Estd. 1962
"A++" Accredited by NAAC (2021)
With CGPA 3.52

SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA
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शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र
दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१-२६०९०९४
०२३१-२६०९४८७

Ref.No.SU/BOS/Science/148 **Date: 26/05/2026**

The Principal,
All Concerned Affiliated Colleges/Institutions
Shivaji University, Kolhapur.

Subject: Regarding revised syllabi of B.Sc. Part-III (Sem.V & VI) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0)

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the syllabi, nature of question paper of B.Sc. Part-III (Sem.V & VI) degree programme under the Faculty of Science and Technology as per NEP-2020 (2.0).

B.Sc. Part-III (Sem. V & VI) as per NEP-2020 (2.0)			
1.	Botany	9.	Geology
2.	Physics	10.	Zoology
3.	Statistics	11.	Chemistry
4.	Mathematics	12.	Electronics
5.	Microbiology	13.	Drug Chemistry
6.	Industrial Microbiology	14.	Pollution
7.	Biochemistry	15.	Food Science and Quality Control
8.	Computer Science (Optional)	16	Biotechnology (Optional/Vocational)

This syllabus, nature of question and equivalence shall be implemented from the academic year 2026-2027 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website **www.unishivaji.ac.in>Syllabus>Syllabus as per NEP2020.**

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2026 & March/April 2027. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dy Registrar

Encl: as above

for information and necessary action

Copy to:

1	Dean, Faculty of Science & Technology	6	Appointment Section A & B
2	Director, Board of Examinations and Evaluation	7	I.T.Cell /Computer Centre
3	Chairman, Respective Board of Studies	8	Eligibility Section
4	B.Sc.-M.Sc. Exam Section	9	Affiliation Section (T.1) (T.2)
5	Internal Quality Assurance Cell (IQAC Cell)	10	P.G. Seminar Section

SHIVAJI UNIVERSITY, KOLHAPUR.

Syllabus
for

B.Sc. Part – III Statistics
SEMESTER V AND VI

AS PER NEP 2020 (2.0)

To be implemented from academic year 2026-27

SHIVAJI UNIVERSITY, KOLHAPUR
Revised Syllabus for Bachelor of Science in Statistics: Semester V and VI.
(As per NEP- 2.0)
Applicable from the Academic Year 2026 –27

1. **Title:** B. Sc.III Statistics, Semester V and Semester VI Revised Syllabus as per NEP – 2.0
2. **Faculty:** Faculty of Science and Technology.
3. **Year of Implementation:** June 2026
4. **Objectives of the Program:**
    a. Build strong statistical and analytical skills.
    b. Apply statistical methods to real-world problems.
    c. Develop computational and data analysis skills.
    d. Use modern tools like AI, ML and R.
    e. Gain practical exposure through projects and training.
    f. Apply statistics in industry and research.
5. **Program Specific Outcomes (PSOs)**
    After completing this program (Semester V and Semester VI), students will be able to:
    a. Apply sampling techniques and analyze data effectively.
    b. Perform statistical inference including parameter estimation, hypothesis testing, and nonparametric methods.
    c. Design experiments (CRD, RBD, LSD, factorial designs) and analyze them.
    d. Model and analyze probability distributions including lognormal, cauchy, logistic, and truncated distributions.
    e. Use R programming for data analysis, visualization, and statistical modeling.
    f. Apply machine learning techniques such as regression, classification, clustering, and neural networks. OR understand actuarial concepts like life tables, survival models, and premium calculations.
    g. Apply statistical quality control techniques such as control charts, Six Sigma, and acceptance sampling OR apply reliability theory and analyze systems using failure rates, hazard functions, and distributions.
6. The B. Sc. III Course (Statistics) (Level 5.5) will be of One year i.e. Two Semesters (Semester V and Semester VI).
7. **Pattern of Examination:** The Examinations will be conducted semester-wise for Theory and Practical.
8. **Fee Structure:** As per Shivaji University Guidelines.
9. **Eligibility Criteria for Admission to B. Sc. Part III (Level 5.5):** As per B. Sc. Rules and Regulations of Shivaji University, Kolhapur.
10. **Medium of Instruction:** English.
11. **Structure of course:** Given on page number 4.
12. **Scheme of Teaching and Examination:**
    - Each theory course paper constitutes of two units require 30 hours of teaching lectures. There shall be two lectures of one hour duration per theory course (2 Credit) per week.

- Each practical course paper constitutes of ten experiments require 60 hours. There shall be four hours teaching per practical course (2 Credit) per week.
- B. Sc. III Statistics Course will be of 44 Credits (1100 marks).
- Examination of each theory course shall be of 50 marks (40 university examination + 10 internal assessment). University examination of 40 marks (1.5 hours duration) will be conducted at the end of each semester. Internal assessment of 10 marks will be done before the semester examination during each semester.
- Examination of practical course shall be of 50 marks (2 Credit) per paper.

13. **Standard of Passing:** The standard of passing shall be as per the following table.

	End Semester Examination	Internal Assessment	Course (Total) Examination
Maximum Marks	40	10	50
Minimum Marks required for passing	14	4	18

i) There shall be a separate head of passing for end semester examination and internal examination.

ii) Minimum 18 marks out of 50 marks are required for passing of practical examination of each course.

iii) Passing criteria for OJT and Field Project (FP) as per the University guidelines.

14. **Nature of Question paper and scheme of marking:**

Theory question paper: Maximum marks -40

a. Total No. of questions – 3.
b. All questions are compulsory.
c. Question number 1: MCQ type 8 sub questions (8 Marks).
d. Question number 2: Long answer type question. This question contains four sub questions each carries 8 marks. Student must attempt any two sub questions (16 marks).
e. Question number 3: Short answer type question. This question contains six sub questions each carries 4 marks. Student must attempt any four sub questions (16 marks).

Practical Question Paper:

a. In each practical question paper, there shall be four questions each of 20 marks and student has to attempt any two questions.
b. Computations should be demonstrated to examiner. Experiment aim, formulae, results etc. should be written on practical answer paper.
c. 5 marks are reserved for the Journal and 5 marks for the Oral examination.
d. Practical examination is of four hours duration which includes viva (oral) examination and online demonstration.

SHIVAJIUNIVERSITY,KOLHAPUR

NEP-2020 (2.0): Credit Framework for UG(B. Sc.) Programme under Faculty of Science and Technology

SEM (Level)	COURSES			OE	VSC/SEC	AEC/VEC/IKS	OJT/FP/CEP /CC/RP	Total Credits	Degree/Cum. Cr. MEME
	Course-1	**Course-2**	**Course-3**						
SEM I (4.5)	DSC-I(2) DSC-II (2) DSC P-I(2)	DSC-I(2) DSC-II (2) DSC P-I(2)	DSC-I(2) DSC-II (2) DSC P-I(2)	OE-1(2) (T/P)		IKS-I(2)		**22**	**UG Certificate 44**
SEM II (4.5)	DSC-III(2) DSC-IV(2) DSC P- II(2)	DSC-III(2) DSC-IV(2) DSC P- II(2)	DSC-III(2) DSC-IV(2) DSC P- II(2)	OE-2(2) (T/P)		VEC-I(2) (Democracy, Election and Constitution)		**22**	
Credits	**8(T)+4(P)=12**	**8(T)+4(P)=12**	**8(T)+4(P)=12**	**2+2=4 (T/P)**	**--**	**2+2=4**	**--**	**44**	**Exit Option:4 credits NSQF/Internship/Skill courses**
	MAJOR		**MINOR**						
SEMIII (5.0)	Major V(2) Major VI (2) Major P III (2)	--	Minor V(2) Minor VI (2) Minor P III(2)	OE-3(2) (T/P)	VSC I (2) (P) (Major specific) SEC I(2) (T/P)	AEC I(2) (English)	CC-I (2)	**22**	**UG Diploma 88**
SEMIV (5.0)	Major VII(2) Major VIII (2) Major P IV (2)	--	Minor VII(2) Minor VIII (2) Minor P IV (2)	OE-4(2) (T/P)	SEC-II(2) (T/P)	AEC-II(2) (English) VEC-II (2) (Environmental studies)	CEP-I(2)	**22**	
Credits	**8(T)+4(P)=12**		**8(T)+4(P)=12**	**2+2=4(T/P)**	**4(T/P)+2(P)=6**	**2+4=6**	**2+2=4**	**44**	**Exit Option:4 credits NSQF/Internship/Skill courses**
SEM V (5.5)	Major IX (2) Major X (2) Major P V (a) (2) Major P V (b) (2)	Major I (ELEC)(2) Major P-I (ELEC) (2)	-	OE-5(2) (T/P)	VSC II (2) (Major specific) (P)	AEC III (2) (English)	**OJT (04)**	**22**	**UG Degree 132**
SEM VI (5.5)	Major XI (2) Major XII (2) Major P VI (a) (2) Major P VI (b) (2)	Major II (ELEC)(2) Major P-II(2) (ELEC)	-		VSC III (2) (Major specific) (P) SEC III (2) (T/P)	AEC IV (2) (English) IKS 2 (Major specific) (2)	**FP-(02)**	**22**	
Credits	**8(T)+8(P)=16**	**4(T)+4(P)=8**	**-**	**2(T/P)**	**2(T/P)+4(P)=6**	**4+2=6**	**4+2=6**	**44**	
Total Credits	**40+20=60**		**24**	**10**	**12**	**16**	**10**	**132**	**Exit Option**

15. **Major Elective (Optional) Course:** Student must choose any one Major Elective Theory Paper and corresponding Major Elective Practical Paper for Semester V and VI.
16. **Titles of the Paper:**

Semester V

THEORY

Paper No.	Title of the paper	Total Marks	Credits
Major IX	Sampling Techniques and Official Statistics	50	2
Major X	Statistical Inference	50	2
Major Elective I(a)	Artificial Intelligence and Machine Learning	50	2
Major Elective I(b)	Actuarial Statistics	50	2

PRACTICAL

Paper No.	Title of the paper	Total Marks	Credits
Major-P-V (a)	Sampling Techniques and Official Statistics	50	2
Major-P-V (b)	Statistical Inference	50	2
Major Elective I(a)-P	Artificial Intelligence and Machine Learning	50	2
Major Elective I(b)-P	Actuarial Statistics	50	2
OE – V	Statistics in Research	50	2
VSC-II	Practical on Data Analysis using R-II	50	2

Semester VI

THEORY

Paper No.	Title of the paper	Total Marks	Credits
Major XI	Design of Experiments	50	2
Major XII	Probability Theory and Distributions	50	2
Major Elective II (a)	Reliability Theory and Multivariate Distributions	50	2
Major Elective II (b)	Statistical Quality Control	50	2
IKS - 2	Indian Statistical System	50	2

PRACTICAL

Paper No.	Title of the paper	Total Marks	Credits
Major-P-VI (a)	Design of Experiments	50	2
Major-P-VI (b)	Probability Theory	50	2
Major Elective II (a)-P	Reliability Theory and Multivariate Distributions	50	2
Major Elective II (b)-P	Statistical Quality Control	50	2
VSC-III	Operations Research	50	2
SEC - III	Statistical Tests in Research	50	2

17. **Equivalence for Theory Papers:** This syllabus is as per structure of NEP 2.0. Hence there is no equivalence with old syllabus.

18. **Guidelines for Practical Course except R:**
    - Students must complete all experiments using MS-Excel.
    - MS-Excel should be used at the time of practical examination for calculation.
    - Student must complete the entire practical to the satisfaction of the teacher concerned.
    - Student must produce laboratory journal along with completion certificate signed by Head of the Department, at the time of practical examination.

    Laboratory Requirements:

    Laboratory should be well equipped with at least 20 computers along with necessary Software's, printers and sufficient back up facility (UPS/ Inverter/ Generator).

19. **Guidelines for On Job Training (OJT):**

    OJT is recommended for 100 marks (Credit 4) for semester V. The split up of marks will be as below:

Sr. No.	Activity	Marks
1	Quality of Presentation and Effectiveness	10
2	Depth of Knowledge and Practical Skills	10
3	Diversity and Relevance of Learning Experience	10
4	Use of Concept and Practical Applications	10
5	Training Report	30
6	Attendance Record, Evaluation of Supervisor	30
	Total	**100**

    i) 70 marks will be for completion of the training, submission and presentation of its report (Sr. No. 1 to 5).
    ii) 30 marks will be for attendance record and evaluation of supervisor (Sr. No. 6).
    iii) The candidate has to summarize the day wise duties and achievements during the training program and the skills/ expertise obtained during the training program in the form of power point presentation.

    Note: For details, please refer Shivaji University Board of Studies Section Letter Number Shivaji Uni./B.O.S./240 Dated 22 April 2024

20. **Field Project (FP):**

    FP is of 50 marks (Credit 2) for Sem VI. The nature of FP will be as below:

    Nature of Field Project

    i) Identification of problem where statistical techniques can be used.
    ii) Planning and execution of data collection.
    iii) Analyze the data using statistical tools.
    iv) Presentation of FP Work before faculty in the Department and then its final report submission.
    v) FP will be conducted in a group of 5 to 6 students.
    vi) The Marking system for the FP work is as below:

Sr. No.	Activity	Marks
1	Data Collection	10
2	Use of Statistical Tools	10
3	Analysis of Data	10
4	Conclusion	10
5	Viva on FP	10
	Total	**50**

B. Sc. Part - III: Semester - V
Major IX: Sampling Techniques and Official Statistics
Theory: 30 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this course, the students will acquire:

i. concept of various sampling methods such as simple random sampling, stratified random sampling and systematic sampling.
ii. an idea of conducting sample surveys and selecting appropriate sampling techniques.
iii. knowledge of ratio and regression estimators.
iv. knowledge of various statistical organizations in India.

Unit- 1: Sampling Techniques (15 hrs.)

1.1 : Simple random sampling:

Sample mean as an estimator of population mean, standard error of sample mean and its estimator under SRSWR and SRSWOR. Sampling from population with dichotomous attributes. Sample proportion (p) as an estimator of population proportion (P), standard error of sample proportion using SRSWOR. Determination of the sample size (n) under SRSWOR for variables and attributes when margin of error and confidence coefficient are known.

1.2 : Stratified sampling:

Real life situations where stratification is appropriate. Description of stratified sampling method where sample is drawn from individual stratum using SRSWOR method. Estimation of the population mean and standard error of this estimator. Problem of allocation: Proportional allocation, Neyman allocation and optimum allocation. Derivation of the expressions for standard errors of sample means under these allocations. Comparison among SRSWOR, stratified sampling with proportional allocation and optimum allocation.

1.3 : Systematic sampling:

Real life situations where systematic sampling is appropriate. Techniques of drawing a sample using systematic sampling (when the population size is multiple of sample size). Estimation of the population mean and standard error of estimator. Comparison between systematic sampling and SRSWOR.

1.4 : Ratio and regression methods:

Ratio method:

Concept and rationale of auxiliary variable and its use in estimation. Situations where ratio method is appropriate. Ratio estimator of the population mean and its standard error (without derivation), estimator of this standard error. Relative efficiency of ratio estimator with SRSWOR.

Regression method:

Situations where regression method is appropriate. Regression estimator of the population mean and its standard error (without derivations), estimator of this standard error. Relative efficiency of regression estimators with SRSWOR and ratio estimator.

Unit 2: Official Statistics: (15 hrs.)

2.1 Indian statistical system:

Indian statistical system, statistical systems at central and state level. Flow chart of Indian statistical system, Ministry of Statistics and Programme Implementation (MOSPI), Data availability at MOSPI, Central Statistical Office (CSO), National Sample Survey Office (NSSO) and its divisions, Training courses and surveys organized by NSSO. Indian Statistical Service (ISS): Examination, selection and training. National Commission of Statistics (NCS): Functions of the NCS, constitution of NCS, National Statistical Organization (NSO) and its functions. National accounts: Different approaches, indices for development, evaluation and monitoring.

2.2 State level statistical systems:

Improving the administrative statistical system, Operational aspects, Computerization of administrative statistics.

Directorate of Economics and Statistics (DES): Role of DES, Common statistical cadre, Statistical divisions in various departments. Training programs at state statistical organizations.

Books Recommended:

1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Sukhatme, P.V. and Sukhatme, B.V.: Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
3. Des Raj: Sampling Theory.
4. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
5. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
6. Parimal Mukhopadhyay (2008): Sampling theory and methods of survey sampling, Prentice Hall of India.
7. e-publication of MOSPI (https://www.mospi.gov.in/publications-reports)
8. Saluja, M.R. (1972), Indian Official Statistical Systems, Statistical Pub. Society.
9. Government of India (1999), 'Guide to Official Statistics', CSO, MOSPI.

B. Sc. Part - III: Semester - V
Major X: Statistical Inference
Theory: 30 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this course, the students will acquire:

i. concepts of consistent and sufficient statistic.
ii. concepts of likelihood function, information function and CR Rao inequality.
iii. knowledge of interval estimation.
iv. concepts and applications of parametric and nonparametric methods.

Unit 1. Consistency, sufficiency and likelihood estimation: (15 hrs.)

1.1: Consistency: Definition, Proof of the results: a) Sufficient condition for consistency, b) If T is consistent for θ and $\Psi(.)$ is a continuous function, then $\Psi(T)$ is consistent for $\Psi(\theta)$.
Likelihood function: Definition of likelihood function as a function of the parameter θ based on a random sample from discrete and continuous distributions.

1.2: Sufficiency: Concept of sufficiency, definition of sufficient statistic through conditional distribution of the sample given the statistic. Neyman factorization criterion, Pitman-Koopman form of sufficient statistic. Properties of sufficient statistic:
a) If T is sufficient for θ then $\Psi(T)$ is also sufficient for θ provided $\Psi(.)$ is a one-to-one function.
b) If T is a sufficient for θ then T is sufficient for $\Psi(\theta)$. Examples.

1.3: Fisher information function: Definition of Information function, amount of information contained in a sample, Cramer Rao Inequality: Statement and proof of Cramer Rao inequality. Definition of Minimum Variance Bound Unbiased Estimator (MVBUE) of $\Psi(\theta)$, Examples.

1.4: Method of maximum likelihood estimation: Definition, derivation of Maximum Likelihood Estimators (MLE) for parameters of standard distributions.
Properties of MLE (without proof):
a) Invariance property,
b) MLE is a function of sufficient statistic,
c) Non-uniqueness property,
d) Asymptotic distribution of MLE, Examples.

Unit 2: Interval estimation, parametric and nonparametric tests: (15 hrs.)

2.1: Interval Estimation: Notion of interval estimation, definition of confidence interval, length of confidence interval, confidence bounds and pivotal quantity.
Interval estimation for the following cases:
i) Mean of normal distribution (variance known and unknown)
ii) Variance of normal distribution (mean known and unknown)
iii) Population proportion

2.2: Parametric tests:
Definition of Most Powerful (MP) test. Neyman- Pearson (NP) lemma for construction of MP test. Examples. Definition of Uniformly Most Powerful (UMP) test, Use of NP lemma for constructing

UMP test. Power function and power curve.

2.3 : Sequential test: General theory of sequential analysis and its comparison with fixed sample procedure. Wald's SPRT of strength (α, β) for simple null hypothesis against simple alternative hypothesis. Illustrations for binomial and exponential distributions, graphical procedure for carrying out the test.

2.4 : Nonparametric tests: Notion of nonparametric statistical inference and its comparison with parametric statistical inference.

Test procedures for:

i) Run test for randomness and equality of distributions.

ii) Sign test for one sample and paired sample observations.

iii) Wilcoxon's signed rank test for one sample and paired sample observations.

iv) Kolmogorov-Smirnov test for one and two independent samples.

Books Recommended:

1. Kale B. K.: A first course in Parametric Inference; Narosa publishing house.
2. Rohatgi V. K.: Statistical Inference; Courier Corporation, 2013.
3. Rohatgi V. K.: An introduction to Probability Theory and Mathematical Statistics; Wiley: New York.
4. Saxena H. C. and Surendreran: Statistical Inference: S. Chand, 1967.
5. Lehmann E. L., George Casella: Theory of Point Estimation: Springer-Verlag New York Berlin Heidelberg: ISBN 0-387-98502-6
6. Dudewicz E. J. and Mishra S. N.: Modern Mathematical Statistics: Wiley: New York.
7. Cassela G. and Berger R. L. Statistical Inference: Chapman and Hall/CRC.
8. Gibbons J. D.: Nonparametric Statistical Inference: Chapman and Hall/CRC.
9. Doniel: Applied Nonparametric Statistics: PWS-KENT Pub., 1990.
10. Kunte S, Purohit S. G and Wanjale S.K: Lecture notes on Non-parametric Tests.
11. Dixit P. G. Patil S.M. Prayag V. R., S. M. Patil and Sunbandh N. J.: Inference: Estimation: Nirali publication.
12. Manojkumar Srivastava, Namita Srivastava: Statistical Inference: PHI Learning.

B. Sc. Part - III Semester - V
Major-P-V (a): Statistics Practical- V (a)
Sampling Techniques and Official Statistics
Practical: 60 hrs. Marks -50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, student will be able to:

i. apply simple random sampling techniques.
ii. apply stratified and systematic sampling techniques.
iii. estimate population parameters using ratio and regression methods of estimation.
iv. access, analyze and interpret secondary data obtained from official sources.

List of Practicals:

1. Simple random sampling with replacement for (i) Variables (ii) Attributes.
2. Simple random sampling without replacement for (i) Variables (ii) Attributes.
3. Determination of sample size in SRS for (i) Variables (ii) Attributes.
4. Stratified Random Sampling-I.
5. Stratified Random Sampling-II.
6. Systematic Sampling.
7. Ratio method of estimation.
8. Regression method of estimation.
9. Analyzing data from data.gov.in.
10. Analyzing data from esankhyiki portal.

B. Sc. Part - III Semester - V
Major-P-V (b): Statistics Practical- V (b)
Statistical Inference
Practical: 60 hrs. Marks -50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, student will be able to:

i. estimate unknown parameters of probability distributions using the method of maximum likelihood estimation.
ii. construct and interpret interval estimators for parameters of standard probability distributions.
iii. construct most powerful test and uniformly most powerful test.
iv. apply nonparametric tests when distributional assumptions are not satisfied.

List of Practicals:

1. Method of Maximum Likelihood (One parameter).
2. Method of Maximum Likelihood (Two parameter).
3. Interval estimation of location and scale parameters of normal distribution.
4. Interval estimation for population proportion.
5. Construction of MP test.
6. Construction of UMP test.
7. Sequential Probability Ratio Test (SPRT).
8. Nonparametric Tests-I: Run test and Sign test.
9. Nonparametric Tests-II: Wilcoxon's Signed Rank test.
10. Nonparametric Test-III: Kolmogorov-Smirnov test.

B. Sc. Part - III: Semester - V
Major Elective I (a): Artificial Intelligence and Machine Learning
Theory: 30 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this course, the students will be able to:

i. explain AI and ML as data-driven extensions of statistical decision-making under uncertainty.
ii. identify data types, data quality issues, and the role of preprocessing and EDA in AI systems.
iii. describe basic supervised and unsupervised learning methods and single-layer neural networks.
iv. interpret AI applications by identifying problem type, data used, and learning approach.

Unit 1. Statistical Foundations for AI and Machine Learning: (15 hrs.)

1.1 Transition from Statistics to AI: Role of data, uncertainty, probability, and variability in decision contexts, from parameter estimation and statistical inference to predictive modeling, limitations of manual statistical analysis in high-dimensional and complex datasets, the requirement for automated and scalable decision-making systems.

1.2 Artificial Intelligence and Machine Learning: Conceptual Framework, Artificial Intelligence: meaning, goals, and scope, rule-based systems vs data-driven systems, Machine Learning (ML) as a subfield of AI, Supervised and Unsupervised learning, AI vs Automation.

1.3 Data Culture for AI and ML Applications: Types of data: structured, semi-structured, and unstructured, importance of data quality in AI systems, common data issues: missing values, outliers, imbalance (conceptual), role of data preprocessing and exploratory data analysis (EDA).

1.4 Overview of Modern AI Subfields:

Natural Language Processing: text as data, basic preprocessing: tokenization, stemming; text representation ideas: bag of words; types of problems addressed-text classification, sentiment analysis.

Computer Vision: image as data, video as data, representation of binary, grayscale and color images, types of problems such as digit recognition, face recognition.

Generative AI: concept of generative approaches; types of problems addressed: text generation, translation and image generation.

Unit 2. Machine Learning Models and Performance Evaluations: (15 hrs.)

2.1 Supervised Learning Models: Regression Models: Linear regression from ML perspective, k-Nearest Neighbors (k-NN) regression, regression trees; model evaluation: Training and testing data, loss functions: Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), over fitting and under fitting. **Classification Models:** Logistic regression, k-Nearest Neighbors (k-NN). Decision tree: basic idea and interpretation; model evaluation: Training and testing data, confusion matrix, accuracy.

2.2 Introduction to Artificial Neural Networks (ANN): Basic idea and motivation, single-layer neural network (perceptron) for regression and binary classification, inputs, weights, activation function: identity, sigmoid; output, loss functions; conceptual introduction to training of ANN.

2.3 Unsupervised Learning: Motivation for unsupervised learning, k-means clustering algorithms and interpretation, distance measures and their role in clustering.

2.4 Demonstration: Demonstration based discussion of real-world AI systems and tools like Google TM, QUICK, DRAW!

Books Recommended:

1. Rohatgi V. K.: Statistical James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013): An introduction to statistical learning with applications in R.
2. Hastie, T., Tibshirani, R., & Friedman, J. (2009): The elements of statistical learning.
3. Alpaydin, E. (2020): Introduction to machine learning. MIT press.
4. Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives and prospects. Science, 349(6245), 255-260.
5. Mitchell, T. M. (1997): Machine Learning. Germany: McGraw-Hill.
6. Boehmke, B. (2019): Hands-On Machine Learning with R.
7. Han, J., Kamber, M., Pei, J. (2011): Data Mining: Concepts and Techniques. Netherlands: Elsevier Science.
8. Hande, S., Shirke, D., Gupta, V., & Pawar, S. (2025): Mathematics Behind Artificial Intelligence and Machine Learning. Shivaji University Press.
9. Russell, S. J., & Norvig, P. (2010): Artificial intelligence: A modern approach; [the intelligent agent book] (pp. I-XXVIII). Prentice hall.

B. Sc. Part - III: Semester - V
Major Elective I(a)-P: Artificial Intelligence and Machine Learning
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After completion of this practical course, the student will be able to:

i. Perform EDA and data preprocessing using R for AI applications.
ii. Implement basic regression and classification models using R.
iii. Apply clustering and simple neural network models and interpret results.
iv. Analyze AI-based applications from literature in terms of data, methods, and tools.

List of Practicals:

1. Statistical thinking in real-world decision problems.
2. Identification of Data Types and Data Quality Issues in AI Applications.
3. Exploratory Data Analysis for AI Readiness (Data sets from UCI ML repository/ Kaggle).
4. Implementation of Linear Regression for Prediction.
5. Binary Classification Using Logistic Regression.
6. Regression and Classification Using k-Nearest Neighbors (k-NN).
7. Decision Trees for Regression and Classification.
8. Single-Layer Artificial Neural Network for Regression and Classification.
9. Clustering of data using k-means algorithm and interpretation of clusters.
10. Review of AI Applications Reported in Literature.

Note: Except for conceptual orientation exercises, all practical shall involve data-based computation and analysis using R software.

B. Sc. Part - III: Semester - V
Major Elective I(b): Actuarial Statistics
Theory: 30 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of the course, the students will be able to:

i. understands fundamentals of insurance and actuarial science.
ii. explain survival models and life tables.
iii. compute actuarial present values and premiums.
iv. understand premium principles and loading.

Unit 1: Introduction to actuarial thinking (15 hours)

1.1 Insurance Business and Indian Insurance System: Meaning of insurance as risk transfer, difference between insurance and gambling, functions of insurance: risk pooling, indemnification, capital formation, types of insurance: life, general, health.

1.2 Structure of Indian insurance market-LIC, private insurers, role of IRDAI, how premiums are collected, invested and claims paid, real examples of LIC policies, insurance as a business based on statistics.

1.3 Risk, pooling, law of large numbers and insurable risk: Pure vs speculative risk; individual vs collective risk; law of large numbers and risk pooling, expected loss, conditions of insurable risk.

1.4 Mortality, survival function and life table: Future lifetime random variable T_x, distribution and survival functions, actuarial notation l_x, d_x, q_x, p_x.

1.5 Curtate life random variable: Curtate lifetime K_x; PMF and relation with T_x.

1.6 Life table construction: Random survivorship model, life table construction and interpretation.

Unit 2: Insurance products and premium computation (15 hours)

2.1 Compound interest and present value: Simple and compound interest, discounting and accumulation.

2.2 Term and endowment insurance: Actuarial present value.

2.3 Life annuities: Annuity due models.

2.4 Loss random variable and equivalence principle: L = PV (benefit) – PV (premium).

2.5 Net premium and variance: Net single and level premium.

2.6 Loading and expenses: Gross premium and safety loading.

Books Recommended:

1 Deshmukh S R. & Prayag V. (2009) Actuarial Statistics: An Introduction Using R, Universities Press (India).
2 Dickson D. C. M., Hardy M. R. & Waters H. R. (2020) Actuarial Mathematics for Life, Contingent Risk, Cambridge University Press.
3 Gupta A. K. & Varga T. (2013) An Introduction to Actuarial Mathematics, Springer.

B. Sc. Part - III: Semester - V
Major Elective I(b)-P
Actuarial Statistics
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successfully completing this practical course, the students will be able to:

i. understand the fundamental concepts of insurance, actuarial science, risk, mortality, and the Indian insurance system.
ii. apply probability, life table techniques, survival models, and Law of Large Numbers to analyze insurable risks.
iii. compute actuarial present values, premiums, annuities, and loss random variables using actuarial principles.
iv. interpret and evaluate insurance products, premium components, loading, expenses, and the role of statistical methods in insurance business.

List of Practicals:

1. Identification and classification of risks.
2. Study of Indian insurance market structure (LIC, Private Insurers, IRDAI).
3. Demonstration of risk pooling using law of large numbers (Simulation/Dataset).
4. Computation of mortality rates (qx, px, lx, dx) from a life table.
5. Construction of a simple life table from given mortality data.
6. Calculation of present value under compound interest.
7. Computation of actuarial present value for term insurance.
8. Computation of actuarial present value for endowment insurance.
9. Calculation of annuity due values (life annuities).
10. Computation of net single and net level premium using equivalence principle.

B. Sc. Part - III: Semester - V
VSC-II: Practical on Data Analysis using R-II
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successfully completing this practical course, the students will be able to:

i. use R to handle data and perform basic operations.
ii. perform exploratory analysis and visualize relationships among variables.
iii. apply probability distributions and statistical tests using R.
iv. write simple R programs using conditional statements and loops.

List of Practicals:

1. Operators: arithmetic, relational and logical operations.
2. Data structure (vector, matrix and data frame): Indexing, slicing and modifying.
3. Generating frequency tables and cross-tabulations.
4. Exploring correlations among the variables: Scatter plot, scatter plot matrix and graph modifications using low-level functions.
5. Probability distributions: p. m. f. / p. d. f., c. d. f. and model sampling.
6. Test for mean (t-test) and test for proportion.
7. Fitting of Binomial, Poisson and Negative Binomial distribution.
8. Fitting of Uniform, Exponential and Normal distribution.
9. Programming using conditional statements and loops-I.
10. Programming using conditional statements and loops-II.

B. Sc. Part - III: Semester - V
OE - V: Statistics in Research
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the student will be able to:

i. prepare a questionnaire to collect the data.
ii. perform classification, tabulation and represent the data using simple diagrams and graphs.
iii. apply sampling techniques in real life.
iv. summarize data by computing measures of central tendency, measures of dispersion, and correlation coefficient.

List of Practicals:

1. Design a questionnaire and collect data from a small sample.
2. Classification, tabulation and frequency distribution of qualitative and quantitative data.

3. Diagrammatic representation of data by using bar diagrams and pie diagrams.
4. Graphical representation of data by using histogram and frequency polygon.
5. Sampling I: Simple random sampling (with and without replacement)
6. Sampling II: Stratified random sampling.
7. Measures of central tendency: mean, median and mode.
8. Measures of dispersion: range, variance and standard deviation.
9. Scatter plot.
10. Karl Pearson's correlation coefficient.

B. Sc. Part - III: Semester - VI
Major XI: Design of Experiments
Theory:30 Hrs.Marks:50 (Credits:02)

Course Outcomes: After successful completion of this course, the students will acquire:

i. knowledge of basic terms used in design of experiments.
ii. concept of one-way and two-way analysis of variance.
iii. knowledge of various designs of experiments: CRD, RBD, LSD and factorial experiments.
iv. knowledge of using an appropriate design to analyze the experimental data.

Unit 1: Simple Design of Experiments: (15 hours)

1.1 : Basic concepts:

Basic terms in design of experiments: Experimental unit, treatment, layout of an experiment. Basic principles of design of experiments: Replication, randomization and local control. Choice of size and shape of a plot for uniformity trials, the empirical formula for the variance per unit area of lots.

1.2 : Completely Randomized Design (CRD):

Application of the principles of design of experiments in CRD, layout, mathematical model assumptions and interpretations. Estimation of parameters, expected values of mean sum of squares, components of variance. Breakup of total sum of squares into components. Visual inspection of treatment effects using treatment wise box plot. Technique of one-way analysis of variance (ANOVA) and its application to CRD. Statement of Chochran's theorem (without proof) for justification of F-test. Tests for equality of treatment effects and their interpretation. Test for equality of two specified treatment effects using Critical Difference (CD).

1.3 : Randomized Block Design (RBD):

Application of the principles of design of experiments in RBD layout, model, assumptions and interpretations. Estimation of parameters, expected values of mean sum of squares, components of variance. Breakup of total sum of squares into components. Visual inspection of treatment effects and block effects using box plots. Technique of two-way analysis of variance (ANOVA) and its application to RBD. Test for equality of two specified treatment effects, comparison of treatment effects using CD. Idea of missing plot technique, analysis of RBD with single missing observation, situations where missing plot technique is applicable.

1.4 : Latin Square Design (LSD):

Application of the principles of design of experiments in LSD layout model, assumptions and interpretations. Estimation of parameters, Standard Error (SE), expected values of mean sum of squares, components of variance. Preparation of analysis of variance (ANOVA) table. Breakup of total sum of squares into components. Visual inspection of treatment effects, row and column effects using box plots. Test for equality of two specified treatment effects, comparison of treatment effects using CD. Analysis of LSD with single missing observation. Residual analysis for model adequacy checking for CRD, RBD, and LSD. Identification of real-life situations where CRD, RBD and LSD are used.

Unit 2: Efficiency and Factorial Experiments: (15 hours)

2.1 : Efficiency of design:

Concept and definition of efficiency of a design. Efficiency of RBD over CRD. Efficiency of LSD

over CRD and LSD over RBD.

2.2 : Factorial Experiments:

General description of factorial experiments, 2^2 and 2^3 factorial experiments arranged in RBD. Definitions of main effects and interaction effects in 2^2 and 2^3 factorial experiments. Model assumptions and its interpretation. Preparation of ANOVA table by Yate's procedure, test for main effects and interaction effects. General idea and purpose of confounding in factorial experiments.

Total confounding (confounding only one interaction): ANOVA table, testing main effects and interaction effects. Partial confounding (confounding only one interaction per replicate): ANOVA table. Testing main effects and interaction effects. Construction of layout in total confounding and partial confounding in 2^3 factorial experiments.

Books Recommended:

1. Montgomery, D.C. (2001): Design and Analysis of Experiments, John Wiley and sons Inc., New Delhi.
2. Dass, M.N. and Giri, N. C. (1986) Design and Analysis of Experiments, II Edition Wiley Eastern Ltd., New Delhi
3. Snedecor, G.W. and Cochran, W.G. (1994). Statistical Methods, 8th edition, Affiliated East- West Press, New Delhi
4. Goon, A.M., Gupta, M. K. and Dasgupta, B. (1998). Fundamentals of Statistics, Vol. II, The world Press Pvt. Ltd. Kolkata.
5. Gupta S.C. and Kapoor V.K.(2006). Fundamentals of Applied Statistics, S. Chand & Sons, New Delhi
6. Wu, C.F.J. and Hamda, M. (2009). Experiments, Planning, Analysis and Parameter Design Optimization, John Wiley & Sons, Inc., Hoboken, New Jersey.

B. Sc. Part - III: Semester - VI
Major XII: Probability Theory and Distributions
Theory:30 Hrs.Marks:50 (Credits:02)

Course Outcomes: After successful completion of this course, the students will acquire:

i. knowledge of lognormal, Cauchy, logistic and other continuous distributions.
ii. knowledge of truncated distributions.
iii. knowledge of order statistics and their associated distributions.
iv. concept of convergence, limit theorems and Chebyshev's inequality.

Unit 1. Univariate probability distributions and truncated distributions (15 hours)

1.1 Univariate probability distributions

Lognormal distribution: Probability density function (pdf) with parameters (μ, σ^2).

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} exp\left[-\frac{(\log x-\mu)^2}{2\sigma^2}\right] \quad ; \ x > 0; -\infty < \mu < \infty; \sigma > 0$$

First four raw moments and variance. Show that if X ~LN(μ, σ^2), then log(X) ~N(μ, σ^2). examples and problems.

Cauchy Distribution: Pdf with parameters (μ, λ),

$$f(x) = \frac{\lambda}{\pi[\lambda^2 + (x-\mu)^2]} \qquad ; -\infty < x, \mu < \infty; \ \lambda > 0$$

Nature of the probability curve, c. d. f., quartiles, nonexistence of moments, additive property for two independent Cauchy variates (statement only), distribution of the sample mean (statement only), relationship with uniform and Student's t-distributions, distribution of Z = X/Y where X and Y are i. i. d. N(0, 1), examples and problems.

Logistic Distribution: pdf with parameters (μ, σ):

$$f(x) = \frac{e^{-(x-\mu)/\sigma}}{\sigma\left[1 + exp\frac{-(x-\mu)}{\sigma}\right]^2} \qquad ; -\infty < x, \mu < \infty;\ \sigma^2 > 0$$

cdf, mean, mode and variance, skewness using mode, examples and problems.

Truncated distributions: Truncated distribution as a conditional distribution. Truncation to the left, right and on both sides.

Truncated Binomial Distribution: Binomial distribution B(n, p) truncated at X = 0, probability mass function (pmf), mean and variance, examples and problems.

Truncated Poisson Distribution: Poisson distribution $P(\lambda)$ truncated at $X = 0$, pmf, mean and variance, examples and problems.

Truncated Exponential Distribution: Exponential distribution with parameter θ left truncated below a, pdf, mean and variance. examples and problems.

Truncated Normal Distribution: Normal distribution N(μ, σ^2) truncated to the: (i) left below a, (ii) right above b, (iii) left below a and to the right above b, pdf and mean, examples and problems.

Unit 2. Order statistics and convergence: (15 hrs.)

2.1 Order statistics: Order statistics for a random sample of size n from a continuous distribution. Joint distribution of order statistics: Definition, derivation of distribution function and density function of the i^{th} order statistic, particular cases for $i = 1$ and $i = n$, derivation of joint pdf of i^{th} and j^{th} order statistics.

2.2 Convergence and limit theorems:

Convergence of Random Variables: Definition of convergence of sequence of random variables: (a) Convergence in probability, (b) Convergence in distribution and (c) Convergence in quadratic mean. If $X_n \xrightarrow{P} X$, Then $g(X_n) \xrightarrow{P} g(X)$, where $g(.)$is a continuous function (without proof), examples and problems.

Chebyshev's inequality: Chebyshev's inequality (Statement and proof), examples.

Weak law of large numbers: Statement and proof for i. i. d. random variables with finite variance, examples.

Central limit theorem: Statement and proof for i. i. d. random variables with finite variance based on m. g. f., examples based on Binomial, Poisson and Chi-square distributions.

Books Recommended:

1. Cramer H.: Mathematical Methods of Statistics, Asia Publishing House.
2. Mood A. M., Graybill F. A., Bose D. C.: Introduction to the Theory of Statistics.
3. Lindgren B. W.: Statistical Theory.
4. Hogg R. V., Craig A. T.: Introduction to Mathematical Statistics.
5. Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics.
6. Rohatgi V. K.: An Introduction to Probability Theory and Mathematical Statistics.
7. Johnson N. L., Kotz S.: Continuous Univariate Distributions.
8. Feller W.: An Introduction to Probability Theory and Its Applications.
9. Bhat B. R.: Modern Probability Theory.

B. Sc. Part - III Semester -VI
Major-P-VI (a): Statistics Practical- VI (a)
Design of Experiments
Practical: 60 hrs. Marks -50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the students will be able to:

i. apply appropriate analysis of variance technique to analyze data arising from CRD, RBD and LSD.
ii. compare and evaluate efficiencies of experimental designs.
iii. analyze factorial experiments by performing ANOVA for 2^2 and 2^3 factorial experiments.
iv. explain partial and total confounding for 2^2 and 2^3 factorial experiments.

List of Practicals:

1. Analysis of CRD.
2. Analysis of RBD.
3. Analysis of LSD.
4. Missing plot technique for RBD with single missing observation.
5. Missing plot technique for LSD with single missing observation.
6. Efficiency of RBD over CRD.
7. Efficiency of LSD over CRD and RBD.
8. Analysis of 2^2 factorial experiment.
9. Analysis of 2^3 factorial experiment.
10. Partial and total confounding.

B. Sc. Part - III Semester -VI
Major-P-VI (b): Statistics Practical- VI (b)
Probability Theory
Practical: 60 hrs. Marks -50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the students will be able to:

i. fit and analyze continuous probability distributions.
ii. model and analyze truncated distributions.
iii. apply concepts of order statistics.
iv. apply concepts of Chebyshev's inequality, weak law of large numbers and central limit theorem.

List of Practicals:

1. Fitting of Lognormal distribution.
2. Study of Cauchy distribution: probability curve, quartiles and illustration of non-existence of moments.
3. Study of Logistic distribution: computation of mean, variance, skewness using mode and comparison with normal distribution.
4. Illustration of the distribution of $Z = X/Y$ where X and Y are independent N(0,1) random variables.
5. Study of truncated Binomial distributions.
6. Study of truncated Poisson distributions.
7. Study of truncated Normal distributions.
8. Study of truncated Exponential distributions.
9. Order Statistics.
10. Convergence and limit Theorems: Chebyshev's inequality, weak law of large numbers and central limit theorem using simulated data.

B. Sc. Part - III: Semester - VI
Major Elective II(a): Reliability Theory and Multivariate Distributions
Theory: 30 Hrs. Marks: 50 (Credits:02)

Course Outcomes: After successful completion of this course, the students will be able to:

i. understand concept of reliability and various concepts involved in reliability theory.
ii. identify cut and path sets, IFR and DFR distributions.
iii. get knowledge of multinomial distribution.
iv. get knowledge of bivariate distribution.

Unit 1: Reliability theory: (15 hrs.)

1.1 Binary System: Block diagrams, definition of binary coherent structure and illustrations, coherent system of at most three components in: (a) Series, (b) Parallel, (c) 2 out of 3 system. Minimal cut and minimal path representation of system.

1.2 Reliability of binary System: Reliability of systems h(p), when components are independent and identically distributed with common probability p of operating.

1.3 Ageing Properties: Definitions of hazard rate, hazard function, survival function, concept of distributions with increasing and decreasing failure rate (IFR, DFR), relation between survival function and hazard function, density function and hazard rate.

Derivations of results:

(i) Hazard rate of a series system of components having independent life times is sum of hazard rates of their components.
(ii) Life time of series system of independent components with independent IFR life times is also IFR.

1.4 Examples on exponential distribution.

Unit 2: Multinomial distribution and bivariate normal distribution: (15 hrs.)

2.1 Multinomial distribution: pmf, moment generating function, marginal distribution, mean, variance, covariance, variance-covariance matrix, correlation coefficient, additive property, Trinomial distribution as a particular case of multinomial distribution.

2.2 Bivariate Normal Distribution: p. d. f. of BN$(\mu_1, \mu_2, \sigma_1^2, \sigma_2^2, \rho)$, marginal and conditional distributions, conditional mean and conditional variance, regression of Y on X and X on Y, independence and uncorrelatedness imply each other, m. g. f, moments, distribution of aX + bY +c, where a, b and c are real numbers, Cauchy distribution as a distribution of Z = X/Y where (X, Y) ~ BN $(0, 0, \sigma_1^2, \sigma_2^2, \rho)$ distribution, examples and problems.

Books Recommended:

1. Barlow R. E. and Proschan Frank: Statistical Theory of Reliability and Life Testing. Holt Rinebartand Winston Inc., New York.
2. Sinha S. K.: Reliability and Life Testing, Second Edition, Wiley Eastern Publishers, New Delhi.
3. Trivedi R. S.: Probability and Statistics with Reliability and Computer Science application, Prentice – Hall of India Pvt. Ltd., New Delhi.
4. Hogg, R. V. and Craig A. T. : Introduction to Mathematical Statistics (Third Edition), Macmillan Publishing Company, Inc. 866, 34d Avenue, New York, 10022.
5. Sanjay Arora and BansiL al : New Mathematical Statistics (First Edition), Satya Prakashan,16/17698, New Market, New Delhi, 5 (1989).
6. Gupta S. C and Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 88, Dariyaganj, New Delhi
7. Bhat B. R.: Modern Probability Theory. New Age International.

B. Sc. Part – III: Semester – VI
Major Elective II(a)-P: Reliability Theory and Multivariate Distributions
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the student will be able to:

i. generate sample from bivariate normal distribution.
ii. generate sample from multinomial distribution.
iii. find minimal path and cut sets for series, parallel and 2 out of 3 system.
iv. compute reliability of series, parallel and 2 out of 3 system.

List of Practicals:

1. Applications of bivariate normal distribution.
2. Applications of multinomial distribution.
3. Model sampling from bivariate normal distribution.
4. Model sampling from multinomial distribution.
5. Constructing block diagram, identifying minimal path sets and cut sets for series system.
6. Constructing block diagram, identifying minimal path sets and cut sets for parallel system.
7. Constructing block diagram, identifying minimal path sets and cut sets for 2out of 3system.
8. Computation of reliability and hazard rate of a series system.
9. Computation of reliability and hazard rate of a parallel system.
10. Computation of reliability and hazard rate of a 2 out of 3system.

B. Sc. Part –III, Semester VI
Major Elective II(b): Statistical Quality Control
Theory: 30 Hours, Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this course, the students will be able to:

i. understand statistical methods used in monitoring and improving quality.
ii. develop ability to construct and interpret control charts.
iii. understand modern process control techniques used in industries.
iv. get knowledge of six sigma limits, acceptance sampling and product quality assurance.

Unit–1: Quality Tools and Shewhart's Control Chart (15 hours)

1.1 Fundamentals of Quality and Quality Tools: Meaning and importance of Statistical Quality Control (SQC), definitions of quality, dimensions of quality, seven Statistical Process Control (SPC) tools, Deming's Plan–Do–Check–Act (PDCA) cycle, process control and product control.

1.2 Control Charts for Variables and Attributes: Chance cause and assignable cause, advantages and limitations of SQC, control limits, warning limits and tolerance limits, specification limits and natural tolerance limits, construction and working of Shewhart's control chart. **Control Charts for Variables:** Construction and interpretation of: Mean ($\bar{X}$) chart, Range (R) chart (with known and unknown standards), revised control limits. **Control Charts for Attributes**: Concepts of defects, defectives and fraction defective, Construction and interpretation of: p-chart, np-chart and c-chart. Situations where these charts are applicable.

Unit–2: Advanced Process Control and Acceptance Sampling (15 hours)

2.1 Advanced Process Control Techniques: Limitations of Shewhart's control chart, CUSUM Chart: Tabular CUSUM chart for monitoring process mean, Moving Average Charts: Moving Average (MA) chart and Exponentially Weighted Moving Average (EWMA) chart for monitoring process mean, Introduction to Six Sigma: Concept and philosophy of Six Sigma, Define–Measure–Analyze–Improve–Control (DMAIC) framework.

2.2 Product Control and Acceptance Sampling: Need for sampling inspection, acceptance sampling v/s 100% inspection, concepts of Acceptable Quality Level (AQL), Lot Tolerance Percent Defective (LTPD), Producer's risk and Consumer's risk, OC curve, Average Outgoing Quality (AOQ), Average Outgoing Quality Limit (AOQL), Average Sample Number (ASN) and Average Total Inspection (ATI). Sampling Inspection for Attributes: Single sampling and double sampling plan for attributes, Determination and interpretation of above measures for single sampling plan and double sampling plans.

Books Recommended

1. Montgomery, D. C. – Introduction to Statistical Quality Control, Wiley.
2. Duncan, A. J. – Quality Control and Industrial Statistics, Richard D. Irwin.
3. Grant, E. L. & Leavenworth, R. S. – Statistical Quality Control, McGraw-Hill.
4. Juran, J. M. & Godfrey, A. B. – Juran's Quality Handbook, McGraw-Hill.
5. Bester field, D. H. – Quality Control, Pearson.
6. Oakland, J. S. – Statistical Process Control, Butterworth-Heinemann.
7. Wheeler, D. J. & Chambers, D. S. – Understanding Statistical Process Control, SPC Press.
8. Gitlow, H. S. et al. – Six Sigma for Green Belts and Champions, Pearson.
9. Gupta, S. C. & Kapoor, V. K. – Fundamentals of Applied Statistics, Sultan Chand.
10. Goon, Gupta & Dasgupta – Fundamentals of Statistics, World Press.

B. Sc. Part – III: Semester – VI
Major Elective II(b)-P: Statistical Quality Control
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the student will be able to:

i. Construct and interpret control charts for variables.
ii. Construct and interpret control charts for attributes.
iii. Design and evaluate single sampling plans.
iv. Design and evaluate double sampling plans.

List of Practicals:

1. Applications of SPC tools (Histogram and scatter plot, Pareto chart and Check sheet).
2. Control charts for variables: Mean ($\bar{X}$) and Range (R)
3. Control charts for attribute I: p- chart and np –chart
4. Control chart for attribute II: c- chart
5. CUSUM control chart for process mean
6. MA control chart
7. EWMA control chart
8. Six sigma limits for mean
9. Single sampling plan
10. Double sampling plan

B. Sc. Part – III: Semester – VI
INDIAN KNOWLEDGE SYSTEM (IKS): INDIAN STATISTICAL SYSTEM
Theory: 30 Hrs. Marks: 50 (Credits: 02)

Course Outcomes:

After completion of this course, students enable to:

i. Understand history of use of Statistics in India before and after independence.
ii. Understand use of Statistics for well-being of society, and also for dominance and ruler over society.
iii. Know various Statistical Institutions and their role in National Development.
iv. Know contribution of Indian Statisticians in Nation Building.

Unit 1: History of Statistics in India (15 hours)

1.1 Statistics in Koutilya's (Chanakya, Vishnugupta) Arthashastra (350 B.C.): Census and Demographics, Taxation and Revenue, Economic Controls, Audit and Accountability, Resource Planning.

1.2 Statistics in Ain-i-Akbari (part of Akbarnama) by Abul Fazl (1590): Revenue and Land Records, Economic Data, Military and Household, Demographic Estimates, Methodology.

1.3 Statistics in British India (1757–1947): Early Surveys and Reports (1800s), Establishment of Departments (1840s-1860s), Decennial Census (1871-1941), Agricultural and Trade Statistics (1880s-1900s). Land Revenue and Taxation, Social and Political Control (Divide and Rule), Military Recruitment, Infrastructure Planning, Famine Management.

Unit 2: Post-Independence Statistical Development in India (15 hours)

2.1 Institutional Framework: Central Statistical Organization (CSO), National Sample Survey Office (NSSO), Data-Driven Planning, Modernization and Surveys, Impact on Metrics.

2.2 Indian Statistical Institute (ISI): History and role of ISI in National Development.
Ministry of Statistics and Program Implementation (MoSPI): Organogram of MoSPI.
Indian Statisticians and their Contribution in Nation Building: P.C. Mahalanobis, C.R. Rao, P.V. Sukhatme.

Books Recommended

1. Ashim Biswas (2023): Census Policy in British India: A Brief Historical Evaluation, Journal of Historical Studies and Research.
2. Colonel Henry Sullivan Jarrett (1891): English translation of the *Ain-i-Akbari* Volume II
3. J.K. Ghosh, P. Maiti, T.J. Rao, and B.K. Sinha (1999): Evolution of Statistics in India.
4. J.K. Ghosh, S.K. Mitra and K.R. Parthasarathy (1992): Glimpses of India's Statistical Heritage , Wiley Eastern Limited.
5. Kautilya, Vishnugupta. [4th century BCE]1992. The Arthashastra. Edited, rearranged, translated, and introduced by L. N. Rangarajan New Delhi: Penguin Books.
6. Pramit Bhattacharya (2023): India's Statistical System: Past, Present, Future, CEIP
7. Rao, M.V.K. (1958) Studies in Kautilya, 2ndedition, Munshi RamManohar Lal, Delhi.
8. Sir Jadunath Sarkar(1949): Corrected and Further Annotated Book of English translation of the *Ain-i-Akbari* Volume II by Colonel Henry Sullivan Jarrett
9. T.J. Rao (2010): Official Statistics in India: The Past and the Present, Journal of Official Statistics, Volume 26, Issue 2, pp. 215-231.
10. https://www.mospi.gov.in/organization-structure

B. Sc. Part – III: Semester – VI
VSC III: Operations Research
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the student will be able to:

i. formulate linear programming problem.
ii. solve LPP by different methods.
iii. solve AP and TP problems.
iv. understand queuing and decision theory.

List of Practicals

1. Formulation of LLP.
2. Solution of LPP by graphical method.
3. Solution of LPP by Simplex method.
4. Transportation problem (N-W method).
5. Transportation problem (least cost method).
6. Transportation problem (VAM method).
7. Balanced assignment problem.
8. Unbalanced assignment problem.
9. Sequencing problem (up to three machines).
10. Decision problem by optimism method.

B. Sc. Part – III: Semester – VI
SEC - III: Statistical Tests in Research
Practical: 60 Hrs. Marks: 50 (Credits: 02)

Course Outcomes: After successful completion of this practical course, the student will be able to:

i. know the concept of testing of hypothesis.
ii. understand the use of statistical tests.
iii. apply large sample tests in various situations.
iv. apply small sample tests in various situations.

List of Practicals:

1. Testing of hypothesis: Test Statistic, Type I error, Type II error, Power, Acceptance and Rejection region.
2. Large sample tests: Test of population mean.
3. Large sample tests: Test of equality of two population means.
4. Large sample tests: Test for proportion (One and Two sample).
5. Chi-square test: Test of population variance.
6. Chi-square test: Test of independence of attributes.
7. t-test: Test of population mean.
8. t-test: Test of equality of two population means.
9. Paired t test.
10. F-test: Test of equality of two population variances.