PUNYASHLOK AHILYADEVI HOLKAR
SOLAPUR UNIVERSITY, SOLAPUR

Name of the Faculty: Science & Technology

Syllabus

M.Sc. Biostatistics

Part-I (Semester-I and II)

As per NEP-2020

To be implemented from Academic Year 2026-27

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY

SCHOOL OF COMPUTATIONAL SCIENCES

DEPARTMENT OF STATISTICS

Syllabus of M.Sc. Biostatistics (NEP-2020)

1) Title of the Programme: M.Sc. in Biostatistics.

2) Duration of the Programme: Two years.

3) Faculty: Science and Technology.

4) Year of Implementation: M.Sc. Part-I : Academic year 2026-27

5) Fee Structure: As per university rules.

6) Medium of Instructions: English.

7) Eligibility criteria for Admission: For M. Sc. in Biostatistics, following candidates are

eligible:

i. Bachelor Degree in Statistics OR
ii. Bachelor Degree in any science subject with Statistics as ancillary /allied subject. OR
iii. Bachelor Degree in Engineering or Pharmacy with at least two full papers of Mathematics or Statistics.

8) Learning Outcomes:

- **Programme Outcomes (PO)**

On successful completion of M.Sc. Biostatistics programme, the students will be able to:

i) Have a specialized knowledge and understanding of application of statistical theory to biological discipline.

ii) Acquire the strong foundation of statistical concepts, which will benefit them to become good academicians.

iii) Have deep understanding of the necessity of statistical analysis inn other disciplines of Science..

iv) Gain the knowledge of software which has wide range of opportunities in the planning and developments, IT sector, business, government and private sectors.

- **Programme Specific Outcomes (PSO)**

i) Understand, implement and develop statistical models in health science, biology and medical science.

ii) Effectively use necessary statistical software and computing environment including R, Python and MS-EXCEL among others.

iii) Acquire wide range of statistical skills in tackling biological problems.

A Four Semester M.Sc. Biostatistics Course Structure as per NEP-2020

M. Sc. program in Biostatistics consists of 88 credits. Credits of a course are specified against the title of the course.

M.Sc. Biostatistics Semester-I			
Course Type	**Course code**	**Course Title**	**No. of Credits**
Major Mandatory	**DSC-1**	Basic Epidemiology	4
	DSC-2	Statistical Inference-I	4
	LAB-1	Biostatistics Practical-I	2
	LAB-2	Biostatistics Practical-II	2
Major Elective	**DSE-1(A)**	Probability Distributions	4
	DSE-1(B)	Statistical Ecology	4
	LAB-3	Biostatistics Practical-III	2
Research Methodology	**RM**	Research Methodology in Biostatistics	4
M.Sc. Biostatistics Semester-II			
Course Type	**Course code**	**Course Title**	**No. of Credits**
Major Mandatory	**DSC-3**	Design of Experiments and Bioassay	4
	DSC-4	Statistical Inference-II	4
	LAB-4	Biostatistics Practical-IV	2
	LAB-5	Biostatistics Practical-V	2
Major Elective	**DSE-2 (A)**	Stochastic Processes	2
	DSE-2 (B)	Nonparametric Methods	2
	LAB-6	Biostatistics Practical-VI	2
On Job Training/ Field Project	**OJT/FP**	----	4
M.Sc. Biostatistics Semester-III			
Course Type	**Course code**	**Course Title**	**No. of Credits**
Major Mandatory	**DSC-5**	Statistical Genetics	4
	DSC-6	Multivariate Analysis	4
	LAB-7	Biostatistics Practical-VII	2
	LAB-8	Biostatistics Practical-VIII	2
Major Elective	**DSE-3 (A)**	Regression Analysis	4
	DSE-3 (B)	Time Series Analysis	4
	LAB-9	Biostatistics Practical-IX	2
Research Project	**RP-1**	Research Project-I	4
M.Sc. Biostatistics Semester-IV			
Course Type	**Course code**	**Course Title**	**No. of Credits**
Major Mandatory	**DSC-7**	Demography and Health Statistics	4
	DSC-8	Clinical Trials	4

	LAB-10	Biostatistics Practical-X	2
Major Elective	**DSE-4 (A)**	Reliability and Survival Analysis	4
	DSE-4 (B)	Data Mining	4
	LAB-11	Biostatistics Practical-XI	2
Research Project	**RP-2**	Research Project-II	6

Punyashlok Ahilyadevi Holkar Solapur University Solapur

M. Sc. (Biostatistics) NEP-2020 Structure w.e.f. 2026-27

M.Sc. (Biostatistics) Semester –I												
Paper Code	**Title of the Paper**	**Credits**	**Contact hours/week**			**Distribution of Marks for Examination**						
			Th (L)	**Pr**	**Total**	**Internal**		**External**		**Total**		
						Th	**Pr**	**Th**	**Pr**	**Th**	**Pr**	
DSC-1	Basic Epidemiology	4	4	---	4	40	---	60	---	100	---	
DSC-2	Statistical Inference-I	4	4	---	4	40	---	60	---	100	---	
DSE-1	(A) Probability Distributions (B) Statistical Ecology	4	4	---	4	40	---	60	---	100	---	
RM	Research Methodology in Statistics	4	4	---	4	40	---	60	---	100	---	
LAB-1	Biostatistics Practical-I	2	---	4	4	---	20	---	30	---	50	
LAB-2	Biostatistics Practical-II	2	---	4	4	---	20	---	30	---	50	
LAB-3	Biostatistics Practical-III	2	---	4	4	---	20	---	30	---	50	
Total for Semester-I		**22**	**16**	**12**	**28**	**160**	**60**	**240**	**90**	**400**	**150**	
M.Sc. (Biostatistics) Semester –II												
Code	**Title of the Paper**	**Credits**	**Contact hours / week**			**Distribution of Marks for Examination**						
			Th (L)	**Pr**	**Total**	**Internal**		**External**		**Total**		
						Th	**Pr**	**Th**	**Pr**	**Th**	**Pr**	
DSC-3	Design of Experiments and Bioassay	4	4	---	4	40	---	60	---	100	---	
DSC-4	Statistical Inference-II	4	4	---	4	40	---	60	---	100	---	
DSE-2	(A) Stochastic Processes (B) Nonparametric Methods	4	4	---	4	40	---	60	---	100	---	
LAB-4	Biostatistics Practical-IV	2	---	4	4	--	20	---	30	---	50	
LAB-5	Biostatistics Practical-V	2	---	4	4	--	20	---	30	---	50	
LAB-6	Biostatistics Practical-VI	2	---	4	4	--	20	---	30	---	50	
OJT/FP	OJT/FP	4	---	8	8	---	40	---	60	---	100	
Total for Semester-II		**22**	**16**	**20**	**32**	**120**	**100**	**180**	**150**	**300**	**250**	

DSC: Discipline Specific Course **DSE:** Discipline Specific Elective **FP:** Field projects
OJT: On Job Training: Internship / Apprenticeship **RM**: Research Methodology

Evaluation Scheme

Each theory paper will have 100 marks out of which 60 marks will be for Term End examination and 40 marks for Internal Assessment. The candidate has to appear for internal evaluation of 40 marks and external evaluation (University Examination) of 60 marks for each theory paper.

Each practical paper will have 50 marks out of which 30 marks will be for Term End examination and 20 marks for Internal Assessment. The candidate has to appear for internal evaluation of 20 marks and external evaluation (University Examination) of 30 marks for each practical paper.

Internal Evaluation

- In case of theory papers internal examinations will be conducted by department / school.
- In case of practical papers, 5 marks shall be for day-to-day journal and 15 marks shall be for internal test, which will be conducted by the department / school.

External Evaluation (End of Term University Examination)

I) Nature of Theory question paper:

1) Each Theory paper is of 60 marks.

2) Each Theory paper will be of 2.5 hours.

II) Nature of Practical question paper: (End of Term Examination)

Sem-I and II: Practical examination will be conducted for 30 marks and is of two hours duration. There shall be 05 questions each of 08 marks, of which student has to attempt any 03 questions. VIVA will be for 06 marks.

M.Sc. (Biostatistics) Semester -I

Major Mandatory	DSC-1: BASIC EPIDEMIOLOGY	Credits: 04

Course outcomes:

Upon successful completion of this course, the students will be able to:
1. Understand and explain the basic concepts of epidemiology.
2. Understand and explain the types and sources of exposures.
3. Understand diseases and measures of disease frequency.
4. Understand types of study design.

Unit-1: Basic concepts and ethics of epidemiology, Measures of exposure and outcome: History of Epidemiology, Emergence of modern epidemiology, Measures of Exposures, Types of exposures, Sources of exposures, Measures of outcome. Measures of exposure effect, relative and absolute measures of effect. Communicable and non-communicable diseases. **(15L)**

Unit-2: Disease registries, International classification of diseases. Measures of disease frequency: Prevalence, Incidence, Risk, Odds of disease, Incidence time, Relationship between prevalence, rate and risk, measures of disease occurrence, direct and indirect method of standardization, cumulative rate, cumulative risk, proportional incidence. Confidence intervals and significance tests for measures of occurrence and effect. **(15L)**

Unit-3: Type of study design: Observational study, Intervention studies, Cohort studies, case-control studies, cross-sectional studies, ecological studies, Prospective and retrospective study. **(15L)**

Unit-4: Validity and reliability of measures of exposure and outcome: Sensitivity, Specificity, positive predictive value and negative predictive value, Intra and Interobserver reliability, Kappa statistic. **(15L)**

Reference Books:

1. Deepti Shyam Sunder (2019) : Fundamentals of Epidemiology and Biostatistics, CBS Publishers & Distributors.
2. Alan J. Silman : Epidemiological Studies, Cambridge University Press
3. K. Park (2013): Parks's Textbook of Preventive and Social Medicine, Banarasidas Bhanot
Publishers, Jabalpur.

Major Mandatory	DSC-2: STATISTICAL INFERENCE-I	Credits: 04

Course outcomes:

Upon successful completion of this course, the students will be able to:
1. Explain the principles of data reduction and obtain sufficient, minimal sufficient and complete statistics for various families of distributions.
2. Obtain UMVUE of parameters of various distributions and determine Cramer-Rao and Chapman-Robbins-Kiefer lower bounds for the variances of unbiased estimators.
3. Apply parametric methods to obtain estimators.
4. Obtain CAN and BAN estimators.

Unit-1: Principles of data reduction: Sufficiency principle; factorization theorem; minimal sufficiency; minimal sufficient partition; construction of minimal sufficient statistic; minimal sufficient statistic for exponential families; power series family and Pitman family; completeness; bounded completeness; ancillary statistic, Basu's theorem and its applications. **(15L)**

Unit-2: Unbiased estimation: unbiased estimators; uniformly minimum variance unbiased estimator (UMVUE); A necessary and sufficient condition for an estimator to be UMVUE; Rao-Blackwell theorem and Lehmann-Scheffe theorem and their applications in finding UMVUEs. Fisher information function and Fisher information matrix; Cramer-Rao lower bound; Chapmann-Robinson-Kiefer lower bound; Bhattacharya lower bound, and their applications. **(15 L)**

Unit-3: Methods of Estimation: Method of maximum likelihood estimation (MLE); method of scoring and its application to estimation in multinomial distribution, method of moments, method of minimum Chi-square. Bayesian Estimation: Concept of prior and posterior distributions, various types of priors, loss functions, conjugate family and standard examples of such family. Bayes estimator under absolute and quadratic error loss functions. **(15L)**

Unit-4: Consistency of an Estimator; weak and strong consistency; joint and marginal consistency; invariance property under continuous transformations; methods of constructing consistent estimators; comparison of consistent estimators; asymptotic relative efficiency; minimum sample size required by the estimator to attain certain level of accuracy. Best Asymptotic Normal (BAN) estimator; Consistent Asymptotic Normal (CAN) estimators; invariance of CAN estimator under differentiable transformation; Methods for constructing CAN estimators for real and vector valued parameters. Cramer regularity conditions; Cramer- Huzurbazar theorem (Statement only). **(15L)**

Reference Books:

1. Rohtagi V.K. & Saleh A.K. Md. E (2001): Introduction to Probability Theory and Mathematical Statistics- John Wiley and Sons Inc.

2. Rao C.R.(1973): Linear Statistical Inference and Applications- John Wiley and Sons, Inc.

3. Casella G. and Berger R.L. (2002): Statistical Inference-Duxbury Advanced Series, 2nd ed.

4. Kale B.K. (2005): First Course on Parametric Inference- 2nd ed. Narosa Publishing House.

5. Lehmann E.L. (1983): Theory of Point Estimation- John Wiley and Sons.

6. Ferguson T.S. (1967): Mathematical Statistics, Academic Press.

7. Statistical Inference : Theory Of Estimation : M. K. Srivastava, A. H. Khan, N. Srivastava

8. Anirban Das Gupta. (2008), Asymptotic Theory of Statistics and Probability, Springer Texts in Statistics.

9. Deshmukh Shailaja and Kulkarni Madhuri (2020). Asymptotic Statistical Inference: A Basic Course Using R, Kindle Edition.

Major Elective	DSE-1 (A): PROBABILITY DISTRIBUTIONS	Credits: 04

Course outcomes:

Upon successful completion of this course, the students will be able to:

1. Understand and explain the concept of univariate and bivariate random variables and related entities.
2. Understand and explain the nature of various probability distributions and perform related computations.
3. Understand probability models for univariate and bivariate data and perform related computations

Unit-1: Random variables (discrete and continuous), Distribution function and its properties, Relation of distribution function with uniform variate. Review of univariate discrete and continuous distributions with special reference to biostatistics; Bernoulli, Binomial, Poisson, Hyper-geometric, Geometric, Negative binomial, Discrete uniform, Power series, Continuous uniform, Normal, Exponential, Gamma, Beta, Cauchy, Weibull, Pareto, Laplace and Lognormal (elementary properties and applications only), Truncated distributions, Compound distributions. **(15 L)**

Unit-2: Brief review of basic distribution theory. Distribution function and its properties, continuous and discrete distributions, mixture of probability distributions, decomposition of mixture of distribution function into discrete and continuous distribution functions. Functions of random variables and their distributions in case of univariate random variables and its applications. Concept of location, scale and shape parameters of distributions with examples. Symmetric distributions and their properties. Probability integral transformation. **(15 L)**

Unit-3: Expectation, moments, probability generating function, moment generating function, convolution and examples. Moment inequalities: Basic, Markov, Chebychev, Holder,Minkowski and Jensen's inequalities with their applications. **(15L)**

Unit-4: Bivariate random vector, joint distribution, independence, variance-covariance matrix, marginal and conditional distributions, conditional expectation and conditional variances. Transformation of bivariate random variables using Jacobian of transformation. Bivariate normal distribution and its properties, bivariate exponential (Marshall and Olkin), bivariate Poisson distributions. Multinomial distribution and its properties. **(15 L)**

Reference Books

1. Rohtagi V.K. & Saleh A.K. Md. E (2001): Introduction to Probability Theory and

Mathematical Statistics- John Wiley and Sons Inc.

2. Rao C.R. (1973): Linear Statistical Inference and Applications- John Wiley and Sons, Inc.

3. Johnson N.L. and. Kotz S. (1996): Distribution in Statistics, Vol-I, II and III- John Wiley

and Sons, Inc.

4. Johnson N.L. and Kotz S.: Multivariate distributions- John Wiley and Sons, Inc.

5. Casella G. and Berger R.L. (2002): Statistical Inference-Duxbury Advanced Series, 2nd ed.

Major Elective	DSE-1(B): STATISTICAL ECOLOGY	Credits: 04

Course Outcomes:

After successful completion of this course, student will be able to-

1. Understand the ecology and evolution.
2. Understand and utilize the population dynamics.
3. Understand game theory in ecology.
4. Understand the applications of Statistics in Ecology.

Unit-1: Introduction to ecology and evolution, population dynamics: single species. Exponential, Logistic and Gompertz models, Leslie matrix model for age and stage Structured population, survivorship curves-Constant, monotone and bath tub shaped hazard rates. **(15L)**

Unit-2: Two Species: Lotka-Volterra equations, isoclines. Abundance estimation: Capture- recapture, Nearest Neighbor, line transect sampling, indirect methods. Ecological Diversity: Species abundance curve, indices of diversity (Simpson's index, Shannon Wiener index). **(15L)**

Unit-3: Game Theory in Ecology - Evolutionarily stable strategy, its properties, simple games such as Hawk-Dove game, Prisoner's dilemma, etc. Preservation of ecology and biodiversity. **(15L)**

Unit-4: Statistics for Ecology- Analysis of variance: basic assumptions and its violations, one and two way classified data. Multivariate analysis: discriminant analysis, hypothesis testing. **(15L)**

Reference Books:

1. Gore, A.P. and Paranjpe S.A. (2001): A course on Mathematical and Statistical Ecology-

Kluwer Academic Publishers.

2. Pielou, E.C. (1977) An Introduction to Mathematical Ecology-Wiley

3. Hilborn and Mangel (1997): The Ecological Detective: Confronting Models with Data-

Princeton University Press.

4. Henry M. and Stevens H. (2009): A primer of ecology with R- Springer.

Research Methodology	RM: Research Methodology in Statistics	Credits: 04

Course outcomes:

After successful completion of this course, student will be able to

1. Understand research methodology and research ethics.
2. Understand the basic concepts involved in research.
3. Understand the basic principles underlying survey design and random sampling.
4. Apply the different sampling methods for designing and selecting a sample from a population.

Unit-1: Meaning of research, Objectives and motivation of research, Types of research. Research approaches, significance of research, Research methods versus research methodology, Importance of knowing how research is done, Research process, criteria of good research. Problems encountered by researchers in India.

(15L)

Unit-2: Meaning of literature survey and review. Understanding and selecting a research problem, steps in formulation of research problem and research objectives. Quality indices of research publication: citations, i10 index, impact factor, H-index, Science citation index, Using Web for literature review: Google scholar, Scopus, Web of Science, Math Sci net.

(15L)

Unit-3: Concept of population and sample, Need for sampling, Census and sample surveys, basic concepts in sampling and designing of large-scale survey design, sampling scheme and sampling strategy. Sampling and non-sampling errors, Response and non-response errors. Probability and non-probability sampling. Examples of non-probability sampling: Quota sampling, snowball sampling, judgment sampling. Basic methods of sample selection: SRSWR and SRSWOR, Stratified and systematic sampling.

(15L)

Unit-3. PPSWR Methods: Cumulative total method, Lahiri's method, related estimation problems, PPSWOR method and related estimation of a finite population mean (Horvitz Thompson and Des Raj estimator for general sample size and Murthy's estimator for sample of size 2, Midzuno sampling. Use of supplementary information for estimation:

Ratio and Regression estimators and their properties. Cluster sampling, Double sampling, Two-stage sampling with equal number of second stage units.

(15L)

Reference Books:

1. Kothari C. R. and Garg G. (2014). Research Methodology: Methods and Techniques, 3rd Edition, New Age International Publisher.
2. Kumar R. (2014). Research Methodology-A step-by-step Guide for Beginners, 4th Edition, Sage Publication.
3. Sukhatme P.V., Sukhatme P.V., Sukhatme S. and Ashok C. (1997): Sampling Theory of Surveys and Applications- Piyush Publications.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory. Narosa publishing House.
5. William G. Cochran (1977): Sampling Techniques, 3rd edition- John Wiley & Sons.
6. Parimal Mukhopadhyay (1988): Theory and methods of Survey sampling, Prentice Hall of India Pvt. Ltd.
7. Murthy M.N. (1977): Sampling Theory and Methods, Statistical publishing Society, Calcutta.
8. Latpate R., Kshirsagar J., Gupta, V. K. and Chandra G. (2021). Advanced Sampling Methods, Springer.
9. Chaudhuri, A., and Stenger, H. (2005). Survey sampling: theory and methods. CRC Press.
10. Cochran, W. G. (1977). Sampling techniques. John Wiley & Sons

LAB-1	Biostatistics Practical-I (Based on DSC-1 and DSC-2)	Credits: 02

Course outcomes:

Upon successful completion of this course, the student will be able to:

1. Sketch various distribution functions and find possible probability distribution to observed Data.

2. Compute UMVUE, MME and MLE using various methods.

- Sketching of PDF/PMF and CDF
- Decomposition of Mixture Distribution
- Construction of UMVUE
- Methods of Estimation (MLE, MME and Method of scoring)
- Bayesian Estimation
- Consistent Estimator and Comparison
- Construction of CAN Estimators
- Measures involved in Epidemiology

LAB-2	Biostatistics Practical-I (Based on MS-EXCEL and R)	Credits: 02

Course outcomes:

Upon successful completion of this course, student will be able to:

1. Perform data organization, data manipulation, statistical and mathematical computations, and data analysis using MS-EXCEL.
2. Perform data organization, data manipulation, statistical and mathematical computations, and data analysis using R.
3. Perform mathematical/statistical computations, statistical data analysis using built-in functions in MS-EXCEL and R and develop programs for various tasks.

Unit-1: MS-EXCEL: Introduction to MS-EXCEL, cell formatting, conditional formatting, data manipulation using EXCEL; Sort and filter, find and replace, text to columns, remove duplicate, data validation, consolidate, what-if analysis. Working with multiple worksheets and workbooks. Built-in mathematical and statistical functions for obtaining descriptive statistics, computing pmf/pdf, cdf and quantiles of well-known distributions, rand and rand-between function, logical functions: if, and, or, not. Look-up functions: hlookup, vlookup, formula errors, creating and working with charts, database functions, text functions, date and ime functions, EXCEL add-ins; analysis tool pack, pivot tables and charts.

MS-EXCEL Exercise

- Reading and creating data, certain computations using data. Descriptive statistics and
- construction of frequency distribution.
- Listing probabilities for standard distributions and plotting its probabilities and
- distributions.
- Plotting density functions and distribution functions for standard continuous
- distributions.
- Using macro programming for certain iterative computing.

Unit-2: Elements of R Programming: Introduction to statistical software R, Data objects in R, Manipulating vectors, matrices, lists, importing of files, data frame, and computations of descriptive statistics measures. R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Plot options; Multiple plots in a single graphic window, frequency table, Plotting of probability distributions and sampling distributions.

R-Programming

- Simple R exercise using –scan function, reading data from EXCEL and exercises,
- vectors, matrices, rbind and cbind.
- Exercises on Matrices

- Reading data from text file. Data frames, names etc. Exercises based on these data

and graphics.

- Exercises on Functions in R
- Generating samples from standard discrete and continuous distributions.
- Verification of law of large numbers and central limit theorem.

LAB-3	**Biostatistics Practical-III (Statistical Computing)**	**Credits: 02**

Course outcomes:

Upon successful completion of this course, the student will be able to:
1. Understand the basic ideas of random number generation using different techniques.
2. Learn theoretical methods and practicable techniques of statistical simulations.
3. Understand how to apply Monte Carlo simulations and the EM algorithm.

Unit 1: Simulation: An introduction, need of simulation, random number generator, true random number and pseudo random number generators, requisites of a good random number generator. Statistical tests for random numbers. Congruential method of generating uniform random numbers, Inverse transforms method, Acceptance-rejection method. Algorithms for generating random numbers from well-known univariate discrete and continuous distributions.

- Generating samples from univariate discrete and continuous distributions.
- Generating random vectors from multinomial, bivariate normal, and bivariate
- exponential distributions.
- Generating random numbers from mixture of distributions.
- Use of random numbers to evaluate integrals and to study the systems involving
- random variables.
- Use of random numbers for performance evaluation of estimators and statistical tests.

Unit 2: Resampling methods

- Bootstrap method: Estimation of bias and standard errors, estimation of sampling distribution, confidence intervals.
- Jackknife method: estimation of bias and standard errors, bias reduction method.
- Numerical methods for finding roots of nonlinear equation: Newton-Raphson method,
- bisection method; Newton-Raphson method for system of non- linear equations.
- Numerical integration: quadrature formula, trapezoidal rule and Simpson's rules for
- single integral.
- Introduction to EM algorithm.

Major Mandatory	DSC-3: DESIGN OF EXPERIMENTS AND BIOASSAY	Credits: 04

Course outcomes:

Upon successful completion of this course, the student will be able to:

1. Understand the basic ideas involved in designing of experiments.
2. Understand basic as well as advanced designs for conducting scientific experiments.
3. Understand the basic concept of Bioassay.
4. Understand use of Statistics in Bioassays.

Unit-1: One way classification, Analysis of variance (ANOVA): One-way and Two-way, Single factor ANOVA, Two-factor ANOVA with unequal and equal replication (with/without interactions). Three basic principles of design of experiments: Randomization, replication and local control. Designs of Experiments: Completely Randomized Designs (CRD), Randomized Block Designs (RBD), Latin Square Designs (LSD). **(15L)**

Unit-2: Advanced Designs for Analysis, Repeated measures designs, ANCOVA (for CRD and RBD), Factorial Designs (22 and 32). **(15L)**

Unit-3: Introduction, component of bioassay, role of statistics in bioassay, Type of biological assays: direct assays, indirect assays, parallel line assays, ratio estimators, asymptotic distributions, Filler's theorem. **(15L)**

Unit-4: Dose response relationship, regression approaches to estimate dose response relationships, Logit and probit approaches when dose response curve for standard preparation is unknown, quantal response, method of estimation of parameters.

(15 L)

Reference Books:

1. Kempthorne O. (2007): Design and Analysis of Experiments, 2nd Edition, Vol I-II, Wiley.
2. Montgomery D. C. (2008): Design and Analysis of Experiment, 7th Edition, John Wiley & sons.
3. Dass M. N. and Giri N. C. (1986): Design and Analysis of Experiments, 2nd Edition, Wiley.
4. Pandey M. (2015): Biostatistics-Basic and Advanced-MV Learning.
5. Govindarajulu Z. (2000): Statistical Techniques in Bioassay, S. Kargar
6. Zar, J.H. (2007): Biostatistical Analysis, Pearson Education 4th edition.

Major Mandatory	DSC-4: STATISTICAL INFERENCE-II	Credits: 04

Course outcomes:

Upon successful completion of this course, the student will be able to:

1. Understand the concept of testing of hypothesis, test statistic, critical region, size and power of a test. Neyman-Pearson fundamental lemma, UMP test and interval estimation.
2. Understand the concept of critical regions, likelihood ratio test with its asymptotic distribution.

Unit-1: Problem of testing of hypothesis, null and alternative hypotheses, simple and composite hypotheses, randomized and non-randomized tests, power function of a test, Most powerful (MP) tests, Neyman-Pearson Lemma and its applications. Monotone likelihood ratio (MLR) property, uniformly most powerful (UMP) tests and their existence for one-sided alternatives. **(15 L)**

Unit-2: UMP tests for two sided alternatives, examples of their existence and non-existence. Generalized Neyman Pearson Lemma, unbiased test, uniformly most powerful unbiased (UMPU) tests and their existence in the case of exponential families (Statements of the theorems only), Similar tests, Test with Neyman structure. **(15L)**

Unit-3: Interval estimation: confidence level, construction of confidence intervals using pivots, shortest length confidence interval, UMA confidence interval and its relation to UMP test, UMAU confidence interval and its relation with UMPU test, variance stabilizing transformations (VST) and their existence, asymptotic confidence intervals based on CAN estimators and VST. **(15L)**

Unit-4: Likelihood ratio test (LRT) and its asymptotic distribution, application of LRT to standard distributions, Wald test, Rao's score test, Pearson Chi-square test for goodness of fit, application to contingency tables, Bartlett's test for homogeneity of variances, Kruskal-Wallis test. **(15L)**

Reference Books:

1. Kale B. K. (1999). A first Course on Parametric Inference, Narosa
2. Rohatgi V.K. (1988), Introduction to Probability and Mathematical Statistics, Wiley Eastern Ltd. New Delhi. Student Edition.
3. Dudewicz E. J. and Mishra S. N. (1988), Modern Mathematical Statistics, Wiley Series
4. Lehman E. L. (1987). Theory of Testing of Hypotheses. Student Edition.
5. Srivastava M. and Srivastava N. (2009): Statistical Inference-Testing of Hypotheses, PHI Learning Pvt. Ltd.
6. Shanthakumaran A. (2001): Fundamentals of Testing of Hypotheses, Atlantic Publishers and Distributors.

Major Elective	DSE-2(A): STOCHASTIC PROCESSES	Credits: 04

Course outcomes:

Upon successful completion of this course, the student will be able to:

1. Study the fundamental concept of stochastic processes and its applications.

2. Understand Markov processes and Markov chains and their applications in real world.

3. Study the branching process and its properties.

4. Understand Poisson processes and its variations.

Unit-1: Definition of Stochastic process, Finite dimensional distributions. Examples of various stochastic processes. Markov chain and its Examples. Chapman-Kolmogorov equation, calculation of n-step transition probabilities. Classification of states of Markov chain, irreducible Markov chain, period of the state, First entrance theorem, First passage time distribution. Long run distribution of Markov chain, relation of mean recurrence time and stationary distribution. **(15L)**

Unit-2: Random walk and gambler's ruin problem. Discrete state space continuous time Markov chain. Poisson process and related results. Birth and death processes and associated cases. M/M/1, M/M/S queuing models and related properties. **(15L)**

Unit-3: Galton-Watson branching process. Probability of ultimate extinction, distribution of population size and associated results. Simulation of Markov chain, Poisson process, branching process (Algorithms). **(15 L)**

Unit-4: Brownian motion, Hitting Time, Maximum, Reflection Principle Stopping Time and Strong Markov Property, Reflection principle. **(15 L)**

Reference Books:

1. Medhi. J. (1982). Stochastic Process- Wiley Eastern.
2. Parzen E. (1962). Stochastic Process-Holden-Pay.
3. Karlin & Taylor (1975). A First Course in Stochastic Processes-Vol-I Academic Press.
4. Cinlar E. (1975). Introduction to Stochastic Process. Prentice Hall.
5. Srinivas and Mehta (1976). Stochastic Processes-Tata MgGraw-Hill.
6. Adke and Manjunath (1984). An introduction to finite Markov Processes- Wiley Eastern.
7. Bhat B. R. (2000). Stochastic Model: Analysis and Application, New Age International.

Major Elective	DSE-2(B): Nonparametric Methods	Credits: 04

Course outcomes:

Upon successful completion of this course, the student will be able to:
1. Learn the basic concepts of nonparametric techniques.
2. Learn about non-parametric methods for computing survival function.
3. Estimate nonparametric survival function of the data.

Unit-1: Definition of nonparametric test, Advantages and disadvantages of nonparametric tests. One sample tests: Sign test, Wilcoxon's signed rank test, Run test. Two sample tests: Wald-Wolfowitz run test, Mann-Whitney test, Median test, Kolmogorov-Smirnov test. **(15L)**

Unit-2: Test for two-sample scale problem: Mood, Klotz, Ansari-Bradley, Siegel-Tukey and Sukhatme tests. Spearman's rank correlation test, Kendall's rank correlation test, Thiel's test for regression coefficients, Hollander's test for parallelism of two regression lines. **(15L)**

Unit-3: Anderson-Darling test, Freidman's test, Kruskal-Wallis test. Estimable parametric functions, kernel, symmetric kernel, Concept of U statistics and examples. Statement of Asymptotic distributions of U-statistics, U-statistics theorem for one sample and two samples (statements only). **(15L)**

Unit-4: Concept of time order and random censoring, likelihood in these cases, survival function, hazard function, nonparametric estimation of survival function, Cox's proportional hazards model, the actuarial estimator, Kaplan-Meier estimator. **(15L)**

Reference Books:

1. Gibbons J. D. and Chakraborti S. (2003). Nonparametric Statistical Inference, 2nd Edition, Marcel Dekker Inc.
2. Randles R. S. and Wolf D. A. (1979). Introduction to Theory of Nonparametric Statistics, John Wiley and Sons.
3. Rohatgi V. K. (1976). An Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons.
4. Daniel W. W. (2000). Applied Nonparametric Statistics, 2nd Edition, Duxbury.
5. Deshpande, J. V. and Purohit, S. G. (2005): Life Time Data: Statistical Models and Methods, Word Scientific.
6. Nelson W. (1982): Applied Life Data Analysis, John Wiley and Sons, Inc.
7. Miller R. C. (1981): Survival Analysis, John Wiley.

LAB-4	BIOSTATISTICS PRACTICAL-IV (Based on DSC-3 and DSC-4)	Credits: 04

Course Outcomes:

Upon successful completion of this course, the student will be able to:

1. Construct MP, UMP and UMPU tests.

2. Construct Confidence Intervals based on CAN and VST.

3. Classify states of a stochastic process.

4. Perform simulations from different stochastic processes such as Counting, Poisson.

- Classification of States
- Simulation from Markov Chain
- Stationary Distribution of Markov Chain
- Simulation from Counting Process
- Computation of Probabilities of Type-I and Type-II Errors
- Construction of MP , UMP and UMPU Tests
- Confidence Intervals
- Asymptotic Confidence Intervals based on CAN Estimators and VST.
- Likelihood Ratio Tests
- Chi-square Test of goodness of fit
- Bartlett's Test For Homogeneity of Variances
- Kruskal-Wallis Test.
- Design of Experiments
- Bioassays

LAB-5	BIOSTATISTICS PRACTICAL-V (Data Analysis Using SPSS)	Credits: 04

Course Outcomes:

Upon successful completion of this course, the student will be able to:

1. Gain expertise in Using SPSS software.

2. Perform various statistical operations using SPSS.

3. Analyze datasets in SPSS.

Unit-1: Getting started with SPSS: Data editor, Output viewer, Syntax editor, Script window, Variable view. Charts and Graphs: Line chart, Scatter Plots, Histogram, Bar chart, Box Plot, Pie chart. Exploratory data analysis: Sum, Mean, Standard deviation, Variance, Minimum value, Maximum value and Range. Correlation and Regression: Correlation: Scatter plots, Karl Pearson correlation coefficient, Partial correlation, Spearman correlation, Regression: Simple and Multiple regression.

Unit-2: Testing of hypotheses: Chi square test for association, Chi square test goodness of fit, Independent sample t test, Paired sample t test, One sample t test, Report generation.

References:

1. William C. Rinaman: Workshop Statistics: SPSS Software Companion Manual, Key College Publishing, 2004.
2. Ton J. Cleophas, Ton J. M. Cleophas, Aeilko H. Zwinderman: Cookbook for Starters on
SPSS, Springer.
3. Eelko Huizingh: Applied Statistics with SPSS, SAGE, 2007

LAB-6	Biostatistics Practical-VI (Data Analysis Using Python)	Credits: 04

Course outcomes:

Upon successful completion of this course, a student will be able to:

i) Develop programmes in Python.

ii) Perform data organization, data manipulation, statistical and mathematical computations, and data analysis using Python.

Unit 1: Introduction, installation, keywords, identifiers: variables, constants, literals; comments, Operators, statements and expressions, data types with methods: numbers, string, lists, tuple, dictionary, set; indexing and slicing of each data type, data type conversion, built- in functions, control statements and loops, list comprehensions, user defined functions, anonymous/lambda function, local and global variables, modules: math, stat, random; creating own modules.

Unit 2: Concept of library and its working, Data storage, manipulation, visualization and analysis using the libraries: Numpy, Pandas, Scipy, statsmodels, Matplotlip, Seaborn, Regular Expressions (RegEx), Ski-kit learn.

References:

1. Gowrishankar S. & Veena, A. (2018). Introduction to Python programming. CRC Press.
2. Guttag J. V. (2021). Introduction to Computation and Programming Using Python: With Application to Computational Modeling and Understanding Data. Mit Press.
3. Haslwanter T. (2016). An Introduction to Statistics with Python. With Applications in the Life Sciences. Switzerland: Springer International Publishing.
4. Nelli F. (2018). Python data analytics with Pandas, NumPy, and Matplotlib.
5. Unpingco J. (2016). Python for probability, statistics, and machine learning (Vol. 1). Springer International Publishing.
6. Vander Plas, J. (2016). Python data science handbook: Essential tools for working with data. " O'Reilly Media, Inc.".
7. Mark Lutz . Programming Python, 4th Edition
8. URLs:
    - https://scikit-learn.org/stable/
    - https://numpy.org/
    - https://scipy.org/
    - https://www.statsmodels.org/stable/index.html
    - https://matplotlib.org/
    - https://pandas.pydata.org/

OJT/FP	On Job Training / Field Project	Credits: 04

On Job Training (OJT)/Field Project aims to provide necessary practical knowledge and hands-on experience in the application of Statistical tools to solve real-world problems. The objectives of OJT/FP in Statistics are as follows:

1. To understand the applications of statistical techniques in different fields.
2. To gain expertise in handling different statistical software.
3. To identify the potential use of statistical tools in different situation.
4. To enhance the revenue by using different statistical optimization techniques.
5. To explore the real-world data with the aim of getting meaningful insights from it.

Course Outcomes:

Upon successful completion of this course, student will be able to:

1. Apply various statistical tools to different societal problems.
2. Analyze the real-world data using Statistical techniques.
3. Enhance the expertise on use of Statistical Software.
4. Interpret the output and convey it efficiently to the end user.
5. Explore himself / herself in competitive corporate environment.

On Job Training (OJT):

1. For On Job Training, students will be asked to work with various govt./semi-govt./private institutions/organizations/industries, where they can explore their statistical knowledge.
2. Students are expected to gain the practical knowledge under the mentoring of personnel available therein.
3. A student is expected to spend not less than 120 working hours for On Job Training and related activities.
4. On Job Training will be carried out in summer vacation after the students complete their second semester examination.
5. Students need to provide the confirmation letter from the organization or the Institute where they have joined for On Job Training.
6. Continuous evaluation of the students' performance in the On Job Training will be carried out with the assistance of the personnel of training institution/organization where the training is being given.
7. The proof of completion of On Job Training (work experience certificate / field report) should be submitted after the completion of On Job Training, duly issued and signed by the concerned training organization.

Evaluation:

Students' performance will be evaluated for 100 marks (04 credits), which will be split into two parts.

Internal Evaluations: 40 marks based on the certificate of assessment issued by organization, where the student completed his/her On Job Training.

External/End Semester Evaluation: 60 marks, out of which 40 marks will be for submitted report of OJT and 20 marks for comprehensive viva-voce examination.

Field Project (FP):

The objective of Field Project is to train the students to undertake projects individually or in groups. The projects shall enable the students to take up their own statistical study and to understand the application of statistical methods that they learned during the course. For the project each student shall work under the supervision of a faculty member of the department. In consultation of the supervisor, students shall decide on a topic for their Field Project The topic shall be presented before all faculty members for approval with details objective and methodology. Once approved, the student shall work on the project. There shall be a mid-term evaluation of the project to appraise the continuous progress. Before the start of the end-semester examination, students are required to submit the project report in hard copy in duplicate. During the end of semester examination, students shall present the same, whereby they shall be evaluated by an external examiner.

- Project report shall contain the Statement of Problem, Data collection, Methodology adopted, Statistical tools used for analysis, Findings, Conclusion, Suggestion and References.
- Project work will be assessed for 100 marks (04 credits), out of which 40 marks are reserved for internal evaluation based on primary preparation for the project like selection of topic, preparation of questionnaire, synopsis presentation and day-to-day project work reporting, mid-term project presentation etc.
- End of Term assessment of the project for 60 marks will be done on the basis of presentation, findings and report of the project, out of which 20 marks are reserved for VIVA**.**

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