analysis using SPSS		6.4.4	Annuities II
6.3.5	Polynomial and Quadratic Regression using SPSS		6.4.5	Life Annuities
6.3.6	EFA, CFA		6.4.6	Assurance Benefits
6.3.7	Structural Equation Model			

COURSE CODE US-TSTP-6:

Sr. No.	Practical topics from US-TST-605
6.5.1	Two-Phase Simplex Method, Dual Simplex Method
6.5.2	Sensitivity Analysis
6.5.3	Deterministic Models
6.5.4	Probabilistic models
6.5.5	Replacement
6.5.6	CPM-PERT : 1
6.5.7	CPM-PERT : 2
6.5.8	CPM-PERT : 3
6.5.9	Practical based on Softwares

*** Each practical will be based on 4 lectures per paper per week.**

*** All practical will be based on the real life/ raw online website data as well as finished data which are analysed using Calculator, SPSS / Excel/R Software/TORA.**

References:

Course Code: US-TST-601

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. & Craig A.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.
3. Mood A M, Graybill F A, Bose D C: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition,

McMillan Publishing Company
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Taha H.A.: Operations Research: An introduction, Eighth edition, Prentice Hall of India Pvt. Ltd.
7. Medhi J: Stochastic Processes, Second edition, Wiley Eastern Ltd.
8. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
9. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company

Course Code: US-TST-602

1. Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics, Fourth edition London Macmillan Co. Ltd.
2. Hogg R.V. and Tanis E.A.: Probability and Statistical Inference, Third edition Delhi Pearson Education.
3. Lehmann, E. L: Testing of Statistical Hypothesis, Wiley &Sons
4. Rao, C. R.: Linear Statistical Inference and its applications, Second Edition Wiley Series in Probability and Statistics.
5. Daniel W.W.:Applied Non Parametric Statistics, First edition Boston-Houghton Mifflin Company.
6. Wald A.: Sequential Analysis, First edition New York John Wiley & Sons
7. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition New Delhi S. Chand & Company Ltd.
8. Sanjay Aroraand BansiLal: New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi, 5(1989).
9. Sidney Siegal& N John Castellan Jr.:Non parametric test for behavioral sciences, McGraw Hill c-1988
10. A. Mood , F. Graybill& D. Boes:Introduction to the theory of Statistics- McGraw Hill
11. Asha Jindal (Ed.)(2018), Analysing and Visualising Data with R software- A Practical Manual, Shailja Prakashan, K.C.College.

Course Code: US-TST-603

1) Draper, N. R. and Smith, H. (1998), Applied Regression Analysis (John Wiley), Third Edition.
2) Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003), Introduction to Linear Regression Analysis (Wiley).
3) Neter, J., W., Kutner, M. H. ;Nachtsheim, C.J. and Wasserman, W.(1996), Applied Linear Statistical Models, fourth edition, Irwin USA.
4) Damodar Gujrati, Sangetha,Basic Econometrics, fourth edition, McGraw Hill Companies.
5) William Geene (1991), Econometrics Analysis, first edition, Mc Millan Publishing Company.
6) Mike W.L.Cheung, Meta Analysis: A structural equation modeling Approach,Wiley
7) Rex B. Kline(2011), Principles and Practice of Structural Equation Modeling, Third Edition, TheGuilford Press, New York London
8) Naresh K. Malhotra and David F. Birks, Marketing Research: An Applied Approach, Third edition, Prentice Hall
9) Structural Equation Modelling (SEM**) by Dr. Suresh Sharma**
Day 1 - https://youtu.be/uWE1rChJtOs
10) Structural Equation Modelling (SEM**) by Dr. Suresh Sharma**
Day 3 - https://youtu.be/2VGIKmOZu9g

Course Code: US-TST-604

1. Neill A. : Life Contingencies, First edition, Heineman educational books London
2. Dixit S.P., Modi C.S., Joshi R.V.: Mathematical Basis of Life Assurance, First edition Insurance Institute of India.
3. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.
4. Asha Jindal (Ed.)(2018), Analysing and Visualising Data with R software- A Practical Manual, Shailja Prakashan, K.C.College

Course Code: US-TST-605

1. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
2. Kantiswarup, P.K. Gupta, Manmohan: Operations Research, Twelfth edition, Sultan Chand & sons.
3. Sharma S. D. : Operations Research, Eighth edition, Kedarnath Ramnath & Co.
4. Taha Hamdy A. : Operations Research : Eighth edition, Prentice Hall of India Pvt. Ltd.
5. Barlow R. E. and Prochan Frank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston.
6. Mann N. R., Schafer R.E., Singapurwalla N. D.: Methods for Statistical Analysis of Reliability and Life Data. First edition, John Wiley & Sons.
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