HSNC University Mumbai

(2024-2025)

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: 2024-2025

For the Course

Statistics

Curriculum – Second Year Postgraduate

Semester-III and Semester –IV

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,** 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;** Professor and 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, 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. Ruchi Pasad** (Postgraduate student 23-24) Email ID-skruchi13@gmail.com; Mobile no-9967281346

b) **Mr. Advitiya Tejasvi** (undergraduate student 23-24) Email ID-tadvitiya@gmail.com; Mobile no- 7761934693

Statistics

Part 1- Preamble

M. Sc. Statistics program is of minimum 80 credits cover four 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. The program emphasizes both theory and modern applications of statistics and is structured to provide knowledge and skills in depth necessary for the employability of students in industry, in academics, government and non-government organizations/agencies. The NEP program has some unique features like independent projects, number of elective courses and extensive computer training of statistical computations including standard software packages like SPSS, SPSS-AMOS, MS-Excel, MINITAB, R and PYTHON etc. Due to State Public Cluster University, the Statistics department of K.C.College got the academic autonomy and it's been utilized to add the new and need based elective courses. The independent project work is one among the important components of this program. The syllabus of the first year (two semesters) covers most of the core courses. In the second year of the syllabus, there are six core/major courses, one minor course and 12 credits two projects. The syllabus has been framed to possess a decent balance of theory, methods and applications of statistics. It is possible for the students to study basic courses from other disciplines like economics, life sciences, computer science and Information Technology in place of optional/electives. The thrust of the course is to prepare students to enter into a promising career after post-graduation, as also provide to them a platform for pursuing higher studies resulting in doctorate degrees.

1. Program Outcomes:

1. **Understanding Core Statistical Concepts**: Students will develop a clear insight and understanding of key statistical principles, including probability theory, inferential statistics, and data analysis. A strong foundational knowledge of these concepts will be essential for deeper learning and future studies in statistics.
2. **Commit to Lifelong Statistical Learning**: Students will cultivate a habit of continuous learning to stay updated with the latest statistical methods, technologies, and software. This mindset will ensure they remain relevant, engaged, and informed throughout their academic and professional careers.
3. **Abilities to Analyze and Evaluate Data**: Students will learn to classify, interpret, and break down complex datasets into manageable parts. They will develop the skills to critically analyze statistical data and evaluate various models, solutions, and hypotheses in real-world contexts.
4. **Assessing Ethical Implications in Data Analysis**: Students will be trained to consider the ethical dimensions of data collection, analysis, and interpretation. They will ensure that their statistical work adheres to ethical standards, especially concerning privacy, data security, and fairness in research.
5. **Designing Statistical Experiments and Innovation**: Students will gain the skills to design and conduct statistical experiments or studies, develop innovative approaches to data collection, and refine their methodologies based on results. Research projects will foster creativity and precision in statistical applications.
6. **Application of Statistical Knowledge to Real-World Problems**: Students will apply statistical theories and methods to solve real-world problems in various sectors, including finance, healthcare, industry, and public policy. This involves translating statistical findings into actionable insights for decision-making.
7. **Communicating Statistical Findings Effectively**: Students will develop the ability to communicate complex statistical results clearly and effectively, both in writing and verbally. Whether presenting research findings, writing technical reports, or creating visualizations, clear communication is crucial for collaboration and knowledge sharing.
8. **Foster an Interdisciplinary Approach to Statistics**: Students will develop the ability to work collaboratively in diverse, interdisciplinary teams. They will cultivate leadership skills such as decision-making and teamwork to achieve successful outcomes in data-driven projects across different domains.
9. **Promote Ethical and Sustainable Data Practices**: Students will understand the societal and environmental impact of statistical work and advocate for responsible, ethical, and sustainable data practices. This will help ensure the long-term positive impact of data-driven decisions on society and the environment.

10. **Enhanced Skills for Data-Driven Entrepreneurship and Employability**: Students will be equipped with essential skills for entrepreneurship and employability in data-driven industries. This includes job readiness, proficiency in statistical software, and practical business knowledge. Internships, hands-on experience, and mentorship will further enhance their readiness for the job market and entrepreneurial ventures.

2. Program Objectives:

1. **Mastery of Statistical Methods**: Equip students with comprehensive knowledge of statistical techniques and methodologies, enabling them to solve real-world problems and make informed decisions in diverse fields like industry, academics, and government.
2. **Application of Statistical Software**: Foster proficiency in the use of statistical software like SPSS, R, Python, and others for data analysis, interpretation, and presentation of statistical findings.
3. **Critical Thinking and Problem Solving**: Develop critical thinking and analytical problem-solving skills in students to tackle statistical challenges effectively.
4. **Interdisciplinary Approach**: Encourage students to apply statistical knowledge to interdisciplinary areas such as economics, life sciences, computer science, and data science.
5. **Research and Development Readiness**: Prepare students for higher research and development roles by introducing them to independent projects, research methodologies, and modern data science techniques.

3. Process adopted for curriculum designing.

The department has conducted multiple meetings with academician, industry experts. After discussion with them, the changes in the syllabus were introduced with the view that students need to learn the core concepts in detail.

4. Salient features, how it has been made more relevant:

After discussion and interaction with the members of BOS and understanding the requirement of the industries certain changes in the syllabus are introduced. Seminars, Interaction with Industry Experts, Field Visits and upcoming technologies like Contingencies, FOSS R/ Python, Data Science etc. have been added keeping the upcoming trends in the field of Statistics.

5. Learning Outcomes:

1. **Technical Proficiency**: Students will be proficient in advanced statistical methods like nonparametric inference, time series analysis, and SEM, applying them across various industries and research areas.

2. **Software Skills**: Students will be adept at using statistical software such as SPSS, AMOS, R, and Python for data analysis, allowing them to present clear and reliable statistical results.
3. **Research Competency**: Through project-based learning, students will develop strong research skills, enabling them to contribute to academic and industrial research effectively.
4. **Problem-Solving Abilities**: Graduates will possess the ability to critically analyze complex statistical problems and develop innovative solutions using both theoretical and practical approaches.
5. **Market Readiness**: With hands-on experience in statistical analysis and real-world applications, students will be prepared for careers in sectors like data science, quality control, and academic research.

Course Outcomes of Semester III

Nonparametric Inference (STA601B)

1. **Unit I: Introduction to Nonparametric Inference and Randomness Tests**
    - Understand the foundational principles of nonparametric inference and apply tests for randomness and runs in real datasets.
    - Perform nonparametric estimation and evaluate properties like UMVUE of U-statistics.
2. **Unit II: Two-Sample Problem and Linear Rank Statistics**
    - Apply nonparametric methods to two-sample problems, including goodness-of-fit and linear rank tests.
    - Conduct and interpret tests such as Wilcoxon-Mann-Whitney, Kolmogorov-Smirnov, and Mood tests.
3. **Unit III: c-Sample Problem and Multivariate Extensions**
    - Analyze multi-sample problems using nonparametric techniques such as Kruskal-Wallis and Jonckheere-Terpstra tests.
    - Understand and apply multivariate rank tests and correlation methods like Kendall's and Spearman’s.

Design of Experiments (STA602B)

1. **Unit I: Basic Designs**
    - Understand and implement basic experimental designs such as Randomized Block and Latin Square Designs.

- Analyze Balanced Incomplete Block Designs and evaluate model adequacy for these designs.

2. **Unit II: Factorial Experiments and Confounding**
   - Analyze two-factor factorial experiments and understand confounding in factorial designs.
   - Implement fractional replication and split-plot designs, analyzing model adequacy and estimation parameters.
3. **Unit III: Response Surface Methods**
   - Apply response surface methods for optimization and experiment design.
   - Implement techniques such as steepest ascent and analyze second-order response surfaces for improving processes.

Time Series Analysis (STA603B)

1. **Unit I: Introduction to Time Series**
   - Understand components of time series and apply techniques for trend estimation and seasonal adjustment.
   - Implement methods such as moving averages and exponential smoothing for time series forecasting.
2. **Unit II: Time Series Formulation and Stationarity**
   - Analyze time series as stochastic processes, and understand concepts of stationarity.
   - Evaluate autocorrelation and partial autocorrelation functions for time series modeling.
3. **Unit III: Time Series Models**
   - Fit and interpret AR, MA, ARIMA, and SARIMA models to non-stationary and seasonal time series data.
   - Apply model diagnostic tools such as AIC/BIC and residual analysis for forecasting accuracy.

Structural Equation Modeling (STA604B)

1. **Unit I: Basics of Structural Equation Modeling (SEM)**
   - Understand core concepts of SEM, including path analysis and factor analysis.
   - Differentiate between endogenous and exogenous constructs and recursive and non-recursive models.
2. **Unit II: Measurement Models**
   - Conduct confirmatory factor analysis (CFA) and assess model fit indices (e.g., RMSEA, CFI, TLI).

- Evaluate the reliability and validity of SEM models through composite reliability and Cronbach's Alpha.

3. **Unit III: Moderation, Mediation, and Latent Growth Models**
   - Analyze complex SEM models involving mediation and moderation using AMOS or PROCESS macros in SPSS.
   - Understand and apply multi-group analysis and latent growth modeling for structural equation analysis.

Course Outcomes of Semester IV

Stochastic Processes (STA605B)

1. **Unit I: Basics of Stochastic Processes**
   - Understand the fundamental concepts of stochastic processes, such as Markov chains, transition probabilities, and classification of states.
   - Solve practical problems involving random walks, gambler's ruin, and stationary distributions.
2. **Unit II: Advanced Stochastic Processes I**
   - Analyze branching processes and extinction probabilities.
   - Apply continuous-time Markov chains and Kolmogorov's forward and backward equations in various applications.
3. **Unit III: Advanced Stochastic Processes II**
   - Understand and implement Poisson processes, including inter-arrival time distributions and compound Poisson processes.
   - Study birth-death processes, renewal processes, and their applications in real-life phenomena.

Survival Analysis (STA606B)

1. **Unit I: Concept of Censoring and Distributions**
   - Understand survival data and handle various censoring mechanisms (Type I, Type II, random).
   - Derive and apply survival and hazard functions for distributions such as Exponential, Weibull, and Lognormal.
2. **Unit II: Advanced Inference for Survival Data**
   - Estimate failure rates and mean residual life and understand their properties.

- Apply parametric models to censored data and perform inference for exponential and Weibull distributions.

3. **Unit III: Estimation and Two-Sample Problems**
    - Use the Kaplan-Meier estimator for survival functions and conduct log-rank tests.
    - Analyze two-sample problems and apply Cox proportional hazards models for survival data analysis.

Statistical Process Control (STA607B)

1. **Unit I: Control Charts and Multivariate Control Charts**
    - Implement control charts for variables and attributes (e.g., X-bar, R-chart, np-chart, p-chart) to monitor process quality.
    - Understand and apply multivariate control charts for monitoring multiple variables in a process.
2. **Unit II: Cumulative-Sum Charts and Process Capability Analysis**
    - Use cumulative-sum (CUSUM) charts and exponentially weighted moving average charts to detect small shifts in processes.
    - Perform process capability analysis and estimate indices like Cp, Cpk, and Cpm to assess process performance.
3. **Unit III: Acceptance Sampling Plans**
    - Design and evaluate single, double, and sequential acceptance sampling plans.
    - Understand operating characteristic curves (OC), average outgoing quality limit (AOQL), and average total inspection (ATI) in sampling plans.

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

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Statistics**)			STA601B, STA602B STA603B, STA601D, STA602D, STA603D	
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)				
	Skill Enhancement Courses (SEC)				
4	Minor			STA604B STA604D,	Structural Equation Modeling
5	Research Individual Project			STA601A	

Second Year Semester III 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	A	SEE	
1	III	STA601B	Nonparametric Inference	Major	3	20 %*	3	0	0	3	10	5	60	100
		STA601D	**Computer Applications & Practical** Based on Nonparametric Inference						2	1			25	
2	III	STA602B	Design of Experiments	Major	3	20 %*	3	0	0	3	10	5	60	100
		STA602D	**Computer Applications & Practical** Based on Design of Experiments						2	1			25	

3	III	STA603B	Time Series Analysis	Major	3	20 %*	3	0	0	3	10	5	60	100
		STA603D	**Computer Applications & Practical** Based on Time Series Analysis						2	1			25	
4	III	STA604B	**Structural Equation Modelling**	Minor	3	20 %*	3	0	0	3	10	5	60	100
		STA604D	**Computer Applications & Practical** Based on Structural Equation Modelling						2	1			25	
5	III		**Individual Statistical Project**							4				(50 Internal + 50 External) = 100
		Total Hours / Credit								20				500

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

SLE: Self Learning Evaluation; L: Lecture; T: Tutorial; P: Practical; CT: Class Test;
AT: Attendance; PA: Practical; SEE: Semester End Exam

Second Year Semester – III Units – Topics – Teaching Hours

S. No	Subject Code	Subject Unit Title		Hours / Lectures	Total No. of hours /lectures	Credit	Total Marks
1	STA601B	I	Introduction, Tests for randomness and One sample Problem	15	45H	3	
		II	Two Sample Problem and Linear Rank Statistics	15			
		III	The General c sample Problem	15			
	STA601D	IV	Practical based on STA601B	30	30H	1	
2	STA602B	I	Design of Experiment	15	45 H	3	100 (60+40)
		II	Factorial Experiments I	15			
		III	Response Surface Methods	15			
	STA602D	IV	Practical based on STA602B	30	30H	1	
3	STA603B	I	Introduction	15	45 H	3	100 (60+40)
		II	Time Series Formulation	15			
		III	Time Series Models	15			
	STA603D	IV	Practical based on STA603B	30	30H	1	
4	STA604B	I	Basics of Structural Equation Modeling (SEM)	15	45 H	3	100 (60+40)
		II	Measurement Models	15			
		III	Structural Equation Modeling , Moderation, Mediation, Multi-group Analysis and Latent Growth Models	15			
	STA604D	IV	Practical based on STA604B	30	30H	1	
5	STA601A	I	Individual Statistical Project	120	120H	4	100
			TOTAL			20	500

- **Lecture Duration – 1 hour**
- **One Credit =15 Classroom 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

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: STA601B
Title of Paper: **NONPARAMETRIC INFERENCE**

Unit	Content	No. of Hours
I	**Introduction, Tests for randomness and One sample Problem**: 1.1 Introduction to Nonparametric Inference**,** Estimable parametric functions, kernel, symmetric kernel, one sample U-Statistic. Two sample U-Statistic, asymptotic distribution of U-Statistics, UMVUE property of U-Statistics. 1.2 Empirical distribution function, confidence intervals based on order statistics for quantiles, tolerance regions. 1.3 Tests for Randomness: Tests based on the total number of runs and runs up and down. 1.4 Rank-order statistics. 1.5 One sample and paired-sample techniques: Sign test and Wilcoxon signed-rank test.	15
II	**Two Sample Problem and Linear Rank Statistics:** 2.1 Goodness of fit problem: Chi-square and Kolmogorov-Smirnov tests. 2.2 The General Two sample Problem: Two sample stochastic dominance problem, stochastic modelling of two sample location and scale problems in Nonparametric setting. Wald Wolfwilz run test and Kolmogorov –Smirnov two sample test. 2.3 Linear Rank Statistics: Introduction to Linear Rank Statistics and its limiting distribution. 2.4 Tests for two-sample location problem: Wilcoxon-Mann-Whitney, Terry-Hoeffding, Van der Waerden, Median tests. 2.5 Tests for two-sample scale problem: Mood, Klotz, Capon, Ansari-Bradley, Siegel – Tukey and Sukhatme tests.	15
III	**The General c sample Problem :** 3.1 Tests for the c-sample problem: Kruskal-Wallis, Jonckheere- Terpstra tests. 3.2 Rank test, MP and LMP rank tests. 3.3 Independence in bivariate sample: Kendall's and Spearman's rank correlation. 3.4 Pitman asymptoitic relative efficiency. 3.5 Concepts of Jackknifing, method of Quenouille for reducing bias, Bootstrap methods.	15

Self-Learning topics (Unit wise)

Unit	Topics
1	Introduction to Nonparametric Inference
2	Goodness of fit problem: Chi-square and Kolmogorov-Smirnov tests
2	Introduction to Linear Rank Statistics
3	Kruskal-Wallis
3	Independence in bivariate sample: Kendall's and Spearman's rank correlation, Equality of k independent samples

Online Resources

Non-parametric Statistical Inference by Prof. Niladri Chatterjee https://nptel.ac.in/courses/111/102/111102143/

Course Code: STA602B
Title of Paper: Design of Experiment

Unit	Content	No. of Hours
1	**Design of Experiment** 1.1 Basics of Design of Experiments, Review of Randomised block design and Latin square design, Youden Square Design, Balanced incomplete block design, PBIBD, Lattice design : Statistical analysis, Estimation of parameters, Model adequacy checking for all designs. 1.2 Design useful for two way elimination of heterogeneity and their general method of analysis by using fixed effect model.	15
2	**Factorial Experiments and Confounding** 2.1 Two factor factorial experiment: Statistical analysis of fixed effect model, Model adequacy Checking, Estimation of parameters. 2^2 , 2^3 , 2^k , 3^2 ,$3^3$and 3^k factorial experiment. 2.2 Factorial designs with mixed levels. 2.3 Confounding in 2^2 , 2^3 factorial designs: Complete confounding, partial confounding, fractional replication and split-plot designs.	15
3	**Response Surface Methods:** 4.1 Introduction, The method of steepest ascent, Analysis of second order response surface, Experimental designs of fitting response surfaces. 4.2 The Taguchi approach to parameter design	15

Self-Learning topics (Unit wise)

Unit	Topics
1	Basics of Design of Experiments, Randomised block design, Latin square design
1	Balanced incomplete block design
2	Confounding, Partial confounding.

Online Resources

Analysis of Variance and Design of Experiments, Swayam Prabha Course, MOE, GOI by Prof. Shalabh, IIT Kanpur **http://home.iitk.ac.in/~shalab/spanova.htm?fbclid=IwAR3mmXTpm6P6BSnoaAX25qkyrLx9LGy5SXLj3CodHFYWwHrnL-5IKI5f6SI**

Course Code: STA603B
Title of paper: Time Series Analysis

Unit	Content	No. of Hours
1	Introduction 1.1 Definition of time series .Its component. Models of time series. 1.2 Estimation of trend by: i) Freehand curve method ii) method of semi average iii)Method of Moving average iv) Method of least squares(linear trend only) 1.3 Estimation of seasonal component by i) method of simple average ii) Ratio to moving average iii) Ratio to trend method iv) Link relative method. 1.4 Exponential smoothing for single parameter. Accuracy measurements: Mean absolute percentage error, Root mean square error.	15
2	Time Series Formulation : 2.1 Mathematical Formulation of time series. Time series as a discrete parameter stochastic process. Concept of strict stationary, stationary upto order 'm', Mean stationary, covariance stationary. Proof of "A strict stationary process will also be covariance stationary provided moments of order 2 exists". Counter example for disproving converse. Concept of Gaussian time series. Examples for mean stationary, covariance stationary, Gaussian time series. 2.2 Auto covariance function (ACVF) and its properties. Auto correlation function (ACF) and its properties. Partial auto correlation function (PACF). 2.3 Portmanteau tests for noise sequences, transformation to obtain Gaussian series. 2.4 Auto regressive (AR), Moving average (MA) and Autoregressive moving average (ARMA), Stationary and inrevertibility conditions. Estimation of mean, auto covariance and autocorrelation functions, Yule-Walker estimation.	15
3	Time Series Models I: 3.1 Non-stationary and seasonal time series models: Auto regressive integrated moving average (ARIMA) models, Seasonal ARIMA (SARIMA) models, Transfer function models (Time series regression). Estimation of ARIMA model parameters, maximum likelihood method, large sample theory (without proofs). Choice of AR and MA periods, AIC, BIC. 3.2 Residual analysis and diagnostic checking, Unit-root non-stationarity, unit-root tests.	15

Self-Learning topics (Unit wise)

Unit	Topics
1.1	Definition of time series .Its component.
2.2	Auto covariance function (ACVF) and its properties. Auto correlation function (ACF) and its properties. Partial auto correlation function (PACF).
3.1	Auto regressive (AR), Moving average (MA) and Autoregressive moving average (ARMA)
3.2	Auto regressive integrated moving average (ARIMA) models

Online Resources

"Applied Time Series Analysis" by Prof Arun K. Tangirala, Department of Chemical Engineering, IIT Madras **Source: https://nptel.ac.in/courses/103/106/103106123/**

Course Code: STA604B

Title of paper: Structural Equation Modelling(Minor)

Unit	**Content**	**No. of Hours**
1	Basics of Structural Equation Modeling (SEM): 1.1 Introduction to SEM 1.2 Different Concepts and Terminology Related to SEM-endogenous & exogenous constructs, recursive & formative constructs, recursive and non-recursive models 1.3 Sample size considerations in SEM 1.4 Path Analysis-direct and indirect effects 1.5 Explanatory Factor Analysis (EFA)	15
3	**Structural Equation Modeling , Moderation, Mediation, Multi-group Analysis and Latent Growth Models** 3.1 Structural Equation Modeling **Moderation and Mediation using AMOS and/or PROCESS macros in SPSS** Installing process macros in SPSS : PROCESS is a macro for SPSS, SAS, and R that conducts observed-variable mediation, moderation, and conditional process analysis. It is documented in Appendices A and B of Hayes (2022). PROCESS can be found at www.processmacro.org http://afhayes.com/spss-sas-and-r-macros-and-code.html 3.2 Mediation Analysis in SEM: incorporating mediating variables	**15**

	a) Serial mediation using Process macro(model 6), modration of mediation effect (model 59), b) Parallel Mediation (Model 4), Multiple independent variables in process (model 4), Moderated serial mediation (model 92), 3.3 Moderation Analysis in SEM: incorporating moderating variables a) continuous moderator using process macro, continuous moderator using interaction software, continuous moderator with more than two categories using process macros, b) categorical moderator with two categories with using process macro model 1,categorical moderator with three categories with using process macro model 1, Mediation using Process macro(model 4), 3.4 Moderated mediation on scale data (model 14), Moderation of moderated mediation, 3.5 Johnson Neyman Chart for Moderator, Model 5 and 7 and 14, Model 2 with visualisation 3.6 Multi-group Analysis and Latent Growth Models	

Self-Learning topics (Unit wise)

Unit	Topics
I and II	Introduction: measurement and structure models, variables and constructs, modelling strategies,
I and II	Exploratory and Confirmatory Factor Analysis: conceptualization Difference between exploratory & confirmatory factor analysis, Model validity
3.2	Mediation Analysis in SEM: incorporating mediating variables Moderation Analysis in SEM: incorporating moderating variables

Online Resources

2.1 Structural Equation Modelling (SEM**) by Dr. Suresh Sharma** **Day 1 - https://youtu.be/uWE1rChJtOs and** **Day 2 - https://youtu.be/2wniJL8M1ZQ**
2.2 'Applied Multivariate Statistical Modeling' by PROF. J. Maiti, Department of Mathematics, IIT Kharagpur, available on the NPTEL portal **https://nptel.ac.in/courses/111/105/111105091/** for unit II
3. Structural Equation Modelling (SEM**) by Dr. Suresh Sharma** **Day 3 - https://youtu.be/2VGIKmOZu9g**
4. **Business Analytics and Data Mining Modeling using R, available on the Swayam portal, GOI by Prof. Gaurav Dixit, IIT Roorkee given on week 10** **https://nptel.ac.in/courses/110/107/110107092/ for unit 4**

Course Code: STA601A
Title of paper: Statistical Research Project
Category: Individual
Project exam will be of 100 marks is evaluated based on the project report submitted by the students and presentation based on the analysis of project as,
Guide's assessment- 50 marks
External judge's Assessment- Total 50 marks =Presentation (30 marks) + Viva (20 marks)

*Statistical Project Guidelines for 4 credits: As decided by University and /or BoS in the subject from time to time.

Part – 4- Detailed Scheme Practical

Practical of Semester III Total Credit: 04

Paper Code	Title	No. of Hours
STA601D	1) Introduction, Empirical Distribution and Test of Randomness 2) One Sample Location and Scale(Sign, Wilcoxon, CI via order stats) 3) Goodness-of-Fit Tests (Chi-square, K–S) 4) Two Sample Location and Scale-I (Mann–Whitney, Median, Wald–Wolfowitz) 5) Two Sample Location and Scale-II(Mood, Ansari–Bradley, Siegel–Tukey) 6) c Sample Location (Kruskal–Wallis, Jonckheere–Terpstra) 7) Linear Rank Statistics and Test for Independence(Kendall, Spearman) 8) Jackknife and Bootstrap Methods	02 Hours per Practical
STA602D	1) Basic Designs 2) Lattice Design, 3) BIBD and PBIBD 4) Latin and Youden Square Design 5) 2k and 3k Factorial Experiment 6) Mixed Level Factorial Experiment 7) Total Confounding in Factorial Experiment 8) Partial Confounding in Factorial Experiment 9) Response Surface Methodology 10) Practical using SPSS on 1 and 5	
STA603D	1) Estimation of trend 2) Estimation of seasonal indices 3) exponential smoothing 4) Stationary 1 5) Stationary 2 6) Autocorrelation function and partial autocorrelation function(ACF, ACVE, PACF) 7) Time Series Modeling of data: ARMA 8) Time Series Modeling of data: ARIMA 9) Time Series Modeling of data: SARIMA	

STA604D	1) Exploratory Factor Analysis 2) Confirmatory Factor Analysis 3) Path Analysis 4) Confirmatory Factor Analysis for higher order 5) Structural Equation Analysis 6) Mediation Analysis 7) Moderation Analysis 8) Moderated mediation on scale data and Moderation of moderated mediation 9) Linear Growth Model	

*Batch Size of 10 students

References:

Course Code: STA601B

Title of Paper: NONPARAMETRIC INFERENCE

1. Gibbons, J.D. (1985), Nonparametric Statistical Inference, 2nd ed., Marcel Dekker, Inc.
2. Randles, R.H. and Wolfe, D.A. (1979), Introduction to the theory of nonparametric statistics, John Wiley and Sons Inc.
3. Davison, A.C. and Hinkley, D.V. (1997), Bootstrap Methods and their application, Cambridge University Press.
4. Daniel, W.W. (2000), Applied Nonparametric Statistics (2nd Ed.), Wiley
5. Hajek, J. and Sidak, Z. (1967), Theory of rank tests, Academic Press.
6. Puri, M.L. and Sen, P.K. (1971), Nonparametric methods in multivariate analysis, John Wiley & Sons, Inc.

Course Code: STA602B

Title of Paper: Design of Experiment

1. Montgomery, D. C. (2017). Design and Analysis of Experiments, 9th Ed, Wiley.
2. Das, M. N. and Giri, N. C. (1986). Design and Analysis of Experiments, New Age International.
3. Dean, A. and Voss, D. (2006). Design and Analysis of Experiments, 2nd, Ed, Springer.
4. Chakrabarti, M. C. (1962), Mathematics of Design and Analysis of Experiments, Asia Publishing House.
5. Raghavarao, D. (1971), Construction and Combinatorial Problems in Design of Experiments, Wiley.
6. Fisher, R. A. (1966), The Design of Experiments, Hafner Publishing Corporation.3. Cornell, J. (2002), Experiments with Mixtures Designs, Models and the Analysis of Mixture Data, 3rd Ed, Wiley.
7. Myers, R. H., Montgomery, D. C. and Cook, C. M. A. (2016). Response Surface Methodology:
8. Process and Product optimization using Designed Experiments, 4th Ed, Wiley.
9. Shah, K. R. and Sinha, B. K. (1989). Theory of Optimal Designs, Springer

Course Code: STA603B

Title of Paper: Time Series Analysis

1. Brockwell, P. J. and Davis, R. A. (2003): Introduction to Time Series Analysis, Springer
2. Chatfield, C. (2001): Time Series Forecasting, Chapman &Hall.
3. Fuller, W. A. (1996): Introduction to Statistical Time Series, 2nd Ed. Wiley.
4. Hamilton, N. Y. (1994): Time Series Analysis, Princeton University press.
5. Kendall, M. and Ord, J. K. (1990): Time Series, 3rd Ed. Edward Arnold.
6. Lutkepohl, H. (2005): New Introduction to Multiple Time Series Analysis, Springer
7. Shumway, R. H. and Stoffer, D. S. (2010): Time Series Analysis & Its Applications, Springer.
8. Tsay, R. S. (2010): Analysis of Financial Time Series, Wiley.

Course Code: STA604B
Title of Paper: **:** Structural Equation Modeling

1. Hayes, A. F. (2022). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (3rd edition). New York: The Guilford Press.
2. Rex B. Kline(2011), Principles and Practice of Structural Equation Modeling, Third Edition, TheGuilford Press, New York London
3. Joseph F. Hair Jr. William C. Black Barry J. Babin Rolph E. Anderson( ), Multivariate Data Analysis, Pearson New International Edition, 7th Edition
4. Lantz, B (2013), Machine Learning with R, 2nd Ed, PACKT Open Source.
5. Miller, J. D. and Forte, R. M. (2015), Mastering Predictive Analytics with R, 2nd Ed, PACKT Open Source.
6. Babcock, J. (2016), Mastering Predictive Analytics with Python, PACKT Open Source

Part -5- The Scheme of Teaching and Examination is as under: Second Year Semester – IV Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Statistics**)			STA605B, STA606B, STA607B, STA605D, STA606D, STA607D	
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)				
	Skill Enhancement Courses (SEC)				
4	Research Individual Project			STA601H	

Detail Scheme

Second Year Semester IV 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	AT	SEE	
1	IV	STA605B	Stochastic Processes	Major	3	20 %*	3	0	0	3	10	5	60	100
		STA605D	**Computer Applications & Practical** Based on Stochastic Processes						2	1			25	
2	IV	STA606B	Survival Analysis	Major	3	20 %*	3	0	0	3	10	5	60	100
		STA606D	**Computer Applications & Practical** Based on Survival Analysis						2	1			25	
3	IV	STA607B	Statistical Process Control	Major	3	20 %*	3	0	0	3	10	5	60	100
		STA607D	**Computer Applications & Practical**						2	1			25	

			Based on Statistical Process Control											
4	IV	STA601 H	**Individual Statistical Project**							8				(100 conference presentation with publication + 50 Internal + 50 External) = **200**
		Total Hours / Credit								20				500

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

SLE: Self Learning Evaluation; L: Lecture; T: Tutorial; P: Practical; CT: Class Test; AT: Attendance; PA: Practical; SEE: Semester End Exam

Second Year Semester – IV Units – Topics – Teaching Hours

S. No	Subject Code	Subject Unit Title		Hours / Lectures	Total No. of hours /lectures	Credit	Total Marks
1	STA605B	I	Basics of Stochastic Processes	15	45H	3	100 (60+40)
		II	Advanced study of Stochastic Process-1	15			
		III	Advanced study of Stochastic Process-2	15			
	STA605D	IV	Practical based on STA605B	30	30H	1	
2	STA606B	I	Concept of censoring and the various distributions	15	45 H	3	100 (60+40)
		II	Advance Inference	15			
		III	Estimation of survival function and Two sample problem	15			
	STA606D	IV	Practical based on STA606B	30	30H	1	
3	STA607B	I	Basic Control Charts and Multivariate Control Chart	15	45 H	3	100 (60+40)
		II	Cumulative-Sum Control Charts and Capability Analysis	15			
		III	Acceptance Sampling Plan	15			
	STA607D	IV	Practical based on STA607B	30	30H	1	
4	STA601H	I	**Individual Statistical Project**	240	240H	8	200
			TOTAL			20	500

- **Lecture Duration – 1 hour**
- **One Credit =15 Classroom 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: STA605B
Title of Paper: **Stochastic Processes**

Unit	Content	No. of Hours
1	**Basics of Stochastic Processes** 1.1 Notion of stochastic processes, Markov chain, one step transition probabilities, Chapman-Kolmogorov equations, evaluation of higher step transition probabilities, Classification of states, periodicity of a Markov chain, 1.2 Concept of closed class, minimal closed class, stationary distribution. 1.3 Concept of absorption probabilities, one dimensional random walk, gamblers	15

	ruin problem, Probability of Ruin, Expected Duration of the Game	
2	**Advanced study of Stochastic Process-1** 2.1 Branching process, classification of states, identification of criticality parameter, extinction probability, relationship between criticality parameter and extinction probability of the process, Expression for mean and variance of the process. 2.2 Extinction probability, Some epidemiological applications, Introduction to Markov chain in continuous time, concept of intensity rate, relationship between intensity matrix and transition probability matrix. 2.3 Kolmogorov's forward and backward equations	**15**
3	**Advanced study of Stochastic Process-2** 3.1 Poisson process, two definitions and their equivalence, Distribution of inter arrival times, conditional joint distribution of inter arrival times. Compound Poisson process, Some applications. 3.2 Review of Introduction to birth process, birth and death process, linear birth and death process 3.3 Growth model with immigration and related results, Expression for mean and variance of a birth process and, birth and death process, Applications of these processes. 3.4 Introduction to renewal process, relationship with Poisson process, key and elementary renewal theorems associated with renewal processes, Some applications.	**15**

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1 Notion of stochastic processes, Markov chain, one step transition probabilities, Chapman-Kolmogorov equations, evaluation of higher step transition probabilities, Classification of states, periodicity of a Markov chain, 1.2 Concept of closed class, minimal closed class, stationary distribution. Some examples such as gamblers ruin problem and one dimensional random walk.

Online Resources

1. 'Introduction to Probability Theory and Stochastic Processes' by Prof. S Dhramaraja from IIT Delhi available on the Swayam portal https://nptel.ac.in/courses/111/102/111102111/
2. 'Stochastic Processes' by Prof. Dharmaraja from IIT Delhi and Prof. N. Selvaraju from IIT Gowahati available on the Swayam portal https://nptel.ac.in/courses/111/102/111102098/# for unit 1.
3. 'Introduction to Stochastic Processes' by Prof. Manjesh hanawal from IIT Bombay available on the Swayam portal https://nptel.ac.in/courses/110/101/110101141/

Course Code: STA606B
Title of paper: Survival Analysis

Unit	Content	No. of Hours
1	**Concept of censoring and the various distributions** 1.1 Introduction to time to event data and Censoring 1.2 Concepts of Type-I (time), Type-II (order) and random censoring likelihood in these cases. 1.3 **Derivations of Survival function and Hazard function of** Life distributions: Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure Rate.	15
2	**Advance Inference** 2.1 Inference for exponential, gamma, Weibull distributions under censoring (**Derivations of Mean and Median Survival**.) 2.2 Failure rate, mean residual life and their elementary properties. 2.3 Ageing classes and their properties, bathtub failure rate.	15
3	**Estimation of survival function**: 3.1 Actuarial estimator, Kaplan –Meier estimator, 3.2 Tests of exponentiality against non-parametric classes: Total time on Test, Deshpande Test. **Two sample problem**: 3.3 Gehan test, 3.4 Log rank test. 3.5 Mantel-Haenszel test, 3.6 Cox's Proportional Hazards Model, 3.7 Competing Risks Model.	15

Self-Learning topics (Unit wise)

Unit	Topics
	Not Available

Online Resources

Need to Develop

Course Code: STA607B
Title of paper: Statistical Process Control

Unit	Content	No. of Hours
1	**Basic Control Charts and Multivariate Control Chart :** 1.1 The meaning of quality, quality assurance, technology and productivity. Statistical methods for quality control and improvement. Chance and assignable causes of quality variation, general theory of control charts, 1.2 Control charts for variables: X bar and R chart, analysis of pattern on control charts, 1.3 Control chart for attributes: np, p, c and u charts. Type I & Type II error and β risk for Control chart for variables & attributes along with the ARL of these Charts. 1.4 Multiple stream processes: Group control charts. Specification	15

	limits and tolerance limits and modified Control limits.	
2	**Cumulative-Sum Control Charts and Capability Analysis** 2.1 The cumulative-sum control charts (cusum-charts): using v – mask, A.R.L of cusum charts, exponentially weighted moving average control charts, control charts based on Moving Average. 2.2 Process Capability Analysis, introduction, Capability indices- Cp , Cpk and Cpm. 2.3 Estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.	15
3	**Acceptance Sampling Plan** 3.1 Acceptance sampling plans for attribute inspection: single, double and sequential sampling plans and their properties, including OC, AOQL, ATI and ASN curves. 3.2 Plans for inspection by variables for one-sided and two-sided specifications. Specification of sampling plan by LTPD and AOQL. 3.3 Mill Std plans, Dodge and Rooming tables. Some brief introduction to Bayesian Sampling plan.	15

Self-Learning topics (Unit wise)

Unit	Topics
1.2 and 1.3	Review of some Basic Control Charts
2.2	Process Capability Analysis

Online Resources

"Quality Control and Improvement With Minitab: by Prof. Indrajit Mukherjee, Management, IIT Bombay, Source:**https://nptel.ac.in/courses/110/101/110101150/**

Course Code: STA601H
Title of paper: Statistical Research Project(8 Credits)
Category: Individual
Semester 3 or Semester 4 Project work need to be presented in State Level Conference/ National Conference /International Conference/ Avishkar with publication to get 4 credits.
For Semester 4, Project exam will be of 100 marks is evaluated based on the project report submitted by the students and presentation based on the analysis of project as,
Guide's assessment- 50 marks
External judge's Assessment- Total 50 marks =Presentation (30 marks) + Viva (20 marks)

*Statistical Project Guidelines for 8 credits: As decided by University and /or BoS in the subject from time to time.

Part – 7- Detailed Scheme Practical

Practical of Semester IV Total Credit: 08

Paper Code	Title	No. of Hours
STA605D	1. **Simulation and Classification of States in a Markov Chain** → Generate a Markov chain, classify states (transient, recurrent), and check periodicity.	02 Hours per Practical per Batch*

	2. **Estimation of Stationary Distribution in an Ergodic Markov Chain** → Simulate long runs to estimate and verify stationary distribution. 3. **One-Dimensional Random Walk and Gambler's Ruin Problem Simulation** → Estimate ruin probabilities and expected game duration for different initial values. 4. **Simulation of a Branching Process and Estimation of Mean and Variance** → Vary offspring distribution to observe extinction behavior and criticality. 5. **Estimation of Extinction Probability in Branching Processes** → Compare subcritical, critical, and supercritical regimes through simulations. 6. **Simulation of a Continuous-Time Markov Chain (CTMC)** → Use intensity matrix to simulate exponential waiting times and transitions. 7. **Verification of Kolmogorov Forward and Backward Equations using CTMC Simulation** → Numerically validate equations for small state space models. 8. **Simulation of a Poisson Process and Inter-arrival Time Distribution** → Demonstrate equivalence of definitions and memoryless property. 9. **Compound Poisson Process: Simulation and Analysis of Total Event Magnitude** → Model random magnitudes associated with Poisson arrivals. 10. **Simulation of Birth-Death Process and Estimation of Limiting Distribution** → Vary birth and death rates; track state changes over time. 11. **Simulation of Growth Model with Immigration** → Compare with pure birth process and estimate expected population size. 12. **Simulation of a Renewal Process and Estimation of Renewal Function** → Apply different inter-arrival distributions and validate renewal theorems.	
STA606D	1. **Analyzing Time-to-Event Data: Introduction to Survival Analysis and Censoring using SPSS** → *Hands-on with SPSS: Data entry, censoring indicators, survival time variables* 2. **Modeling Censoring Mechanisms: SPSS Implementation of Type-I, Type-II, and Random Censoring** → *Simulating censoring in SPSS and interpreting survival curves under different mechanisms* 3. **Deriving and Visualizing Survival and Hazard Functions for Common Distributions using SPSS**	

	→ *Use SPSS syntax and charts to model exponential, Weibull, and other distributions* 4. **Comparative Life Distribution Models in SPSS: Exponential vs. Weibull vs. Lognormal** → *Fitting parametric models to data and comparing AIC/BIC values in SPSS* 5. **Inference under Censoring: Estimating Survival Functions in SPSS for Exponential and Weibull Models** → *SPSS survival procedures for mean and median survival estimation* 6. **Failure Rate and Mean Residual Life: Concepts and Graphical Interpretation in SPSS"** → *Use SPSS plots and survival tables to calculate and interpret hazard rates* 7. **Ageing and Reliability Analysis: Modeling Bathtub-Shaped Failure Rates in SPSS** → *Simulating and interpreting complex hazard patterns using parametric survival models* 8. **SPSS-Based Analysis of Ageing Classes and Life Expectancy in Engineering and Medical Data** → *Application with real datasets (medical equipment, patient survival, etc.)* 9. **Non-Parametric Estimation of Survival Functions: Kaplan-Meier and Actuarial Methods using SPSS** → *Step-by-step survival curve estimation and comparison in SPSS* 10. **Testing for Exponentiality in SPSS: Applying the Total Time on Test (TTT) and Deshpande Tests** → *Performing graphical and numerical diagnostics for exponentiality* 11. **Two-Sample Survival Comparisons in SPSS: Gehan, Log-Rank, and Mantel-Haenszel Tests** → *Running group comparisons for survival times (e.g., treatment vs. control)* 12. **Modeling Covariates in Survival Data: Cox Proportional Hazards and Competing Risks in SPSS** → *Using Cox Regression procedure in SPSS with stratification and covariate adjustment*	
STA607D	1. Control Chart for Attributes 2. Control Chart for Variables 3. EWMA 4. Control Chart for Correlated Data 5. Cumsum Chart 6. Process Capability Analysis 7. Acceptance Sampling Plan-I 8. Acceptance Sampling Plan-II	

*Batch Size of 10 students.

REFERENCES:

Course Code: STA605B

Title of paper: Stochastic Processes

1. Bhat B.R.: Stochastic Models: Analysis and Applications.
2. Medhi, J.: Stochastic Processes
3. Pinsky M. A. and Karlin, S.: An Introduction to Stochastic Modeling.
4. Ross, S.: Introduction to Probability Models
5. Feller, W.: An Introduction to Probability Theory and its Applications.
6. Hoel, P.G. Port, S.C. & Stone, C.J.: Introduction to Stochastic Processes.
7. Karlin, S & Taylor, H.M.: A First Course in Stochastic Processes (Second. Edition).
8. Serfozo, R.: Basics of Applied Stochastic Processes.

Course Code: STA606B

Title of paper: Survival Analysis

1. Miller, R.G. (1998), Survival Analysis, Second Edition, Wiley Interscience.
2. Cox, D.R. and Oakes, D.(1984), Analysis of Survival Data, Chapters 1, 2, 3,4. Taylor and Francis
3. Applied Survival Analysis- A Practical Approach by David Machin, Yin Bun Cheung and Mahesh K. Parmer, Wiley Publication, 2nd Edition
4. Jayant V. Despande and Sudha Purohit(2005), LifeTime Data: Statistical Models and Methods, World Scientific Publishing Co. Pvt. Ltd
5. Survival Analysis: A Self Learning Text by David G. Kleinbaum and M. Klein, Third Edition
6. Wayne W. Daniel (1995). Biostatistics , ch-Applied Survival Analysis, Wiley
7. Crowder M. J.(2001), Classical Competing Risks, Chapman & Hall, CRC, London.
8. Gross, A.J. & Clark, V.A. (1976), Survival Distributions-Reliability Applications in Bio-medical Sciences, Chapters 3,4, John Wiley and Sons.
9. Kalbfleisch J.D. and Prentice R.L. (1980) ,The Statistical Analysis of Failure Time Data, John Wiley and Sons.

Course Code: STA606B

Title of paper: Statistical Process Control

1. Duncan, A. J. (1986), Quality Control and Industrial Statistics. Irwin. 5th Edition.
2. Grant, E. L. and Leavenworth, R. (2017), Statistical Quality Control. McGraw Hill. 7th Edition.
3. Johnson, N. L. (1977), Statistics and Experimental Design in Engineering and Physical Science. John Wiley.
4. Montgomery, D. C. (2004), Introduction to Statistical Quality Control. John Wiley. 4th Edition.
5. Muralidharan, K. (2015), Six sigma for organizational Excellence: A statistical approach. Springer.
6. Phadke, M. S. (1989), Quality Engineering Using Robust Design. Pearson.
7. Taguchi, G. (1986), Introduction to Quality Engineering: Designing quality into products and processes. Quality resources.

Examination Pattern for Second Year Degree as per NEP 2020 Academic Year 2023-2024

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

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Note: As per Honorable Vice Chancellor's instruction major and minor to be treated as same.

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% **40 marks**

Practical's (internal Components of the Practical Course)

1. **For Theory Courses**

Sr.No.	Particulars	Marks
1	One class open book test / online examination to be conducted in the given semester/Project	25 Marks
2	Self-Learning Evaluation with Active participation in routine class instructional deliveries	10+5 Marks

2. For Courses with Practicals

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.

Practical's (Internal component of the Practical Course)

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

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** ii) **Theory**

Question Paper Pattern:-

i. There shall be three questions each of 20 marks. On each unit there will be one question based on syllabus.

ii. All questions shall be compulsory with internal choice within the questions. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depend on the weightage of the topic.

b. For Practical Courses

i) **Duration** – **2 Hours** ii) **Practical Question Paper Pattern**:-

1. There shall be four questions each of 10 marks. On each unit there will be one question based on the syllabus and the fourth one will be based on entire syllabus.
2. All questions shall be compulsory with internal choice within the questions. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depend on the weightage of the topic.