



HSNC UNIVERSITY, MUMBAI

(2025-2026)

Ordinances and Regulations With
Respect to
Choice Based Credit System (CBCS)
For the Programmes Under

The Faculty of Science and Technology

Framed According to the National Education Policy (NEP 2020)

To be implemented from Academic Year: 2025-2026

For the Course

Statistics

Curriculum – Third Year Undergraduate

Semester-V and Semester -VI

2025-2026



HSNC UNIVERSITY, MUMBAI

Board of Faculty of Science & Technology

Board of Studies in the Subjects of Statistics

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

- a) **Dr Asha Jindal**, Professor and (UG: Head & PG: Coordinator), 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**, Associate 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**; Professor and Former 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**, Senior Professor, Department of Statistics, Panjab University, Chandigarh.
Email ID ssharma643@yahoo.co.in, **Mobile No**-9815911381
- b. **Mr Mukesh Jain**, Vice President and Chief Technological Officer, Capgemini. Email ID mdjain@hotmail.com, **Mobile No**-7972637347.
- c. **Dr Santosh Gite**, Professor and Head, 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) **Mr. Neel More**((Postgraduate student 23-25) Email ID- neelmore85@gmail.com ; Mobile no- 9867374401
- b) **Ms. Sarrah Pittalwala** (undergraduate student 22-25) Email [ID;](mailto:sarrah.pittalwala@gmail.com) sarrah.pittalwala@gmail.com; Mobile no- 9892828381

Statistics

Part 1- Preamble

B. Sc. Statistics program is of minimum 120 credits cover six 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. Its 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. The thrust of the course is to prepare students to enter into a promising career even after graduation, as also provide to them a platform for pursuing higher studies resulting in post-graduate or doctorate degrees. The program has some unique features like number of elective courses and extensive computer training of statistical computations including standard software packages like IBM SPSS, Excel, MINITAB, R and PYTHON. The integration of continuous assessment, project work, and applied learning ensures that students develop not only academic knowledge but also critical thinking, ethical decision-making, and effective communication skills, essential for careers in statistics, data science, finance, research, and beyond. The curriculum supports the objectives of the National Education Policy (NEP 2020) by focusing on interdisciplinary collaboration, sustainable practices and lifelong learning.

1. Programme Outcomes

- 1) **Understanding Core Scientific Concepts:** Students will gain clear insight and understanding to recall key scientific principles across various fields. A well-established foundational knowledge of the subject will play a crucial role for deeper learning and future studies.
- 2) **Commit to Lifelong Scientific Learning:** Students will cultivate a habit of continuous learning and shall learn to stay updated with the latest scientific and technological advancements. This mindset will ensure that they remain relevant, engaged and informed throughout their future academic journey.
- 3) **Abilities to Analyse and Evaluate:** Students will learn to classify and scrutinize complex problems into manageable parts, critically analyse data, and evaluate potential solutions to scientific problems.
- 4) **Assessing Ethical Implications:** Students will be trained to evaluate the ethical dimensions of research and technological innovations, ensuring that their decisions consider societal impacts and they adhere to ethical standards. This is vital for responsible and sustainable practices.
- 5) **Design Experiments and Innovate:** Students will learn to design and conduct experiments, developing innovative solutions to challenges through Research Projects. They will also learn to evaluate their results and refine their experimental approaches over time.

- 6) **Application of Scientific and Technical Knowledge to Real-World Problems:** Students will use their scientific and Technical knowledge and expertise to identify and solve real-world problems. This would involve applying theoretical concepts to practical situations, bridging the gap between classroom learning, Industry-academia and real-life applications.
- 7) **Communicating Scientific Findings Effectively:** Students will develop the ability to communicate scientific information clearly and effectively, both in writing and verbally. Whether presenting research findings or writing technical reports, clear communication is key to knowledge sharing and collaboration.
- 8) **Foster an Interdisciplinary Approach:** Students will cultivate leadership and teamwork skills, enabling them to collaborate effectively in diverse, interdisciplinary teams. Leadership qualities such as decision-making and delegation will help them achieve successful outcomes in various projects.
- 9) **Promote Environmental Sustainability:** Students will understand the environmental impact of scientific activities and advocate for sustainable practices. By considering environmental factors in their work, they will contribute to the long-term health of the planet.
- 10) **Enhanced Skills for Entrepreneurship and Employability:** Students will be equipped with essential skills for entrepreneurship and employability, focusing on job readiness, soft skills, and practical business knowledge. Hands-on experience through internships and mentorship will further enhance their readiness for the job market and entrepreneurial ventures.

2. Program Objective: The main objectives of the course are-

- 1) Graduates will build a strong foundation in core statistical principles and methodologies, allowing them to apply statistical techniques to real-world problems.
- 2) Graduates will commit to lifelong learning and remain updated on emerging statistical methods, computational tools, and technological advancements.
- 3) Graduates will develop problem-solving and analytical skills, enabling them to apply statistical models and methods in various industries, including finance, healthcare, and research.
- 4) Graduates will demonstrate professionalism, ethical responsibility, and effective communication in multidisciplinary and collaborative environments.
- 5) Graduates will possess the skills necessary for employability and entrepreneurship, and they will be well-prepared to pursue higher education or careers in data analysis, statistical consulting, or related fields.

3. 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.

4. 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 two papers having three 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 soft skills like analysis using Statistical Software.

Several radical changes have been made in the syllabi. Firstly, the concept of having separate papers in practicals has been abandoned. All the numerical / practical work has been integrated with the teaching of theory courses. **Primarily, the numerical/practical work will be carried out on computers.**

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 statistics, agricultural statistics, weather forecasting, civil services, stock market, machine learning and artificial intelligence related job opportunities in Statistics.

5. Program-Specific Outcomes (PSOs)

- 1. Comprehension of Statistical Concepts:** Develop a strong foundational understanding of probability, statistical distributions, and inference.
- 2. Analytical and Critical Thinking:** Apply statistical techniques to analyze data, solve problems, and make informed decisions.
- 3. Technological Proficiency:** Gain hands-on expertise in statistical software such as R, Python, Excel, and Power BI for data analysis and visualization.
- 4. Data Interpretation and Experimentation:** Design experiments, interpret data meaningfully, and apply statistical reasoning in real-world applications.

5. **Interdisciplinary Integration:** Collaborate with other disciplines and integrate statistical methods for diverse applications like business, health, and environment.
6. **Communication and Collaboration:** Communicate statistical concepts effectively in both written and verbal formats, fostering teamwork and interdisciplinary collaboration.
7. **Ethics and Sustainability:** Ensure ethical data handling, emphasizing sustainable practices and societal responsibility.

6. Learning Outcomes:

Semester 5 – Course Outcomes

Probability and Distribution Theory

By the end of the course, students will be able to:

CO1	Apply advanced concepts of probability to solve theoretical and practical problems.
CO2	Use the Laws of Large Numbers and probability inequalities in statistical analysis.
CO3	Use Order Statistics for statistical inference and in the study of distributions.
CO4	Work with Joint Moment Generating Functions, and apply Trinomial and Multinomial Distributions.

Theory of Estimation

By the end of the course, students will be able to:

CO1	Distinguish between various types of estimators and understand their properties.
CO2	Construct and evaluate point estimators using criteria such as bias and mean square error.
CO3	Apply different methods of estimation, and construct confidence intervals for population parameters.
CO4	Implement Bayesian estimation and analyze effectively.

Statistics Everywhere (Indian Knowledge System)

By the end of the course, students will be able to:

CO1	Analyze the integration of statistical and probabilistic concepts in ancient Indian texts such as the <i>Arthashastra</i> , <i>Rigveda</i> , <i>Mahabharata</i> , and Jain mathematical treatises.
CO2	Apply descriptive statistical methods, including measures of central tendency and dispersion, to analyze ancient Indian data sets such as land measurements and trade records.
CO3	Investigate the role of statistical analysis in ancient Indian agriculture and various other domains of Indian society including rainfall prediction models and crop yield assessments.

Biostatistics (DSE-1)

By the end of the course, students will be able to:

CO1	Explain the spread and control of epidemics using mathematical models.
CO2	Estimate epidemic parameters using stochastic and deterministic models.
CO3	Understand and apply bioassay techniques for drug potency evaluation.
CO4	Analyze data from clinical trials and bioequivalence studies under various conditions.

Actuarial Statistics(DSE-2)

By the end of the course, students will be able to:

CO1	Calculate and interpret key measures in vital statistics and mortality tables.
CO2	Evaluate annuities under various conditions and scenarios.
CO3	Analyze assurance plans and compute benefits for different types of insurance contracts.

Applied Statistics (Vocational Minor-1 (BSc/BA)

CO1	Apply mathematical concepts to analyze economic behaviors, including demand and supply functions, elasticity, cost structures, and production theories.
CO2	Analyze and decompose time series data to identify trends, seasonal components, and cyclical patterns using various estimation methods.

Elementary Operations Research Techniques (Vocational-2)

CO1	Understand and apply the fundamental concepts of information theory, including entropy, mutual information, and channel capacity, to analyze and optimize communication systems.
CO2	Design and implement simulation models using Monte Carlo techniques to generate random variables from various distributions, and apply these models to solve real-world problems in areas such as inventory management and queuing systems.

Semester 6 – Course Outcomes

Distribution Theory and Stochastic Processes

By the end of the course, students will be able to:

CO1	Analyze and apply properties of the Bivariate Normal Distribution.
CO2	Analyze and model system reliability, and identify potential causes and solutions for failures.
CO3	Understand and model real-life processes using stochastic process theory.
CO4	Analyze and apply different queueing models, including M/M/1, M/M/c, M/M/∞, and (M/M/c) : (GD/ N /∞), to evaluate system performance metrics such as waiting times, queue lengths, and server utilization in diverse real-world scenarios.

Testing of Hypotheses

By the end of the course, students will be able to:

CO1	Formulate and test statistical hypotheses using various testing procedures.
CO2	Apply the Neyman-Pearson Lemma and Likelihood Ratio Tests for specific distributions.
CO3	Understand and implement Sequential Probability Ratio Tests (SPRT).
CO4	Apply non-parametric testing methods to real-world data and interpret results effectively.

Optimization Techniques:

CO1	Apply deterministic inventory models, including EOQ with constant demand and instantaneous replenishment, to optimize order quantities and minimize costs, incorporating safety stock calculations.
CO2	Evaluate and implement deterministic EOQ models with one and two price breaks and probabilistic models for single-period inventory decisions.
CO3	Evaluate and apply various replacement models—including individual and group replacement policies, and those accounting for depreciation and time value of money—to determine the optimal replacement strategies for equipment and machinery, thereby minimizing operational costs and maximizing efficiency.

Multivariate Analysis (DSE-3)

By the end of the course, students will be able to:

CO1	Build and interpret regression models involving single and multiple independent variables including quadratic and weighted models.
CO2	Detect and address common regression problems using SPSS.
CO3	Use dummy variables, conduct moderated regression.
CO4	Apply Factor, Confirmatory and structural equation modelling on real-life data.

Demography (DSE-4)

By the end of the course, students will be able to:

CO1	Analyse population dynamics in terms of size, structure, and composition.
CO2	Evaluate the impact of fertility, mortality on population growth or decline.
CO3	Apply demographic methods in policy planning and socio-economic analysis.
CO4	Construct and analyse different types of life tables to assess mortality patterns and life expectancy across diverse populations.

Network Models and Scheduling Techniques using MS Excel-I (Vocational -3)

CO1	Formulate and solve Linear Programming Problems (LPPs) using graphical methods and the Simplex method, including handling special cases and applying the Big M method for infeasible constraints.
CO2	Utilize Excel Solver to model and solve LPPs, applying duality theory to interpret economic implications and optimize product mix and production scheduling decisions.
CO3	Apply various methods (North-West Corner, Least Cost, Vogel's Approximation) to find initial basic feasible solutions for transportation problems.
CO4	Optimize transportation schedules using the MODI (UV) method in Excel Solver to minimize transportation costs and handle unbalanced or maximization-type problems.

Network Models and Scheduling Techniques using MS Excel-I (Vocational -4)

CO1	Formulate and solve Transshipment Problems using linear programming techniques to determine optimal transportation routes and schedules.
CO2	Apply the Hungarian method to solve Assignment Problems, including variants such as unbalanced and maximization-type problems, using MS Excel Solver.
CO3	Construct and analyze project networks using Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) to determine project timelines and identify critical activities.
CO4	Evaluate time and cost trade-offs in project scheduling through Crashing techniques to expedite project completion.

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

Sr. No.	Choice Based Credit System		Subject Code	Remarks
1	Core Course (Statistics)		STA301B, STA301D, STA302B, STA302D,	Nil
2	Elective Course	Discipline Specific Elective (DSE) Course		
		2.1	Interdisciplinary Specific Elective (IDSE) Course	
		2.2	Dissertation/Project	
		2.3	Generic Elective (GE) Course	
3	Ability Enhancement Courses (AEC)			
4	Vocational and Skill Enhancement Courses (VSEC)		STA302C, STA303C	

Third Year Semester V Internal and External Detailed Evaluation Scheme

Sr. No.	Semester	Subject Code	Subject Title	NEP Course Type	Hours Per Week					Credit	Seasonal Evaluation Scheme (Internal + External)			Total Marks
					Units	S. L. E.	L	T	P		S. L. E.	P A / A T	SE E	
1	V	STA301B	Probability and Distribution Theory	Major	3	20%	3	0	0	3	10	5	60	100
		STA301D	Practical Based on Probability and Distribution Theory						2	1			25	
2	V	STA302B	Theory of Estimation	Major	3	20%	3	0	0	3	10	5	60	100
		STA302D	Computer Applications & Practical Based on Theory of Estimation						2	1			25	
3	V	STA303B	Biostatistics	DSE	3	20%	3	0	0	3	10	5	60	100
		STA303D	Computer						2	1			25	

			Applications & Practical Based on Biostatistics											
4	V	STA304B	Actuarial Science	DSE	3	20%	3	0	0	3	10	5	60	100
		STA304D	Computer Applications & Practical Based on Actuarial Science						2	1			25	
5	V	STA301C	Statistics Everywhere	IKS	2		2	0	0	2		20	30	50
6	V	STA302C	Applied Statistics	VSEC Minor	2		0	0	2	2		10	40	50
7	V	STA303C	Elementary Operations Research Techniques	VSEC	2		0	0	2	2		10	40	50

***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		Hou rs	Total No. of hours	Cre dit	Total Marks
1	STA301B	I	Probability and Inequalities & Law of Large Numbers	15	45	3	100 (60+40)
		II	Order Statistics	15			
		III	Joint Moment Generating Function, Trinomial Distribution and Multinomial Distribution	15			
	STA301D	IV	Practical based on STA301B	30	30	1	
2	STA302B	I	Point Estimation and Properties of Estimators	15	45	3	100 (60+40)
		II	Methods of Point Estimation	15			
		III	Bayesian Estimation Method & Interval Estimation	15			
	STA302D	IV	Practical based on STA302B	30	30	1	
3	STA303B	I	Epidemic Models	15	45	3	100 (60+40)
		II	Bioassays	15			
		III	Clinical Trial and Bioequivalence	15			
	STA303D	IV	Practical based on STA303B	30	30	1	
4	STA304B	I	Compound Interest and Annuities Certain	15	45	3	100 (60+40)
		II	General Annuities and Life Annuities	15			
		III	Assurance Benefits	15			
	STA304D	IV	Practical based on STA304B	30	30	1	
5	STA301C	I	Foundations of Statistical Thought in Indian Knowledge Systems	10	30	2	50(30+20)
		II	Core Statistical Concepts in Indian Context	10			
		III	Applications of Statistics in Indian Society	10			

6	STA302C	I	Mathematical Economics	8	30	2	50
		II	Introduction to Time Series				
7	STA303C	I	Information Theory	8	30	2	50
		II	Simulation	7			

- **Lecture Duration – One hour**
- **One Credit =15 class room teaching hours.**

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

TYBSc SEM V Syllabus

Course Code: STA301B

Course Title: Probability and Distribution Theory (Major-Paper I)

Unit	Content	No. of Hours
I	<u>PROBABILITY</u> (i) Review of Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. (ii) Mathematical, Statistical, Axiomatic and Subjective probability. (iii) Review of Addition Theorem for (a) two events (b) three events (iv) Review of Conditional Probability: Multiplication Theorem for two events, three events. (v) Review of Bayes' theorem. (vi) Theorems on Probability of realization of : (a) At least one (b) Exactly m (c) At least m of N events $A_1, A_2, A_3 \dots A_N$. (vii) Matching and Guessing problems. Problems based on all above of them. <u>INEQUALITIES AND LAW OF LARGE NUMBERS</u> (i) Markov Inequality (ii) Tchebyshev's Inequality (iii) Boole's Inequality (iv) Cauchy Schwartz's Inequality (v) Weak law of large numbers. (Ref.9,10)	17
II	<u>ORDER STATISTICS</u> (i) Definition of Order Statistics based on a random sample. (ii) Derivation of: (a) Cumulative distribution function of r^{th} order statistic. (b) Probability density functions of the r^{th} order statistic. (c) Joint Probability density function of the r^{th} and the s^{th} order statistics ($r < s$) (d) Joint Probability density function of all n ordered statistics. (e) Distribution of Maximum observation (n^{th} order statistic) and Minimum observation (first order statistic) in case of uniform and	15

	Exponential distribution. (f) 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)	
III	JOINT MOMENT GENERATING FUNCTION, TRINOMIAL DISTRIBUTION AND MULTINOMIAL DISTRIBUTION (i) Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables. Concept and definition of Bivariate MGF. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between (X, Y). (ii) Trinomial distribution Definition of joint probability distribution of (X, Y). Joint moment generating function, moments μ_{rs} where $r=0, 1, 2$ and $s=0, 1, 2$. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between (X, Y). Distribution of the Sum $X+Y$. Extension to Multinomial distribution with parameters (n, $p_1, p_2, \dots, p_{k-1}$) where $p_1 + p_2 + \dots + p_{k-1} + p_k = 1$. Expression for joint MGF. Derivation of: joint probability distribution of (X_i, X_j) . Marginal & Conditional probability distribution of X_i .	13

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	(iii) Definition of Order Statistics based on a random sample. (iv) 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.

References:

1. Feller W: An introduction to probability theory and its 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,

Course Code: STA302B

Course Title: Theory of Estimation (Major-Paper II)

Unit	Content	No. of Hours
	Content	
	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 i. Unbiasedness: Definition of an unbiased estimator, Illustrations and examples. ii. Proofs of the following results: A. Two distinct unbiased estimators of $U(\theta)$ give rise to infinitely many unbiased estimators. B. If T is an unbiased estimator of θ then $U(T)$ is an unbiased estimator of $U(\theta)$ provided $U(\cdot)$ is a linear function. iii. Consistency: Definition of Consistency. Sufficient condition for consistency, proof & Illustrations iv. Sufficiency : Concept. Definition of sufficient statistic. Neyman's Factorization theorem (without proof). v. Relative efficiency of an estimator & illustrative examples. 1.5 Minimum variance unbiased estimator (MVUE) and Cramer Rao Inequality: A. Definition of MVUE B. Uniqueness property of MVUE (proof). C. Fisher's information function	

	D. Regularity conditions. E. Statement and proof of Cramer-Rao inequality. F. Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. G. Condition when equality is attained in Cramer Rao Inequality and its use in finding MVUE. 1.6 Rao Blackwell Theorem with proof and Application	
	<u>METHODS OF POINT ESTIMATION</u> 2.1 Method of Maximum Likelihood Estimation (M.L.E.): A. Definition of likelihood as a function of unknown parameter for a random sample from: Discrete distribution & Continuous distribution. B. Derivation of Maximum likelihood estimator (M.L.E.) for parameters of Standard distributions (case of one and two unknown parameters). C. Properties of MLE (without proof). 2.2 Method of Moments: A. Derivation of Moment estimators for standard distributions (case of one and two unknown parameters) B. 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	
	<u>BAYESIAN ESTIMATION METHOD & INTERVAL ESTIMATION</u> 3.1. Bayes Estimation: A. Prior distribution, Posterior distribution B. Loss function, Risk function C. Types of Loss function: Squared error Loss function (SELF), Absolute error Loss function (AELF) D. Bayes' risk. E. 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: A. Concept of confidence interval & confidence limits. B. Definition of Pivotal quantity and its use in obtaining confidence limits. C. Derivation of $100(1-\alpha)\%$ equal tailed confidence interval for : i. The population mean : μ when Population variance is known and Population variance is unknown. ii. $\mu_1 - \mu_2$ (population variance known/ unknown) iii. the population variance: σ^2, Ratio of variances iv. Confidence limits of Parameter θ from a uniform distribution in terms of Largest observations L and α, the given confidence coefficient. v. Confidence Interval for Median and Quartiles using Order Statistics	

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.) Derivation of MLE of the parameter for an Exponential distribution.
3	Bayes Estimation: Bayes' method of finding Point estimator (assuming SELF) for Poisson- Gamma Interval Estimation: 1. Concept of confidence interval & confidence limits. 2. Derivation of $100(1-\alpha)\%$ equal tailed confidence interval for : (a) The population mean : μ and $\mu_1 - \mu_2$ (population variance is unknown)

Online Resources

“Statistical Inference”, Prof. Somesh Kumar, IIT Kharagpur
available at NPTEL **LINK:** <https://nptel.ac.in/courses/111105043>

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1. Hogg R.V., Craig A.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
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9. Asha Jindal (Ed.)(2018), Analysing and Visualising Data with R software- A Practical Manual, Shailja Prakashan, K.C.College.
10. Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London
11. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R, second edition. Narosa
12. Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall /CRC Press, New York

Course Code: STA303B

Course Title: **Biostatistics (DSE-1)**

Unit	Content	No. of Hours
I	<u>EPIDEMIC MODELS</u> The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals (for 'a' introductions), Carrier model. 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	<u>BIOASSAYS</u> Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. 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. Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit and Logit analysis. (Ref.2, 3)	15
III	<u>CLINICAL TRIAL AND BIOEQUIVALENCE</u> 3.1 Brief History and Introduction to Clinical Research Brief history of clinical trials in India and worldwide. Common terminology used in clinical trials. Overview of phases like Pre-clinical phase, Phase-0 to Phase-IV. Ethics of clinical trials, Ethics Committee, and their responsibilities. 3.2 Study Designs and Methodology Study Designs: Parallel, Cross-Over (advantages and disadvantages). Study Protocol, Case Record/Report Form. Blinding (Single/Double). Randomized Controlled Trials (Placebo/Active Controlled). Types of Trials: Inferiority, Superiority, Equivalence, Multi-centric Trials. Inclusion and Exclusion Criteria. 3.3 Statistical Methods in Clinical Trials Use of Two Sample Tests (Parametric and Non-Parametric Tests). Analysis of Variance (One-way, Two-way, and Repeated Measures). Chi-square Test and Odds Ratio for Clinical Trial Data Analysis. 3.4 Bioequivalence Trial	15

	Definitions of Generic Drug Product, Bioavailability, and Bioequivalence. Pharmacokinetic (PK) Parameters: C _{max} , AUC _t , AUC _{0-∞} , T _{max} , K _{el} , T _{half} . 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). (Ref. 4, 5, 6, 7, 8)	
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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	Ethics of clinical trials, Ethics Committee and their responsibilities and its Need Types of Trials (Inferiority, Superiority and Equivalence, Multi-centric trial), Inclusion/Exclusion Criteria. Bioequivalence trial: Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (PK) parameters C _{max} , AUC _t , AUC _{0-∞} , T _{max} , K _{el} , T _{half} .

Online Resources

Unit-2 and Unit-3 : 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>)

References:

1. Bailey N.T.J. : 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.
7. Friedman L. M., Furburg C., Demets D. L. : Fundamentals of Clinical Trials, First edition, Springer Verlag.
8. Fleiss J. L. The Design and Analysis of Clinical Experiments, Second edition, Wiley and Sons.
9. Shein-Chung-Chow ; Design and Analysis of Bioavailability & Bioequivalence studies, Third Edition, Chapman & Hall/CRC Biostatistics series.

Course Code: STA304B

Course Title: Actuarial Science (DSE-2)

Unit	Content	No. of Lectures
I	<u>COMPOUND INTEREST AND ANNUITIES CERTAIN</u> Introduction to Life Insurance. Concept of Life tables and its functions l_x, q_x, d_x, p_x, 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 calculation, Comparison of all compounding methods. Concept of Annuity, Types of annuities. 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. (Ref.2,3)	15
II	General Annuities and Life Annuities Derivation for 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 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. Present values of Variable, increasing life annuities and increasing Temporary life annuities (immediate and due). Concept of Continuous annuity.	15
III	<u>ASSURANCE BENEFITS</u> Concept of Assurance, Benefit, Types of premiums: Single, Level Annual, Natural and Office premiums. Concept of Perpetuity, difference between annuity and Perpetuity. Derivation for Present value for perpetuity (immediate and due) with and without deferment Period. Present value of Assurance benefits in terms of commutation functions of: (i) pure endowment assurance (ii) temporary assurance (iii) endowment	15

	assurance (iv) whole life assurance (v) double endowment assurance (vi) special endowment assurance (vii) deferred temporary assurance. Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Redemption of loan concept and case study	
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Self-Learning topics (Unit wise)

Unit	Topics
1	Important functions l_x, q_x, d_x, p_x
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.
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
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

References:

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.

Course Code: STA301C

Course Title: Statistics Everywhere (Indian Knowledge System)

Unit	Content	No. of Lectures
I	<u>Foundations of Statistical Thought in Indian Knowledge Systems</u> 1.1 Indian Knowledge Systems (IKS): Understanding IKS as an interwoven part of Indian culture, philosophy, and practice. 1.2 Ancient Indian Texts and Data Collection (i) Arthashastra (Kautilya): Economic and demographic data collection, quantitative methods in governance and taxation (ii) Rigveda and Mahabharata: Early applications of probability and statistics in rituals and games of chance (iii) Jain Mathematics: Permutations, combinations, and early probabilistic reasoning. 1.3 Mathematical Contributions to Statistics (i) Aryabhata's early probability concepts in planetary motion models. (ii) Bhaskaracharya's statistical insights in algebra and combinatorial mathematics. (iii) Kerala School of Mathematics (Madhava): Contributions to series expansions and statistical applications. 1.4 Ethics in Ancient Indian Statistics (i) Role of data integrity in ancient census and economic surveys. (ii) Ethical considerations in taxation records and trade assessments	10
II	Core Statistical Concepts in Indian Context 2.1 Descriptive Statistics (i) Measures of central tendency and dispersion used in Vedic land measurements and trade. (ii) Concept of skewness and kurtosis in ancient economic planning. 2.2 Probability and Sampling (i) Ancient probability applications in dice games and gambling (e.g., Mahabharata) (ii) Sampling techniques in revenue collection and population estimation from Mauryan era. 2.3 Data Visualization and Measurement (i) Use of geometric techniques in astronomy and land surveys. (ii) Influence of Vedic mathematics on early data tabulation.	10
III	Applications of Statistics in Indian Society 3.1 Agriculture & Environmental Statistics (i) Ancient rainfall prediction models and monsoon cycle calculations (ii) Statistical analysis of crop yield and soil quality in traditional farming. 3.2 Healthcare & Ayurveda (i) Use of statistical inference in Ayurvedic formulations and Siddha medicine (ii) Traditional public health surveys and their role in early epidemic control.	10

	3.3 Economic and Social Statistics (i) Statistical tools for studying caste, gender, and rural-urban disparities . (ii) Use of statistical surveys in ancient and medieval Indian economic planning. 3.4 Modern Indian Statistical Systems (i) Evolution of census operations in India (1872–present) (ii) Role of NSSO, RBI, and SEBI in contemporary Indian statistics	
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References

1. Datta, B., & Singh, A. N. (1962). History of Hindu Mathematics: A Sourcebook. Asia Publishing House.
2. Plofker, K. (2009). Mathematics in India. Princeton University Press.
3. J. K. Ghosh, P. Maiti, T. J. Rao, and B. K. Sinha. (1999). Evolution of Statistics in India. International Statistical Review, ISI.
4. Singh, A.K. & Kapoor, K. (2021). Indian Knowledge Systems - Vol 1 & 2.
5. Mahalanobis, P.C. (1944). On large-scale sample surveys. Philosophical Transactions of the Royal Society B, 231(584), 329-451.
6. Srinivasan, T.N. (1994). Data Base for Development Analysis: An Overview. Journal of Development Economics, 44(1), 3-27.

Additional Reference:

- 1 Indian Knowledge Systems - Vol 1 & 2, Avadhesh K. Singh, Kapil Kapoor (2021)
- 2 Weighted Arithmetic Mean in Ancient India by Amartya Kumar Dutta, Bhavana Oct., 2017.
- 3 Official Statistics in India: The past and the present. T.J. Rao. Journal of Official Statistics vol. 26, no.2,2010.
- 4 Probability in Ancient India. C. K. Raju, Handbook of Philosophy of Statistics, edited by Paul Thagard Dov M. Gabbay and John Woods, handbook of Philosophy of Science, Elsevier, 2011.
- 5 Kautilya's Arthashastra: The Origin of Statistical Economics During -4ce By Balbir S. Sihag Jrsa, Vol. 2, No. 1, June-2013, Pp 1-14 Issn : 2278-4845
- 6 Statistics for everyone, Anil Gore, Sharayu Paranjpe, Madhav Kulkarni, SIPF Academy, Nashik, second edition, 2012
- 7 Basu, D. (1980). Statistical Information and Likelihood. Sankhya: The Indian Journal of Statistics.
- 8 Rao, C.R. (1992). R.A. Fisher: The Founder of Modern Statistics. Statistical Science, 7(1), 34-48.
- 9 Stigler, S.M. (1999). Statistics on the Table: The History of Statistical Concepts and Methods. Harvard University Press.
- 10 Sarukkai, S. (2005). Indian Philosophy and Philosophy of Science. Project of History of Indian Science, Philosophy and Culture. Centre for Studies in Civilizations.
- 11 Yadav, R.S. (2018). Ancient Indian Mathematics: Vedic, Post-Vedic and Modern Era. Journal of Applied Science and Computations, 5(10), 1320-1326.
- 12 Prasad, S. (2020). Digital Transformation of Official Statistics in India: Challenges and Opportunities. Journal of the Indian Society of Agricultural Statistics, 74(2), 97-104.

Course Code: STA302C

Course Title: Applied Statistics (Vocational Minor (BSc/BA))

Unit	Content	Credits
I	Mathematical Economics Introduction to Demand and Supply: Behaviour of Demand and Supply, Demand Functions, Elasticity of a Function, Elasticity of Demand, Complementary and Competitive Goods Cost Analysis and Market Structures: Cost Functions, Normal Conditions of Cost, Features of Perfect Competition, Monopoly and Duopoly Experiential Learning on Econometrics I : Demand And Supply Functions Econometrics II : Cost Analysis Econometrics III : Profit and Revenue Analysis Econometrics IV: Monopoly and Duopoly Isoquant Analysis and Cost Minimization: Isoquant and Isocost Lines, Ridge Lines, Expansion Path Production Theory and Optimization: Production Function, Euler's Theorem, Linear Homogeneous Production Function, Cobb-Douglas Production Function, CES Production Function, Elasticity of Substitution Experiential Learning on Econometrics V: Cobb-Douglas Production Function, CES Production Function, Elasticity of Substitution	1
II	Introduction to Time Series Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Multiplicative and additive models of time series. Trend estimation methods include the freehand curve method, the method of semi-averages, and the method of moving averages up to 5-point moving averages, fitting various mathematical curves. (Method, Merits and demerits, applications and Numerical and case study) Accuracy measurements: Inspectional method, Mean absolute percentage error, Root mean square error. Experiential Learning on Time Series: Trend Estimation Seasonal Component: Estimating seasonal component by Method of simple averages, Ratio to Trend, Ratio to Moving Averages and Link Relative method, and Deseasonalization. Experiential Learning on Time Series: Seasonal Estimation Time Series: Case Study on secondary data using Excel	1

Reference:

1. Allen, R. G. D. (Year). *Mathematical Economics*. Macmillan and Co. Ltd., London, & St. Martin's Press, New York.
2. Chiang, A. C. (1984). *Fundamental Methods of Mathematical Economics* (3rd ed.). McGraw-Hill.
3. Dowling, E. T. (1993). *Theory and Problems of Mathematical Methods for Business and Economics*. McGraw-Hill.
4. Dowling, E. T. (2004). *Introduction to Mathematical Economics* (Schaum's Outline Series in Economics). Tata McGraw-Hill.
5. Gujarati, D. N. (Year). *Basic Econometrics*. McGraw-Hill.
6. Gupta, S. C., & Kapoor, V. K. (Year). *Fundamentals of Applied Statistics*. Sultan Chand & Sons.

Course Code: STA303C**Course Title:** Elementary Operations Research Techniques (Vocational)

Unit	Content	Credits
I	<u>Information Theory</u> Introduction. Fundamental Theorem of Information Theory. Measures of Information. Properties of Entropy Function. Communication System. Memory less channel, Binary Symmetric channel, channel matrix, joint, marginal and conditional Entropies. $H(X, Y) = H(X/Y) + H(Y) = H(Y/X) + H(X)$ $H(X) \geq H(X/Y)$ Channel capacity, Efficiency and Redundancy, Encoding, Shannon – Fano Encoding Procedure. Experiential Learning: _____ Problem solving Information Theory-I and Information Theory-II	1
II	<u>Simulation</u> Concept and Scope of simulation. Monte Carlo Technique of Simulation Generation of random numbers using (i) Mid. Square Method and (ii) Multiplicative Congruential Method. Inverse method of generation of random observations from (i) Uniform distribution, (ii) Exponential distribution, (iii) Gamma distribution, (iv) Normal distribution. Experiential Learning: _____ Applications of Simulation techniques in queueing model Applications of Simulation techniques in inventory Applications of Simulation techniques in other domain Applications of Simulation techniques in inventory and queueing model, computer-aided (MS Excel) simulation problems	1

Reference:

1. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
2. Operations Research: S.D.Sharma. 11th edition, KedarNath Ram Nath & Company.
3. Operations Research: Kantiswaroop and Manmohan, Gupta. 12th Edition; S Chand & Sons.
4. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata McGraw Hill Publishing Company Ltd.
5. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
6. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.
7. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
8. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
9. Banerjee B. : Operations Research Techniques for management, 1st edition, Business Books.
10. Jerry Banks : Discrete-Event System Simulation, 4th and 5th edition, Pearson Education India.

Practical of Semester-VTotal Credit: 03

Major papers Practical

COURSE CODE: STA301D		COURSE CODE: STA302D	
Sr. No.	Practical topics from STA301B	Sr. No.	Practical topics from STA302B
1)	Probability-I	1)	Unbiasedness
2)	Probability-II	2)	Consistency
3)	Inequalities -I	3)	Sufficiency
4)	Inequalities -II	4)	MVUE and MVBUE
5)	Order statistics-I	5)	Methods of Estimation-I
6)	Order statistics-II	6)	Methods of Estimation-II
7)	Joint MGF	7)	Baye's Estimaion
8)	Trinomial and Multinomial Distribution	8)	Confidence Interval
		9)	Use of R software

DSE Practical:

COURSE CODE : STA303D		COURSE CODE: STA304D	
Sr. No.	Practical topics from STA303B	Sr. No.	Practical topics from STA304B
1)	Epidemic Models-1 (Deterministic Models)	1)	Mortality table
2)	Epidemic Models-2 (Carrier Models)	2)	Annuities-1
3)	Epidemic Models-3 (Chain Binomial Models)	3)	Annuities-2
4)	Direct Assays	4)	Annuities-3
5)	Parallel Line Assays	5)	Life Annuity-1
6)	Quantal Response Assays	6)	Life Annuity-2
7)	Clinical Trials-1	7)	Perpetuity
8)	Clinical Trials-2	8)	Assurance Benefit-1
9)	Bio-equivalence-1	9)	Assurance Benefit-2
10)	Bio-equivalence-2		

* Each practical will be based on 2 Hours 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/ SPSS / SPSS AMOS/ Excel.

**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)			STA306B STA306D STA307B STA307D	Nil
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course	STA308B STA308D STA309B STA309D STA304C	
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
4	Vocational and Skill Enhancement Courses (VSEC)			STA305C STA306C	

Third Year Semester VI Internal and External Detailed Evaluation Scheme

Sr. No.	Semester	Subject Code	Subject Title	NEP Course Type	Hours Per Week						Seasonal Evaluation Scheme (Internal + External)			Total Marks
					Units	S. L. E.	L	T	P	Credit	S. L. E.	PA / AT	SE	
1	VI	STA306B	Distribution Theory and Stochastic Processes	Major	3	20%	3	0	0	3	10	5	60	100
		STA306D	Practical Based on Distribution Theory and Stochastic Processes						2	1			25	
2	VI	STA307B	Testing of Hypotheses	Major	3	20%	3	0	0	3	10	5	60	100
		STA307D	Computer Applications & Practical Based on						2	1			25	

			Testing of Hypotheses											
3	VI	STA308B	Multivariate Analysis-I	DSE	3	20 %	3	0	0	3	10	5	60	100
		STA308D	Computer Applications & Practical Based on Multivariate Analysis						2	1			25	
4	VI	STA309B	Demography	DSE	3	20 %	3	0	0	3	10	5	60	100
		STA309D	Computer Applications & Practical Based on Demography						2	1			25	
5	VI	STA304C	Optimisation Techniques	DEE	2		2	0	0	2		20	30	50
6	VI	STA305C	Network Models and Scheduling Techniques using MS Excel-I	VSEC	2		0	0	2	2		10	40	50
8	VI	STA306C	Network Models and Scheduling Techniques using MS Excel-II	VSEC	2		0	0	2	2		10	40	50

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

Third Year Semester VI - Units – Topics – Teaching Hours

S. No.	Subject Code	Subject Unit Title		Hou rs	Total No. of hours	Cre dit	Tot al Marks
1	STA306B	I	Bivariate Normal Distribution and Reliability	15	45	3	100 (60+40)
		II	Stochastic Processes	15			
		III	Queuing Theory	15			
	STA306D	IV	Practical based on STA306B	30	30	1	
2	STA307B	I	Most Powerful Tests	15	45	3	100 (60+40)
		II	Uniformly Most Powerful & Likelihood Ratio Tests and Sequential Probability Ratio Tests	15			
		III	Non-Parametric Tests	15			
	STA307D	IV	Practical based on STA307B	30	30	1	
4	STA308B	I	Simple Linear Regression Model	15	45	3	100 (60+40)
		II	Multiple Linear Regression Model	15			
		III	Basics of Structural Equation Modelling (SEM)	15			
	STA308D	IV	Practical based on STA308B	30	30	1	

5	STA309B	I	Population Theories, Quality of Age Sex Data and Growth Model	15	45	3	100 (60+40)
		II	Measurement of Fertility and Reproduction, Measurement of Mortality	15			
		III	Construction of Life Tables	15			
	STA309D	IV	Practical based on STA309B	30	30	1	
3	STA304C	I	Inventory Control	15	30	2	50
		II	Inventory Control and Replacement	15			
6	STA305C	I	Linear Programming Problem	8	15	1	50 (25+
		II	Transportation problem	7			
		III	Practical based on	30	30	1	25)
7	STA306C	I	Transshipment Problem and Assignment problem	8	15	1	50 (25+
		II	Project Scheduling	7			
		III	Practical based on	30	30	1	25)

- Lecture Duration – One hour
- One Credit =15 class room teaching hours.

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: STA306B

Course Title : **Distribution Theory and Stochastic Processes**

Unit	Content	No. of Hours
I	BIVARIATE NORMAL DISTRIBUTION (i) Definition of joint probability distribution (X, Y). Joint Moment Generating function, moments μ_{rs} where $r=0, 1, 2$ and $s=0, 1, 2$. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between the random variables. Necessary and sufficient condition for the independence of X and Y. Distribution of $aX + bY$, where 'a' and 'b' are constants. (ii) Distribution of sample correlation coefficient when $\rho = 0$. Testing the significance of a correlation coefficient. Fisher's z – transformation. Tests for i) $H_0: \rho = \rho_0$ ii) $H_0: \rho_1 = \rho_2$, Confidence interval for ρ. (Ref. 2,3,5,9) <u>RELIABILITY:</u> Concept of reliability, Hazard-rate. Bath tub curve. Failure time distributions : (i) Exponential, (ii) Gamma, (iii) Weibull, (iv) Gumbel, Definitions of increasing (decreasing) failure rate. System Reliability. Reliability of (i) series (ii) parallel system of independent components having exponential life distributions. Mean Time to Failure of a system (MTTF). Application of Reliability	18

II	STOCHASTIC PROCESSES Definition of stochastic process. Examples of Stochastic Process, 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. Derivation of $P_n(t)$, mean and variance where ever applicable. (Ref.1,7,9)	12
III	QUEUEING THEORY 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/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)	15

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>

References:

Course Code:

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
10. Barlow R. E. and ProchanFrank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston.
11. Mann N. R., Schafer R. e., Singapurwalla N. D. : Methods for Statistical Analysis of Reliability and Life Data. First edition, John Wiley & Sons.

Course Code: STA307B

Course Title: **Testing of Hypothesis**

Unit	Content	No. of Lectures
I	<u>MOST POWERFUL TESTS</u> 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	<u>UNIFORMLY MOST POWERFUL& LIKELIHOOD RATIO TESTS</u> 2.1.Definition, Existence and Construction of Uniformly most powerful (UMP) test (Ref. 1,2,10) 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) <u>SEQUENTIAL PROBABILITY RATIO TESTS</u> 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
III	<u>NON-PARAMETRIC TESTS</u> 4.1.Need for non parametric tests. 4.2. Distinction between a parametric and a non parametric test.	15

	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)	
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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

REFERENCES:

- Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics, Fourth edition London Macmillan Co. Ltd.
- Hogg R.V. and Tanis E.A.: Probability and Statistical Inference, Third edition Delhi Pearson Education.
- Lehmann, E. L: Testing of Statistical Hypothesis, Wiley & Sons
- Rao, C. R.: Linear Statistical Inference and its applications, Second Edition Wiley Series in Probability and Statistics.
- Daniel W. W.: Applied Non Parametric Statistics, First edition Boston-Houghton Mifflin Company.
- Wald A.: Sequential Analysis, First edition New York John Wiley & Sons
- Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition New Delhi S. Chand & Company Ltd.
- Sanjay Arora and Bansilal: New Mathematical Statistics, Satya Prakashan, New Market, New Delhi, 5 (1989).
- Sidney Siegal & N John Castellan Jr.: Non parametric test for behavioral sciences, McGraw

Course Code: STA308B

Course Title: Multivariate Analysis-I (DSE-3)

Unit	Content	No. of Lectures
I	<u>Introduction</u> <u>Simple linear regression model</u> 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, Properties of least square estimators (without proof), Coefficient of determination R^2 and adjusted R^2 , Procedure of testing - Overall significance of the models - Significance of individual coefficients - Confidence intervals for the regression coefficients Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building, Moderated Regression Analysis: Concept and Case Study_ <u>Validity of Assumptions</u> Residual, Diagnostics in Linear Regression Model: Standardized residuals, Studentized residuals, residual plots, Interpretation of four plots and corrective measures such as transformation of response variable, Heteroscedasticity: Concept and detection using Graph and Breusch – Pagan-Godfrey Test Estimation of parameters for Weighted Least Square Method, Polynomial Regression Models (Ref. 1,2,3,4,5)	15
II	<u>Multiple linear regression model</u> Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models with 2 and k explanatory variables, Coefficient of determination R^2 and adjusted R^2 , Procedure of testing - Overall significance of the models - Significance of individual coefficients - Significance of incremental contribution of explanatory variable for $k=2$. - Confidence intervals for the regression coefficients Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building. <u>Validity of Assumptions</u> Autocorrelation: Concept and detection using Durbin Watson Test, Heteroscedasticity: Concept and detection using Graph and Breusch – Pagan-Godfrey Test Multicollinearity: Concept and detection using R^2 and t-ratios ii) pairwise correlation between repressors iii) Variance Inflation Factor(VIF),	15

	Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures, Dummy Variables (Ref. 1,2, 4,5)	
III	Basics of Structural Equation Modelling (SEM): - Introduction: measurement and structure models, variables and constructs, modelling strategies, conceptualization - Structural Equation Modelling: Six stages in Model Development, - Identification - Specification - Research design and related issues - SEM Model Estimation Measurement: Model Structure, Different Estimation Techniques, Issues of Identification - Model Validity Measurement Mode: GOFs - Specifying Structural Models: incorporating theoretical models - Model validity: Structural models GoFs, Competitive fit, Comparing Models - Exploratory and Confirmatory Factor Analysis: Conceptualization Difference between exploratory & confirmatory factor analysis, Objective of CFA, CFA model & assessing measurements, Model validity	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
I	Polynomial Regression Models
I	Diagnostics in Linear Regression Model: Standardized residuals, Studentized residuals, residual plots,
II	Variable selection and Model building
III	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

Reference:

Course Code: STA308B

- 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) DamodarGujrati, 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, The Guilford 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: STA309B

Title of paper: Demography (DSE-4)

Unit	Content	No. of Lectures
I	Population Theories, Quality of Age Sex Data and Growth Model: Coverage and content error in demographic data, Evaluation and adjustment of age-sex data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Introduction and sources of collecting data on vital statistics, error in census and registration data. Measurement of population, rate and ratio of vital events. Population composition, dependency ratio, adjustment of age data- use of Whipple, Myer and UN indices. Models of population growth and their fitting to population data.	15
II	Measurement of Fertility and Reproduction, Measurement of Mortality : Measurement of Fertility and Reproduction Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Gross Reproduction Rate (GRR) and Net Reproductive Rate (NRR). Measurement of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates.	15
III	Construction of Life Tables Life (Mortality) Tables: Assumption, description, Construction of Complete Life Table, Case studies on construction of Life Tables based on various Socio-demographic Characteristics and Uses of Life Tables. Abridged Life Table; Concept and construction of abridge life tables by Reed-Merrell method and King's method. Difference/Similarities in various Life Tables	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
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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](https://www.youtube.com/watch?v=hCZveJwP9Rg)

Reference

Course Code:

1. Pathak K.B. and Ram F., Techniques of Demographic Analysis, Himalaya Publishing House.
2. Gupta S.C. and Kapoor, V.K. (2008), Fundamentals of Applied Statistics, 4 th Edition (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.
9. Wolfenden, H.H. (1954), Population Statistics and Their Compilation, Am Actuarial Society.

Course Code: STA304C

Title of paper: Optimization Techniques

Unit	Content	No. of Lectures
I	<u>INVENTORY CONTROL</u> Introduction to Inventory Problem, Inventory Planning and control <u>Deterministic Models :</u> 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 Single item static EOQ models using Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks. ABC Analysis.	15
II	<u>INVENTORY CONTROL AND REPLACEMENT</u> <u>Probabilistic models :</u> Single period with (i) Instantaneous demand (discrete and continuous) without setup cost. (ii) Uniform demand (discrete and continuous) without set up cost. <u>REPLACEMENT</u> Replacement of items that deteriorate with time and value of money (i) remains constant, (ii) changes with time.	15

	Replacement of items that fail completely : Individual replacement and Group replacement policies.	
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Self-Learning topics (Unit wise)

Unit	Topics
2	Inventory Planning and control Examples of Safety Stock Calculation

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

Reference:

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.
7. Shrinath L. S. : Principles and application : PERT and CPM : Affiliated East West press pvt ltd.
8. 'Obtaining decision variables through simple approach in deterministic inventory control by Dr. Asha Jindal and Dr. Pankit Gandhi, International Journal of Research, Rizvi college

Course Code: STA305C

Course Title: Network Models and Scheduling Techniques using MS Excel-I (VSEC)

Objective: This paper focuses on the various types of scheduling problems and techniques that can be employed to solve concerned problems and to equip students with practical implication of LPP.

Unit	Topics	Credits
I	Network optimization models: Introduction, Basic concepts and Its Applications <u>Linear Programming Problem (L.P.P)</u> Mathematical Formulation and Introduction to Linear Programming Problem: Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal Solution. Graphical Solution for problems with two variables. and various cases Simplex Method :Simplex method of solving problem with two or more variables and solutions to various cases.. Concept of duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and dual. Economic interpretation of Dual, application of LP model to product mix and production scheduling problems.	1

	Experiential Learning: _____ i. Formulation of LPP ii. Graphical Methods in LPP(All Cases) iii. Simplex Method(Slack, Surplus and Artificial Variables) iv. Simplex Method with special cases(Degeneracy, Infeasible and Unbounded Solution) v. Duality vi. Solve LPP with Solver (Under Data toolpak)	
II	<u>Transportation problem</u> Introduction, Mathematical formulation as a linear programming problem, methods to find initial basic feasible solution (NWCM, LCM, VAM) and optimal solution (MODI), Variants in Transportation Problem: Unbalanced, Maximization type. Experiential Learning: _____ i. Obtaining Initial BFS solution of Transportation Problem ii. Obtain optimum route/schedule with minimum cost for Transportation Problem iii. Transportation problems: Special Cases iv. Solve Transportation Problem as a LPP (Solver).	1

References:

1. Quantitative Techniques For Managerial Decisions: J.K.Sharma, (2001), MacMillan India Ltd.
2. Mathematical Models in Operations Research: J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.
3. Operations Research: S.D.Sharma.11th edition, KedarNath Ram Nath& Company.
4. Operations Research: Kantiswaroop and Manmohan, Gupta. 12thEdition; S Chand & Sons.
5. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata McGraw Hill Publishing Company Ltd.
6. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
7. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and
8. Lawrence Friedman,(1959), John Wiley & Sons.
9. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
10. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
11. Banerjee B. : Operations Research Techniques for management 1st edition, Business Books.

Course Code: STA306C

Course Title: Network Models and Scheduling Techniques using MS Excel-II (VSEC)

Objective: This paper focuses on the various types of scheduling problems and techniques that can be employed to solve concerned problems and to equip students with practical implication of LPP.

Unit	Topics	Credits
I	<u>Transshipment Problem and Assignment problem:</u> Transportation problem: Extension to Transshipment Problem	1

	Experiential Learning: Obtain optimum route/schedule with minimum cost for Transshipment Problem Assignment problem: Introduction, Mathematical formulation as a linear programming problem, Hungarian method, Variants in Assignment Problem: Unbalanced, Maximization type, Travelling salesman problem: Branch and Bound solution algorithm. Experiential Learning: - i). Transshipment Problem - ii). Solve Assignment Problem - iii). Solve Assignment Problem: Special Case - iv). Solve Assignment Problem as a LPP (Solver). - v). Solve travelling salesman problem with/without Solver.	
II	<u>Project Scheduling:</u> Network representation of project, Project scheduling: critical path method and PERT, Types of Floats, Crashing: Time and cost trade-off. Extension to minimal spanning Tree Experiential Learning: - i). To perform Project scheduling of a given project (Deterministic case-CPM). - ii). To perform Project scheduling of a given project (Probabilistic case-PERT). - iii). To perform Crashing of a given Project. - iv). To Solve Minimal Spanning Tree and Various Floats - v). PERT-CPM with TORA	1

References:

12. PERT and CPM, Principles and Applications: Srinath. 2nd edition, East-West Press Pvt. Ltd.
13. Quantitative Techniques For Managerial Decisions: J.K.Sharma, (2001), MacMillan India Ltd.
14. Mathematical Models in Operations Research: J K Sharma, (1989), Tata
15. McGraw Hill Publishing Company Ltd.
16. Operations Research: S.D.Sharma. 11th edition, KedarNath Ram Nath & Company.
17. Operations Research: Kantiswaroop and Manmohan, Gupta. 12th Edition; S Chand & Sons.
18. Schaum Series book in O.R. Richard Bronson. 2nd edition Tata McGraw Hill Publishing Company Ltd.
19. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
20. Operations Research: Methods and Problems: Maurice Sasieni, Arthur Yaspan and
21. Lawrence Friedman, (1959), John Wiley & Sons.
22. Operations Research: H. A.Taha., 6th edition, Prentice Hall of India.
23. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
24. Banerjee B. : Operations Research Techniques for management 1st edition, Business Books.

Part – 7- Detailed Scheme Practical

COURSE CODE : STA306D		COURSE CODE : STA307D	
Sr. No.	Practical topics from STA306B	Sr. No.	Practical topics from STA307B
6.1.1	Bivariate Normal Distribution	6.2.1	Testing of Hypothesis
6.1.2	Tests for correlation and Interval estimation	6.2.2	Most powerful tests
6.1.3	Reliability	6.2.3	Likelihood Ratio tests
6.1.4	Stochastic Process-I	6.2.4	Uniformly most powerful tests
6.1.5	Stochastic Process-II	6.2.5	SPRT
6.1.6	Queuing Theory - I	6.2.6	Non-parametric Test - I
6.1.7	Queuing Theory - II	6.2.7	Non-parametric Test - II
6.1.8	Queuing Theory - III	6.2.8	Use of R software
6.1.9	Queuing Theory - IV		

COURSE CODE : STA308D		COURSE CODE : STA309D	
Sr. No.	Practical topics from STA308B	Sr. No.	Practical topics from STA309B
6.3.1	Simple Linear Regression using SPSS	6.4.1	Evaluation and adjustment of age-sex data,
6.3.2	Weighted Estimation using SPSS	6.4.2	Population Growth Models
6.3.3	Multiple Linear Regression using SPSS	6.4.3	Measurements of Mortality
6.3.4	Regression Diagnostics	6.4.4	Measurements of Fertility
6.3.5	Quadratic Regression and Regression with Dummy Variables using SPSS	6.4.5	Measurement of Reproduction
6.3.6	Moderated Regression Analysis using SPSS	6.4.6	Construction of Complete Life Table
6.3.7	EFA	6.4.7	Construction of Abridged Life Table
6.3.8	CFA		
6.3.9	Structural Equation Model		

*** Each practical will be based on 2 hours 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.**

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.

Examination Pattern for Third Year Degree as per NEP 2020 Academic Year 2025-2026**1) Evaluation of Major and Minor Subjects**

Subject	Formative Assessment (Marks)	Summative Assessment (Marks)
Major Subject	40	60
Minor Subject	40	60
Major (Practical based Subject)	-	25
Minor (Practical based Subject)	-	25
General Elective (GE/OE)	20	30

FORMATIVE 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). Formative Assessment – 40**1. For Theory Courses**

Sr.No.	Particulars	Marks
1	Assessment of Practical exercise / case study / presentation, assignment presentation / MCQ designed with experiential learning and hands on learning experience OR	20/25 Marks
2	Self-Learning Evaluation	10 Marks
3	Active participation in routine class instructional deliveries	5 Marks

2. Practical's (internal Components of the Practical Course)**40 marks****For Courses with Practical**

Each practical course can be conducted out of 50 marks with 10 marks for internal **component of the Practical** and 40 marks for formative assessment which will be converted to 25 marks.

(i) Practical's (Internal component of the Major and DSE Practical Course)

Sr. No	Evaluation type	Marks
1	Journal	5
2	Viva	5

(ii) Practical's (Internal component of the Vocational Practical Course)

Sr. No	Evaluation type	Marks
1	Journal	10
2	Class Participation and Attendance	10

B). SUMMATIVE ASSESSMENT =SEMESTER END EXAMINATION :-

It is defined as the examination of the learners on the basis of performance in the semester end theory / written examinations.

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

a. For Theory Courses

i) Duration – 2 Hours

Theory Question Paper pattern for Major and DSE Papers of 60 Marks:

Sr. No.	All questions are Compulsory.	Marks
Q. 1	Attempt either a & b or p & q based on unit 1.	20
Q. 2	Attempt either a & b or p & q based on unit 2.	20
Q. 3	Attempt either a & b or p & q based on unit 3.	20

ii) Duration – 1 Hours

Theory Question Paper pattern for IKS Papers of 30 Marks:

Sr. No.	All questions are Compulsory.	Marks
Q. 1	Attempt any two out of four based on unit 1.	10
Q. 2	Attempt any two out of four based on unit 2.	10
Q. 3	Attempt any two out of four based on unit 3.	10

Theory Question Paper pattern for DSE Papers of 30 Marks:

Sr. No.	All questions are Compulsory.	Marks
Q. 1	Attempt any two out of four based on unit 1.	15
Q. 2	Attempt any two out of four based on unit 2.	15

b. For Practical Courses

(i) Duration – 2 Hours

Practical Question Paper for Major and DSE Papers of 40 Marks:-

Sr. No.	All questions are Compulsory.	Marks
Q. 1	Attempt any three out of five based on unit 1.	10
Q. 2	Attempt any three out of five based on unit 2.	10
Q. 3	Attempt any three out of five based on unit 3.	10
Q.4	Attempt any three out of five based on all units.	10

(ii) Duration – 3 Hours

Practical Question Paper for Vocational Papers of 80 Marks:-

Sr. No.	All questions are Compulsory.	Marks
Q. 1	Attempt any two out of three based on unit 1 Theory.	20
Q. 2	Attempt any two out of three based on unit 1 Practical.	20
Q. 3	Attempt any two out of three based on unit 2 Theory.	20
Q. 4	Attempt any two out of three based on Unit 2 Practical.	20