M.Sc., Statistics with Computer Applications

Syllabus

UNIVERSITY DEPARTMENT

Program Code: STAB

2023 – 2024 onwards

BHARATHIAR UNIVERSITY

(A State University, Accredited with "A++" Grade by NAAC,
Ranked 21st among Indian Universities by MHRD-NIRF)

Coimbatore - 641 046, Tamil Nadu, India

Program Educational Objectives (PEOs)	
On successful completion of the M. Sc., Statistics with Computer Applications program, the graduates will be able to:	
PEO1	Get employment in government, public, private, industrial, health, business, banking, agricultural and educational sectors
PEO2	Expand their knowledge to set their career in research and higher studies
PEO3	Comprehend the statistical concepts and principles for interdisciplinary research
PEO4	Excel in statistical computing
PEO5	Acquire proficiency in adopting statistical software for data analysis
PEO6	Nurture advancement in statistical theory and applications

Program Specific Outcomes (PSOs)	
On successful completion of the M. Sc., Statistics with Computer Applications program, the students will be expected to:	
PSO1	Comprehend the theoretical aspects of statistics
PSO2	Recognize the application of statistics in diversified fields
PSO3	Develop computer programs and codes for statistical computation
PSO4	Utilize statistical software effectively for data analysis
PSO5	Understand the conditions and limitations of statistical methods in application
PSO6	Critically analyze statistical data and make interpretations

Program Outcomes (POs)	
On successful completion of the M. Sc., Statistics with Computer Applications program, the graduates will be able to:	
PO1	Possess adequate knowledge in theory and applications
PO2	Adopt conceptual ideas, principles and methods in diversified fields of study
PO3	Utilize analytical skills for basic mathematical computation
PO4	Utilize software skills for statistical computation
PO5	Prepare to participate in competitive examinations at the state and national level
PO6	Acquire skills to meet the challenges in job placements
PO7	Gain impetus to move for learning at higher level
PO8	Gain effective skills to perform data analysis using statistical tools
PO9	Identify potential areas of applications of statistical theory
PO10	Recognize the importance and value of statistical principles and approach for problem solving on a diversified disciplines

BHARATHIAR UNIVERSITY, COIMBATORE 641 046

M. Sc., Statistics with Computer Applications Curriculum
(University Department)

(For the students admitted during the academic year 2023 – 24 onwards)

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
FIRST SEMESTER							
21S13A	Real Analysis and Linear Algebra	4	5	-	25	75	100
21S13B	Measure and Probability Theory	4	5	-	25	75	100
21S13C	Distribution Theory	4	5	-	25	75	100
21S13D	Sampling Theory and Methods	4	5	-	25	75	100
21S13E	Object Oriented Programming with C++	4	5	-	25	75	100
Supportive	Offered by other Departments	2	2	-	12	38	50
	Total	**22**					**550**
SECOND SEMESTER							
21S23A	Statistical Estimation Theory	4	5	-	25	75	100
21S23B	Multivariate Statistical Analysis	4	5	-	25	75	100
21S23C	Statistical Quality Control and Reliability Theory	4	5	-	25	75	100
21S23EA	Elective I	4	5	-	25	75	100
21S2P1	Programming Lab I: Object Oriented Programming with C++	4	-	5	40	60	100
Supportive	Offered by other Departments	2	2	-	12	38	50
	Total	**22**					**550**
THIRD SEMESTER							
21S33A	Testing Statistical Hypotheses	4	5	-	25	75	100
21S33B	Linear Models and Design of Experiments	4	5	-	25	75	100
21S33C	Programming in R	4	5	-	25	75	100
21S33EB	Elective II	4	5	-	25	75	100
21S3P2	Statistical Software Practical using SPSS and MINITAB	4	-	5	40	60	100
Supportive	Offered by other Departments	2	2	-	12	38	50
	Total	**22**					**550**
FOURTH SEMESTER							
21S43A	Stochastic Processes	4	5	-	25	75	100
21S43	Biostatistics and Survival	4	5	-	2	75	100

B	Analysis				5		
21S43EC	Elective III	4	5	-	25	75	100
21S4P3	Programming Lab II: Computational Statistics	4	-	5	40	60	100
21S4P4	Statistical Software Practical using R	4	-	5	40	60	100
21S4PV	Project and Viva-voce*	4	5	-	25	75	100
	Total	**24**					**600**
	Grand Total	**90**					**2250**
* Project evaluation – 50 marks | Viva-voce – 25 marks in ESE							
CO-SCHOLASTIC COURSES							
ONLINE COURSE							
	SWAYAM – MOOC Course	2					50
VALUE ADDED COURSES							
	Course 1	2					50
	Course 2	2					50
CERTIFICATE COURSES							
	Course 1	2					50
	Course 2	2					50
SWAYAM – MOOC – online course shall be for duration at least 4 weeks with at least 2 credits. The course shall be mandatory and shall be completed within third semester (i.e., before the beginning of fourth semester).							

Distribution of Marks and Credits

	Subjects						**Total**
	Core	Elective	Supportive	Swayam / MOOC	VAC	JOC	
Marks	1800	300	150	50	100	100	**2500**
Credits	72	12	06	02	04	04	**100**

VAC: Value Added Course **JOC: Job Oriented Course**


First
Semester

Course Code	21S13A	TITLE OF THE COURSE	L	T	P	C
Core		Real Analysis and Linear Algebra	4	1	-	4
Pre-requisite		Skills in Basic Mathematics and Matrices	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Impart the understanding of the basic concepts of real analysis and linear algebra
2. Enhance the ability of proving the theorems in real analysis and linear algebra
3. Understand the meaning of convergence of sequence and series of real numbers
4. Comprehend the concepts which are essential for learning other courses

Expected Course Outcomes

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

1	Identify the given functions are continuous or discontinuous	K2,K3
2	Examine the convergence of sequence and series of real numbers	K2,K4
3	Understand the conditions for integrability of a real valued function	K1,K3
4	Derive the characteristic roots and vectors	K2,K5
5	Determine the nature of quadratic forms and reduction of quadratic forms	K4,K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Real Valued Functions	12 hours

Limits, continuity and uniform continuity of functions – Algebra of continuous functions - Differentiability – Algebra of Derivatives - Maxima and Minima of functions – Mean value theorems - Taylor's theorem – Functions of several variables.

Unit:2	Sequences and Infinite Series	12 hours

Boundedness and limit of a sequence - Convergence of sequences and series of real numbers – absolute and conditional convergence – Point - wise and uniform convergence – Tests for absolute, conditional and uniform convergence – Properties of uniform convergence.

Unit:3	Rieman-Stieljtes (R-S) Intergrable Functions	12 hours

Upper and lower R-S integrals. Necessary and sufficient condition for R-S integrability. Algebra of R-S integrable functions. Class of R-S integrable functions. Integration by parts. First mean value theorem and Cauchy's mean value theorem for R-S integrals.

Unit:4	Characteristic Roots and Characteristic Vectors	12 hours

Cayley-Hamilton theorem. Minimum polynomial, similar matrices, algebraic and geometric multiplicities of a characteristic root. Spectral decomposition of a real symmetric matrix.

Unit:5	Quadratic Forms	12 hours

Congruent transformations, congruence of symmetric matrices. Canonical reduction and orthogonal reduction of real quadratic forms. Nature of quadratic forms. Sylvester's law of inertia. Simultaneous reduction of a pair of quadratic forms.

Unit:6	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars	
Total Lecture Hours	**62 hours**
Books for Study	
1	Ajit Kumar and Kumaresan, S. (2014). A Basic Course in Real Analysis, Chapman and Hall/CRC Press.
2	Arora, S. (1988). Real Analysis, Satya Prakashan Mandir, New Delhi.
3	Goldberg, R. R. (1976). Methods of Real Analysis, Oxford & IBH Publishing Company, New Delhi
4	Malik, S.C., and Arora, S. (2009). Mathematical Analysis, Second Edition, New Age International, New Delhi.
5	Rao, A. R., and Bhimasankaram, P. (2000). Linear Algebra, Second Edition, Hindustan Book Agency, Hyderabad.
Reference Books	
1	Apostol, T. M. (1986). Mathematical Analysis, Second Edition, Addison-Wesley, New York (Twentieth Reprint, 2002).
2	Graybill, F.A. (1983). Matrices and Applications in Statistics, Wadsworth Publishing Company, Belmont, California, USA.
3	Rudin, W. (1985). Principles of Mathematical Analysis, McGraw-Hill, New York
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.jirka.org/ra/realanal.pdf
2	http://synechism.org/primer/primer-real-analysis.pdf
3	http://www.astronomia.edu.uy/progs/algebra/Linear_Algebra,_4th_Edition__(2009)Lipschutz-Lipson.pdf
4	https://nptel.ac.in/courses/111/101/111101134/
5	https://nptel.ac.in/courses/111/106/111106051/
Course Designed By: Dr. R. Vijayaraghavan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	L	S	M	S	L	L	L
CO2	S	S	S	L	S	M	S	L	L	L
CO3	S	S	S	L	S	M	S	L	L	L
CO4	M	S	S	L	M	M	S	L	L	L
CO5	M	S	S	L	M	M	S	L	L	L

*S-Strong; M-Medium; L-Low

Course Code	21S13B	TITLE OF THE COURSE	L	T	P	C
Core		Measure and Probability Theory	4	1	-	4
Pre-requisite		Basics in Set theory, Liner Algebra and Probability	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the concept of measure and probability theory.
2. Explore the basic and advance concepts available in measure and probability.
3. Develop the mathematical probability and their applications.

Expected Course Outcomes

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

1	Understand the meaning of measure and probability	K1
2	Comprehend the concepts of sets, functions, measure and probability space	K2
3	Provide basic and advanced applications of measure and probability	K3
4	Identify application of inequalities in probability theory	K4
5	Explore the application of law of large numbers and central limit theorems	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Sets, Measure Space and Measurable Functions	13 hours

Sets: Finite and infinite sets, Sequences and Limits - Functions - Field, sigma field and Borel field – Functions and inverse functions – Set functions – Measure: Inner and outer Measure - Measure space - Measurable functions: Combinations of measurable functions - Sequences of measurable functions - Convergence in measure.

Unit:2	Integration and Integrable Functions	13 hours

Integration: Integrable simple functions - Sequences of Integrable simple functions - Integrable Functions: Sequences of integrable functions - Properties of integrals – Signed Measures – Absolute Continuity – Radon – Nikodym theorem (Statement only) – Product measures – Fubini's theorem (Statement only).

Unit:3	Random Variables and Inequalities	12 hours

Random variables: Limits of random variables – Probability, probability space, induced probability space and discrete probability space - Properties. Distribution functions. Expectation and Conditional Expectation – Properties – Inequalities: Jensen's, Holder's, Minkowski's, Cauchy – Schwartz's inequalities - Basic Inequality – Chebychev's and Markov's inequalities.

Unit:4	Convergence and Characteristic functions	12 hours

Convergence of random variables: Convergence in probability - convergence almost surely - convergence in distribution - Convergence in r^{th} mean - monotone convergence theorem – Characteristic functions: Definition - Properties – Inversion formula – Problems - Borel 0 – 1 law - Borel Cantelli lemma – Uniqueness theorem – Helly-Bray lemma.

Unit:5	Law of Large Numbers and Central Limit Theorems	10 hours

Law of Large Numbers: Weak and Strong Law of Large Numbers – Bernoulli's Weak Law of Large Numbers - Kolmogorov's Strong law of large numbers – Central Limit Theorems: Lindeberg –

Levy's central limit theorem - Liaponov's central limit theorem - Lindberg – Feller's central limit theorem (Statement only).		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Basu, A. K. (2012). Measure Theory and Probability, Prentice Hall India Learning Private Limited, New Delhi.
2	Bhat, B. R. (2009). Modern Probability Theory – An Introductory Text Book, Third Edition (Reprint), New Age International Private Ltd., New Delhi.
3	Halmos, P. R. (1978). Measure Theory, (First Edition in 1950), Second Printing, Springer-Verlag, NY.
Reference Books	
1	*de* Barra, G. (2000), Measure Theory and Integration, New Age International Private Ltd., New Delhi.
2	Rohatgi, V. K., and Saleh, A.K.M.E. (2015), An Introduction to Probability and Statistics, Third Edition, John Wiley & Sons, NY.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/101/111101005/
2	https://nptel.ac.in/courses/111/102/111102111/
3	https://nptel.ac.in/courses/111/102/111102111/
Course Designed By: Dr. V. Kaviyarasu	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	L	S	S	S	M	M	M
CO2	S	M	M	L	S	S	S	M	M	M
CO3	S	M	M	L	S	S	S	M	M	M
CO4	M	M	M	L	S	S	S	M	M	M
CO5	S	M	M	L	S	S	S	M	M	M

*S-Strong; M-Medium; L-Low

Course Code	21S13C	TITLE OF THE COURSE	L	T	P	C
Core		Distribution Theory	4	1	-	4
Pre-requisite		Basic knowledge in probability theory	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the advanced concepts of probability distributions
2. Study essential properties of probability distributions
3. Create and apply customized probability distributions

Expected Course Outcomes

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

1	Describe the fundamental concepts of probability distributions	K2
2	Derive the properties of continuous probability distributions	K5
3	Develop the properties of bivariate probability distributions	K6
4	Define order statistics and obtain their sampling distributions	K4
5	Find empirical probablity distributions and derive the distributions of quadratic forms	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Continuous Probability Distributions	12 hours

Probability distributions: Cauchy distribution – Laplace distribution - Pareto distribution – Lognormal distribution – Power series distribution – Logarithmic series distribution – Distribution of functions of random variables

Unit:2	Bivariate and Truncated Distributions	12 hours

Bivariate binomial, Bivariate Poisson and Bivariate normal distributions - Concept of truncated distribution – compound distribution – mixture distribution and their properties.

Unit:3	Non-central Probability Distributions	12 hours

Non-central t, chi-square and F distributions and their properties.

Unit:4	Order Statistics and Their Properties	12 hours

Order Statistics: Distribution of order statistics - Joint distribution of order statistics – Asymptotic distribution of rth order statistics - Joint distribution of range and mid range.

Unit:5	Quadratic Forms and Their Distributions	12 hours

Distribution of Quadratic forms – Properties – Cochran's Theorem – Empirical Distributions – Properties.

Unit:6	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

Total Lecture Hours **62 hours**

Books for Study

1 Rohatgi V.K. (1976). Introduction to Probability Theory and Mathematical Statistics, John

	Wiley & Sons, NY.
2	Johnson, N. L., Kemp, A.W., and Kotz, S. (2005). Univariate Discrete Distributions, Third Edition, John Wiley and Sons, New York.
3	Johnson, N. L., Kotz, S., and Balakrishnan, N. (2004). Continuous Univariate Distributions. Vol. I, John Wiley and Sons (Asia), Singapore.
4	Johnson, N. L., Kotz, S., and Balakrishnan, N. (2014). Continuous Univariate Distributions, Vol. II. John Wiley and Sons (Asia), Singapore.
Reference Books	
1	Hogg, R.V., McKean, J. W., and Craig, A. T. (2012). Introduction to Mathematical Statistics, Seventh Edition, Pearson Education, London.
2	Johnson, N. L., and Kotz, S. (1972). Distributions in Statistics, Princeton University Press, Princeton.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd2_cec20_ma01/preview
2	https://nptel.ac.in/courses/111/104/111104032/
Course Designed By: Dr. K. M. Sakthivel	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	S	S	M	M	M
CO2	S	S	M	L	S	S	S	M	M	M
CO3	S	S	M	L	S	S	S	M	M	M
CO4	S	S	M	L	S	S	S	M	M	M
CO5	S	S	M	L	S	S	S	M	M	M

*S-Strong; M-Medium; L-Low

Course Code	21S13D	TITLE OF THE COURSE	L	T	P	C
Core		Sampling Theory and Methods	4	1	-	4
Pre-requisite		Basics notions of descriptive statistics and sampling	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Impart the significance of theory and applications of sampling
2. Enhance the ability of deriving the properties of methods of drawing samples
3. Comprehend the concepts of sampling for effective application for designing sample surveys

Expected Course Outcomes

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

1	Understand the importance of sampling and sample surevyes	K2
2	Adopt suitable sampling methods for given situations	K2,K3
3	Observe the effectiveness of sample surveys	K1,K4
4	Design and perform sample suerveys	K3,K5
5	Draw random samples using various sampling methods and study the properties	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Notions of Sample Survey	12hours

Population and Sample – Census and sample survey – sampling – sampling unit, sampling frame, sampling distribution, standard error, questionnaire and schedule, sampling design – sampling and non-sampling errors – non-response and its effects – sample surveys – principles of sample survey - principal steps in sample survey - limitations of sampling.

Unit:2	Simple Random Sampling	12 hours

Simple Random Sampling (with and without replacement): Notations and terminology - Estimates of population total, mean and their variances and standard errors – Pooling of estimates - Determination of sample size. Simple random sampling for attributes -

Unit:3	Stratified Random Sampling	12 hours

Stratified random sampling: Estimates of population total, mean and their variances - Related properties – Allocation of sample sizes – Neyman's proportional and optimum allocations - Comparison of stratified sampling with simple random sampling - Estimation of proportion under stratified random sampling.

Unit:4	Systematic and Cluster Sampling	12 hours

Systematic sampling: Estimates of population total, mean, and their variances and standard errors – systematic sampling with linear trend – comparison of systematic sampling with stratified and simple random sampling – circular systematic sampling - Two stage sampling with equal number of second stage units and cluster sampling.

Unit:5	Varying Probability Sampling, Ratio and Regression Estimators	12 hours

Varying Probability Sampling: Probability proportional to size (PPS) sampling (with and without replacement) – Stratified PPS – Selection procedures – Ordered and unordered estimates – Desraj, Horwitz – Thompson and Murthy's estimates. Ratio Estimates – Methods of estimation, approximate variance of the Ratio Estimate - Regression Estimators – Difference Estimators, Regression Estimators in Stratified Sampling..		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Cochran, W.G. (1977). Sampling Techniques, Third Edition, John Wiley & Sons, NY.
2	Des Raj (1978), Sampling Theory, Tata-McGraw Hill, New Delhi.
3	Singh D., and Chowdhary, F. S. (2018). Theory and Analysis of Sample Survey Design, New Age International Private Ltd., New Delhi.
Reference Books	
1	Murthy, M. N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
2	Sampath, S. (2000). Sampling Theory and Methods, Narosa Publishing Company, New Delhi.
3	Sukhatme, P. V., and Sukhatme, B. V. (1970). Sampling Theory of Surveys with Applications, Asia Publishing House, New Delhi.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/104/111104073/
2	https://nptel.ac.in/content/storage2/courses/111104073/Module14/Lecture42.pdf
3	https://www.mooc-list.com/tags/sampling-methods
Course Designed By: Dr. S. Gandhiya Vendhan / Dr. R. Vijayaraghavan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	M	S	S
CO2	M	S	M	L	S	M	S	M	S	S
CO3	S	S	M	L	S	M	S	M	S	S
CO4	S	S	M	L	S	M	S	M	S	S
CO5	S	S	M	L	S	N	S	M	S	S

*S-Strong; M-Medium; L-Low

Course Code	21S13E	TITLE OF THE COURSE	L	T	P	C
Elective		Object Oriented Programming with C++	4	1	-	4
Pre-requisite		Basic knowledge on high level programming languages	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Develop skills to write codes in C++ language.
2. Develop an understanding of the compilation process.
3. Develop skills to design programs using a variety of data structures

Expected Course Outcomes

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

1	Write inline functions for efficiency and performance	K1-K6
2	Overload functions and operators in C++.	K1-K6
3	Design and implement generic classes with C++ templates	K1-K6
4	Design C++ classes for code reuse.	K1-K6
5	Identify syntax and semantics of the C++ programming language.	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**12 hours**

Principles of Object – Oriented Programming – Software Evolution Procedure and Object Oriented Paradigm – Basic concepts of Object – Oriented Programming – Benefits of OOP – Object Oriented Languages – Application of OOP - Beginning with C++ - What is C++?. - Application of C++ - C++ statements – Structure of C++ Program – Tokens , Expressions and Control Structures – Tokens – Identifiers – Basic and User – Defined Data Types – Operators in C++ - Operator Overloading – Operator precedence – Control Structures.

Unit:2	**12 hours**

Functions in C++:- The Main Function – Function Prototyping – Call by Reference – Return by Reference – Inline functions – Function Overloading – Friend and Virtual Functions – Classes and Objects – Introduction – Specifying a Class – Defining Member function – Nesting of Member Function – Private member Functions – Arrays within a Class – Static Data Members- Static Member Function – Array of Objects – Objects as Function Arguments, Friendly Functions – Pointers to Members.

Unit:3	**12 hours**

Constructors and Destructors:– Constructors – Copy Constructor Dynamic Constructor-Constructing Two – Dimensional Arrays – Destructors – Operators Overloading – Type Conversions.

Unit:4	**12 hours**

Inheritance, Extending Classes:– Defining Derived classes – Single, Multilevel, Multiple, Hierarchical and Hybrid inheritance – Virtual Base Classes – Abstract Classes-Pointers, Virtual Functions and Polymorphism – Pointers to Derived Classes – Virtual Functions.

Unit:5	**12 hours**

Managing Console I/O Operations:–C++ streams – C++ stream Classes – Unformatted I/O Operations - Formatted Console I/O Operations – Managing output with Manipulators- Working with Files:– Classes for File Stream Operations- Opening and Closing a File - File Pointers and their manipulators – sequential I/O Operations. Simple Statistical Problems		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Books for Study	
1	Balagurusamy, E. (1998). Object Oriented Programming with C++, Tata McGraw Hill Publishing Company Limited, New Delhi.
2	Venugopal, K. R., Rajkumar, B., and Ravi Shankar, T. (1999). Mastering C++, Tata McGraw – Hill, New Delhi.

Reference Books	
1	Somashekar, M. T., Guru, D. S., Negendraswamy, H. S., and Manjunatha, K. S. (2012). Object Oriented Programming with C++, Prentice Hall Learning (India) Private Limited.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.tutorialspoint.com/cplusplus/index.htm
2	https://www.learncpp.com/
3	https://nptel.ac.in/courses/106/105/106105151/

Course Designed By: Dr. R. Muthukrishnan / Dr. R. Vijayaraghavan

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	M	S	S	M	M	M	M
CO2	S	S	L	M	S	S	M	M	M	M
CO3	S	S	L	M	S	S	M	M	M	M
CO4	S	S	L	M	S	S	M	M	M	M
CO5	S	S	L	M	S	S	M	M	M	M

*S-Strong; M-Medium; L-Low


Second
Semester

Course Code	21S23A	TITLE OF THE COURSE	L	T	P	C
Core		Statistical Estimation Theory	4	1	-	4
Pre-requisite		Knowledge in Probability Theory and Probability Distributions	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Review the basic concepts of parametric estimation
2. Study properties and methods of statistical estimation theory
3. Study various method of construct confidence intervals

Expected Course Outcomes

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

1	Understand the concepts and importance of properties of estimators	K3
2	Obtain the optimal estimator for a given parametric function	K6
3	Study the different methods of point estimation	K3
4	Observe consistent and asymptotic behavior of estimators	K5
5	Construct confidence intervals for population parameters	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Properties of Estimator	12 hours

Estimation and point estimation - Sufficiency – Factorization Theorem – Minimal sufficiency, likelihood equivalence – Completeness – Uniformly minimum variance unbiased estimator – Rao - Blackwell and Lehmann - Scheffe theorems.

Unit:2	Bounds of Optimal Estimator	12 hours

Mean-squared error, Fisher's information measure. Cramer-Rao inequality, Bhattacharya inequality, Chapman-Robbins inequality - Fisher's information matrix-simultaneous of parameters in normal (univariate and bivariate) distribution.

Unit:3	Methods of Estimation	12 hours

Methods of point estimation-maximum likelihood method (asymptotic properties of ML estimators are not included), method of moments, method of minimum chi-square and modified minimum chi-square.

Unit:4	Consistent Estimators and Asymptotic Properties	12 hours

Consistency and CAN estimators. Asymptotic properties of maximum likelihood estimators. Example of consistent but not asymptotic normal estimators from Pitman family. Fisher's lower bound for asymptotic variance. Asymptotic relative efficiency. Method of least squares.

Unit:5	Interval Estimation	12 hours

Interval estimation: Confidence level and confidence coefficient. Duality between acceptance region of a test and a confidence interval. Pivotal quantity method. Shortest length confidence intervals. Construction of confidence intervals for population proportion (small and large samples) and between two population proportions (large samples) - Confidence intervals for mean, variance of a normal population, difference between mean and ratio of two normal populations.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Goon, A. M., Gupta, M. K., and Dasgupta, B. (1989). An Outline of Statistical Theory-Vol.II, World Press, Calcutta. .
2	Kale, B. K. (1999). A First Course on Parametric Inference, Narosa Publishing House, New Delhi.
3	Rohatgi, V. K. (1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NY.
Reference Books	
1	Dudewicz, E. J., and Mishra, S. N. (1988). Modern Mathematical Statistics, John Wiley & Sons, NY.
2	Lehman, E. L., and Cassella, G. (1998). Theory of Point Estimation, Second Edition, Springer, NY.
3	Rajagopalan, M., and Dhanavanthan, P. (2012). Statistical Inference, PHI Learning Pvt., Ltd., New Delhi.
4	Rohatgi, V. K., and Saleh, A.K.M.E. (2015), An Introduction to Probability and Statistics, Third Edition, John Wiley & Sons, NY.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayamprabha.gov.in/index.php/Syllabus/detail/10774
2	https://swayam.gov.in/nd1_noc20_ma19/preview
3	https://nptel.ac.in/courses/111/105/111105043/
Course Designed By: Dr. K. M. Sakthivel	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	M	M	S
CO2	S	M	M	L	S	M	S	M	M	S
CO3	S	M	M	L	S	M	S	M	M	S
CO4	S	S	M	M	S	M	S	M	M	S
CO5	S	M	M	M	S	M	S	M	M	S

*S-Strong; M-Medium; L-Low

Course Code	21S23B	TITLE OF THE COURSE	L	T	P	C
Core		Multivariate Statistical Analysis	4	1	-	4
Pre-requisite		Linear Algebra, Calculus of Several Variables, Probability theory, Sampling theory, Statistical Inference-Estimation theory	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Inculcate deep knowledge on various multivariate distribution and multivariate techniques
2. Develop clear idea on when and where to use dependence and interdependence multivariate methods
3. Bridge the relation between multivariate analysis and machine learning and strengthen the applications in diversified spectrum of fields.

Expected Course Outcomes

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

1	Understand the characteristics of Multivariate Normal Distribution and estimation of parameters, necessary and sufficient conditions for a quadratic form to be distributed as Chi-Square distribution	K1
2	Derive multivariate sampling distributions that includes Wishart distribution, Hotelling T^2 distribution and Mahalanobis D^2 distribution and its existence in use	K2
3	Have clear idea about multivariate statistical methods that includes Principal Component Analysis and Factor Analysis and its application in diversified fields	K3
4	Understand the concept of classification and discriminant function analysis , cluster analysis and able to use statistical software packages to apply multivariate techniques	K4
5	Possess clear idea about Machine Learning and significance of Multivariate analysis in machine learning,deep learning and reinforcement learning	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Multivariate Normal Distribution and Properties	14 hours

Multivariate Normal Distributions - Marginal and Conditional Distributions - Characteristic Function and Moments - Distribution of Linear Combinations of Multivariate Normal Vector - Determination of Mean and Covariance Matrix of Multivariate Normal Distribution-Maximum likelihood estimators of the parameters of multivariate normal distribution - Distribution of sample mean vector - Necessary and sufficient conditions for a quadratic form to be distributed as a chi - square distribution - Inference concerning the sample mean vector when covariance matrix is known.

Unit:2	Sampling Distributions in Multivariate Analysis	10 hours

Wishart Distribution – Characteristic function and properties. Hotelling's T^2 Distribution – Properties and Applications - Two sample problems with unequal covariance matrices - Likelihood Ratio Criterion - Mahalanobis D^2 Distribution - Relationship between T^2 and D^2 statistics – Behrens-Fisher problem.

Unit:3	Factor Analysis and Canonical Correlations	12 hours

Principal components: Objectives – Extraction of principal components - Factor analysis: Objectives – Estimation of factor loadings - Canonical variables and canonical correlations:

Determination of canonical correlation coefficients. Concepts of multidimensional scaling and correspondence analysis.		
Unit:4	**Discriminant Function and Cluster Analysis**	**12 hours**
Discriminant Analysis: Objectives and assumptions - Fisher's Discriminant Function - Problem of Classification with Two or More Populations - Cluster Analysis: Objectives, Assumptions, Research design. – Formation of clusters – Clustering algorithm.		
Unit:5	**Preliminaries of Artificial Intelligence and Machine Learning**	**12 hours**
Artificial Intelligence and Machine Learning-Supervised Learning-Classification and Regression-Unsupervised Learning-Semi-Supervised Learning-Reinforcement Learning- Support Vector Machines		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley – Interscience, NY.
2	Johnson, R. A., and Wichern, D. W. (2013). Applied Multivariate Statistical Analysis Sixth Edition, Pearson New International Edition.
3	Jambu, M., and Lebeaux, M.-O. (1983). Cluster Analysis and Data Analysis, North-Holland, NY.
Reference Books	
1	Kshirsagar, A. M. (1972), Multivariate Analysis, Marcel Decker, Inc., NY.
2	Morrison, D. F. (2004). Multivariate Statistical Methods, Fourth Edition, Duxbury Press, CA
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/104/111104024/
2	https://nptel.ac.in/courses/111/105/111105091/
3	https://nptel.ac.in/courses/106/106/106106139/
Course Designed By: Dr. K. Pradeepa Veerakumari	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	S	M	S
CO2	S	M	M	L	S	M	S	S	M	M
CO3	S	M	M	M	S	M	S	S	M	M
CO4	S	M	M	M	S	S	S	S	S	M
CO5	S	S	M	M	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course Code	21S23C	TITLE OF THE COURSE	L	T	P	C
Core		Statistical Quality Control and Reliability Theory	4	1	-	4
Pre-requisite		Basics in Descriptive Statistics and Probability Distributions	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the application of statistics in industrial environment.
2. Acquire knowhow on manufacturing process changes and process variability.
3. Attain proficiency in process capability analysis,
4. Instruct theory and practice of product control methodology.
5. Comprehend the importance of reliability theory in industries.

Expected Course Outcomes

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

1	Construct control charts for large and smaller shifts in the process parameters	K1,K3
2	Effectively interpret the results from the control charts	K4,K5
3	Carry out process capability analysis	K2,K3,K5
4	Adopt appropriate sampling inspection plans for given conditions	K2,K3,K6
5	Find failure rate, identify failure rate distributions, compute reliability of components and systems	K4,K5,K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Basic Control Charts and Capability Analysis	12 hours

Meaning and scope of statistical quality control - Causes of quality variation - Control charts for variables and attributes - Rational subgroups - Construction and operation of $\bar{x}$, σ, R, np, p, c and u charts - Operating characteristic curves of control charts. Process capability analysis using histogram, probability plotting and control chart - Process capability ratios and their interpretations.

Unit:2	Control Charts for Small Shifts	12 hours

Specification limits and tolerance limits - Modified control charts - Basic principles and design of cumulative-sum control charts – Concept of V-mask procedure – Tabular CUSUM charts. Construction of Moving range, moving-average and geometric moving-average control charts..

Unit:3	Product Control: Attributes and Variables Sampling Plans	12 hours

Acceptance sampling: Sampling inspection by attributes – single, double and multiple sampling plans – Rectifying Inspection. Measures of performance: OC, ASN, ATI and AOQ functions. Concepts of AQL, LTPD and IQL. Dodge – Romig and MIL-STD-105D tables. Sampling inspection by variables - known and unknown sigma variables sampling plan - Merits and limitations of variables sampling plan - Derivation of OC curve – determination of plan parameters.

Unit:4	Product Control: Continuous Sampling and Sequential Sampling	12 hours

Continuous sampling plans by attributes - CSP-1 and its modifications - concept of AOQL in CSPs - Multi-level continuous sampling plans - Operation of multi-level CSP of Lieberman

and Solomon – Wald - Wolfowitz continuous sampling plans. Sequential Sampling Plans by attributes – Decision Lines - OC and ASN functions.		
Unit:5	**Reliability Theory**	**12 hours**
Concept of reliability, components and systems, coherent systems, reliability of coherent systems - Reliability function, hazard function, hazard rate, failure rates - IFR and DFR distributions - Common life distributions: exponential, Weibull, gamma distributions - Estimation of parameters. - Reliability of a system with independent components. Series, parallel and mixed systems with several components.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Duncan, A. J. (2003.). Quality Control and Industrial Statistics, Irwin-Illinois, US.
2	Grant, E. L., and Leavenworth, R. S. (2000). Statistical Quality Control, Seventh Edition, Tata McGraw Hill, New Delhi.
3	Montgomery, D. C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.
4	Ross, S. M. (2009). Introduction to Probability Models, Tenth Edition, Academic Press, MA, US.
5	Zacks, S.(1992). Introduction to Reliability Analysis: Probability Models and Statistical Methods, Springer, New York.
Reference Books	
1	Barlow, E.B., and Proschan, F. (1981). Statistical theory of Reliability and Life Testing: Probability Models, Second Edition, Published by Holt, Rinehart & Winston, Inc.
2	Bowker, A.H., and Lieberman, G.J. (1982). Engineering Statistics, Second Edition, Prentice Hall, New Delhi,
3	Schilling, E. G., and Nuebauer, D.V. (2009). Acceptance Sampling in Quality Control Second Edition, CRC Press, New York.
4	Wetherill, G.B. (1977). Sampling Inspection and Quality Control, Second Edition, Chapman and Hall, London.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	http://bmepedia.weebly.com/uploads/2/6/6/8/26683759/unit_4_quality_control.pdf
2	http://www2.ing.unipi.it/lanzetta/stat/Chapter20.pdf
3	https://www.win.tue.nl/~adibucch/2WS10/SPClecturenotes.pdf
4	https://wps.prenhall.com/wps/media/objects/7117/7288732/65767_28_SuppG.pdf
5	https://www.cs.odu.edu/~zeil/cs795SR/Papers/TextBook/Appendix_B.pdf
6	https://www.ravenshawuniversity.ac.in/Study_Materials/Statistics_PG/PG 2nd Year / reliability.pdf
7	https://nptel.ac.in/courses/116/102/116102019/
Course Designed By: Dr. R. Vijayaraghavan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	M	S	M	S	S	M	M
CO2	S	S	M	M	S	M	S	S	M	M
CO3	S	M	M	M	S	S	S	S	M	M
CO4	S	M	M	M	S	M	S	S	M	M
CO5	S	M	M	M	S	S	S	S	M	M

*S-Strong; M-Medium; L-Low


Third
Semester

Course Code	21S33A	TITLE OF THE COURSE	L	T	P	C
Core		Testing Statistical Hypotheses	4	1	1	4
Pre-requisite		Sampling, Distribution, Estimation Theory	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Draw inference about unknown population parameters based on random samples
2. Impart knowledge on statistical hypothesis
3. Understand Neyman-Pearson fundamental lemma for testing statistical hypothesis
4. Understand the test procedures MPT,UMPT,LMPT, LRT and SPRT
5. Inculcate various parametric and non-parametric, sequential test procedures

Expected Course Outcomes

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

1	Make inferences about statistical unknown population parameters based on random samples	K1-K5
2	Formulate statistical hypothesis	K3
3	Test statistical hypothesis by selecting suitable test procedure.	K3-K4
4	Determine the size of critical region and power of test function.	K5
5	Solve real life problems by applying suitable parametric / nonparametric / sequential testing procedures.	K3-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Hypothesis Testing Preliminaries	12 hours

Fundamental notions of hypothesis testing: null and alternative hypothesis, simple and composite hypothesis, critical region, type I and type II errors, test function, level of significance, randomized and non-randomised tests, power function, P-value - Neyman-Pearson lemma - most powerful test -Applications to standard statistical distributions.

Unit:2	Most Powerful Tests and its variants	12 hours

Monotone likelihood ratio property - Uniformly most powerful tests - Construction of uniformly most powerful tests for one-parameter and multi-parameter exponential families - Unbiased and Invariant tests – Similar test - Applications to standard statistical distribution- Locally most powerful test.

Unit:3	Likelihood Ratio Tests	12 hours

Likelihood ratio (LR) test - asymptotic distribution of LR test statistic-consistency of LR test - Construction of LR tests for testing mean and variance of normal distributions of one or more populations.

Unit:4	Non-Parametric Tests	12 hours

U statistic – mean and variance of U statistic – One sample: Goodness of fit - Kolmogorov-Smirnov test, Problem of location: Sign test - Wilcoxon's signed-rank test - Two samples: Kolmogorov-Smirnov test - Wald-Wolfowitz runs test - Median test - Mann-Whitney-Wilcoxon test - Chi-square test of independence - More than two samples: Kruskal-Wallis test -Friedman's Test - Concept of Robustness.

Unit:5	**Sequential Probability Ratio Tests**	**12 hours**
Basic ideas of sequential sampling - Wald's equation - sequential probability ratio test (SPRT) - error probabilities and approximation of stopping bounds - OC and ASN functions of SPRT - Properties of SPRT - applications to standard distributions - statement of Wald's fundamental identity of sequential analysis.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Text Book(s)	
1	Rohatgi, V. K. (1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NY. **(For units 1,2,3,4,5)**
2	Gibbons, J. D. and Chakrabarthi, S. (2010). Nonparametric Statistical Inference, Fifth Edition, Chapman and Hall/CRC Press, FL **(For unit 4)**
3	Wald, A. (1982). Sequential Analysis. John Wiley & Sons, NY. **(For unit 5)**
Reference Books	
1	Lehmann, E. L. (1986). Testing Statistical Hypotheses, Second Edn., John Wiley & Sons, NY
2	Goon, A. M., Gupta, M. K., Das Gupta. B. (1973). An outline of Statistical Theory, Vol. II, World Press, Calcutta.
3	Rao, C.R. (1973). Linear Statistical Inference and Its Applications, 2nd Edn., Wiley Eastern Ltd.
4	Gupta, S. C., and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi
5	Rajagopalan, M., and Dhanavanthan, P. (2012). Statistical Inference, PHI Learning Pvt., Ltd., New Delhi.
6	Conover, W. J. (1980). Practical Nonparametric Statistics, Second Edn., John Wiley & Sons, NY.
7	Rohatgi, V. K., and Saleh, A.K.M.E. (2015), An Introduction to Probability and Statistics, Third Edition, John Wiley & Sons, NY.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=34 Paper: P-04.Statistical Inference I P-05.Statistical Inference II
2	https://nptel.ac.in/courses/103/106/103106120/ Introduction to Statistical Hypothesis Testing – IIT Madras
Course Designed By: Dr. R. Muthukrishnan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	M	S	M	S	S	M	M
CO2	S	S	S	M	S	M	S	S	M	M
CO3	S	S	M	M	S	M	S	S	M	M
CO4	S	S	M	M	S	M	S	S	M	M
CO5	S	S	M	M	S	M	S	S	M	M

*S-Strong; M-Medium; L-Low

Course Code	21S33B	TITLE OF THE COURSE	L	T	P	C
Core		Linear Models and Design of Experiments	4	1	-	4
Pre-requisite		Knowledge on Analysis of Variance and Basics of Design of Experiments	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To teach the students to understand the theoretical concepts of the general linear model and its types.
2. To make the students familiar with various experimental designs.
3. To make the students understand some advanced concepts of design of experiments like factorial experiments.

Expected Course Outcomes

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

1	Remember and understand the theoretical underpinning of the linear model, analysis of variance and design of experiments.	K1,K2
2	Understand the type of any given experiment and the type of design apt for its analysis.	K2
3	Apply various designs of experiments in several practical situations and evaluate its results.	K3, K5
4	Make further analyses which are specific to the objectives of any experiment.	K4
5	Create new types of designs as per the requirements and study their behaviour while proceeding to the research.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Linear Models and Basic Designs	12 hours

Linear Models - Assumptions on Error Components - Fixed/Mixed and Random effect Models – Generalized linear model - Gauss-Markov setup – Estimation of parameters – Least square method – MLE method - Gauss-Markov theorem-BLUE – Linear parametric function and the condition for its estimability -Test for Linear Hypothesis - Principles of Experimentation - Review of Basic Designs and CRD-RBD-LSD with their merits and limitations.

Unit:2	Comparison Tests and Some Special Types of Designs	12 hours

Multiple Comparison and Multiple Range Tests: Need – Tukey's Test – Fisher's Least Significance Difference method, Duncan's multiple range test, Neyman-Kauls test - Analysis of Covariance – One-way and two-way - Analysis of Graeco Latin Squares, Cross Over Designs, Split Plot and Strip Plot Designs.

Unit:3	Factorial Experiments and Confounding	12 hours

Factorial Experiments – Advantages and limitations – main effects and interaction effects - Analysis of 2^n, 3^n, s^n and n x p Asymmetrical Factorial Experiments – Concept of confounding and its advantages and limitations - Total, partial and balanced Confounding in Symmetrical Factorial experiments –- Analysis of confounded 2^n and 3^n factorial experiments.

Unit:4	Fractional Factorial and Response Surface Designs	12 hours

Concept of Fractional Replication in Symmetrical Factorial experiments - 1/2 and 1/4 replicate of 2^n, 1/3 replicate of 3^n experiments - Construction and Analysis – Concept of response surface

experiments - First order Response surface designs – steepest ascent method – Second-order Response surface designs.		
Unit:5	**Incomplete Block Designs**	**12 hours**
Incomplete Block Designs, Incidence matrix and its properties, C- matrix and its significance - Concept of Connectedness and Orthogonality – Balanced Incomplete Block Design - parametric relationships – inter and intra block analyses. Partially Balanced Incomplete Block Design and its analysis - Youden Square Design - Simple and Balanced Lattice Designs.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study

1	Montgomory, D.C. (2012). Design and Analysis of Experiments, Eighth Edition, John Wiley & Sons, NY.
2	Das, M. N., and Giri, N. C. (2011). Design and Analysis of Experiments, Second Edition, New Age International Private Ltd., New Delhi
3	Graybill, F.A. (1961): An Introduction to Linear Statistical Models, McGraw Hill Co., London.
4	Graybill, F. A. (2000). Theory and Applications of Linear Models, Duxbury Press, First Edition, MA.
5	Peterson, R. G. (1985). Design and analysis of experiments, Marcel Dekker, NY.
6	Paneerselvam, R. (2012). Design and Analysis of Experiments, PHI Learning Private Ltd., New Delhi.

Reference Books

1	Fisher, R.A. (1966). The Design of Experiments, 8th Edition, Oliver and Boyd, London.
2	Federer, W. T. (1967). Experimental Design: Theory and Application, Indian Edition, Oxford and IBH Publishing Co., New Delhi.
3	Kempthorne, O. (1965). The Design and Analysis of Experiments, Wiley Eastern India Limited, New Delhi
4	Cochran, W.G. and Cox, G.M. (1992). Experimental Designs, Second Edition, John Wiley & Sons, New York.
5	Nigam, A. K., Puri, P. D., and Gupta, V. K. (1988). Characterizations and Analysis of Block Designs, John Wiley & Sons, NY.
6	John, P.W.M. (1971). Statistical Design of Experiments, Macmillan Co., NY.
7	Joshi, D.D. (1987). Linear Estimation and Design of Experiments, First Edition, New Age International (P) Ltd, New Delhi.
8	Searle, S.R. and Gruber, M. H. J. (2016). Linear Models, Second Edition, John Wiley & Sons, Inc.,

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/110/105/110105087/

Course Designed By: Dr. R. Jaisankar

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	M	S	M	S	M	M	M
CO2	S	S	M	M	S	M	S	M	M	M
CO3	S	S	M	M	S	M	S	M	M	M
CO4	S	S	L	M	S	M	S	M	M	M
CO5	S	S	L	M	S	M	S	M	M	M

*S-Strong; M-Medium; L-Low

Course Code	21S33C	TITLE OF THE COURSE	L	T	P	C
Core		Programming in R	4	1	-	4
Pre-requisite		Knowledge in object oriented language	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the operations and functions of R Programming
2. Perform statistical analysis using built-in functions
3. Learn and write customized program for mathematical and statistical problems

Expected Course Outcomes

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

1	Understand the basics of R Language	K2
2	Apply the logical skills for performing statistical analysis	K4
3	Use appropriate plots, charts and diagrams for all kinds of data	K3
4	Perform parametric methods	K3
5	Write and execute the code for multivariate analysis	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Essentials of R Language	12 hours

Expressions and objects, Assignments, creating vectors, Vectors, vector arithmetic, logical vectors, Index vectors, objects, their modes and attributes, ordered and unordered factors.

Unit:2	Basic Operations and functions	12 hours

Arrows and matrices, List and data frames, List and data frames, conditional statements - functions – built-in and user defined; Data entry – reading from text file, data editor; examples.

Unit:3	Basic Statistics and Graphical methods	12 hours

Descriptive Statistics and Graphics: Obtaining summary statistics; generating tables; Bar plots, Pie charts, Box plots, Histogram; exercises.

Unit:4	Probability distributions and Statistical Inference	12 hours

Probability and Distributions: obtaining density, cumulative density and quantile values for discrete and continuous distributions; generating samples from discrete and continuous distributions; Plotting density and cumulative density curves, parametric and non-parametric methods

Unit:5	Model building and Multivariate Analysis	12 hours

Correlation: Pearson, Spearman and Kendall's correlation; Regression – fitting, obtaining residuals and fitted values; one and two sample tests for mean and variance – one way and two way ANOVA, Multivariate analysis

Unit:6	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

	Total Lecture Hours	62 hours

Books for Study

1 Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing

	House, New Delhi.
2	Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer
3	Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.
Reference Books	
1	De Vries, A., and Meys, J. (2016). R For Dummies, Second Edition, John Wiley & Sons Private Ltd, NY.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd1_noc19_ma33/preview
2	https://swayam.gov.in/nd2_aic20_sp35/preview
3	https://nptel.ac.in/courses/111/104/111104100/
Course Designed By: Dr. K. M. Sakthivel	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	S	S	M	M	M
CO2	S	S	L	S	S	S	M	M	M	M
CO3	S	S	L	S	S	S	M	M	M	M
CO4	S	S	L	S	S	S	M	M	M	M
CO5	S	S	L	S	S	S	S	M	M	M

*S-Strong; M-Medium; L-Low


Fourth
Semester

Course Code	21S43A	TITLE OF THE COURSE	L	T	P	C
Core		Stochastic Processes	4	1	1	4
Pre-requisite		Real Analysis and Linear Algebra, Measure and Probability Theory, Distribution Theory	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the fundamental concept of random process and its variants.
2. Understand the Chapman-Kolmogorov equation and its applications.
3. Compute transition probability matrix and its long run distribution.
4. Inculcate various models of stochastic process and its applications.
5. Impart knowledge on various stationary time series modeling techniques

Expected Course Outcomes

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

1	Compute n-step transition probability matrix and its long run.	K5
2	Classify the states of Markov chain	K1-K2
3	Know the concept of branching process and to compute extinction probabilities	K2-K4
4	Know the concept of renewal process and its applications	K2-K4
5	Forecast using various stationary time series techniques.	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Stochastic Processes Preliminaries	12 hours

Random variables – Generating Function – Probability generating function – generating function of bivariate distribution – Concept of Laplace and inverse Laplace transform – Laplace transform of probability distribution - Introduction to Stochastic Processes - Classification of Stochastic Processes - Markov Chain - Transition Probability Matrix, Transition graph - Chapman-Kolmogorov Equation -Calculation of n-step transition probability and its limit.

Unit:2	Markov Process	12 hours

Classification of states and chains: communication relation, periodicity, irreducible – transient persistent, ergodic states - limit theorems - Random Walk and Gambler's Ruin Problem - Markov process with discrete state space: Poisson process - postulates and properties - pure birth process - birth and death process - Kolmogorov differential equations - Markov process with continuous state space: Wiener process - differential equations for a Wiener process.

Unit:3	Renewal Process	12 hours

Renewal Processes – Renewal Process in Discrete and Continuous Time – Renewal Interval – Renewal Function and Renewal Density – Renewal Equation – Wald’s equation - Renewal theorems: Elementary Renewal Theorem - Probability Generating Function of Renewal Processes.

Unit:4	Branching Process	12 hours

Branching Processes – Properties of generating function of branching process (Galton-Watson process) – Probability of ultimate extinction - Distribution of total number of progeny – conditional limit laws - Concept of Bellman-Harris process.

Unit:5	**Stationary Process**	**12 hours**
Stationary Processes – Gaussian process - application to Time Series: auto-covariance and auto-correlation functions and their properties - Pure random process – first order Markov process - Moving Average - Autoregressive, Autoregressive Moving Average - Autoregressive Integrated Moving Average Processes - Box-Jenkins Methodology: Model building strategy, basic ideas of residual analysis, diagnostic checking, forecasting.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Text Book(s)	
1	Karlin, S. and Taylor, H.M. (1975): A First Course in Stochastic Processes, Second Edition, Academic Press, Inc., NY **(For units 1,2,3,4,5)**
2	Medhi, J. (2011): Stochastic Processes, Third Edition, New Age International Private Ltd., New Delhi. **(For units 1,2,3,4,5)**
3	Hanke, J.E and Wichern, D.W. (2009). **Business Forecasting**, PHI Learning Pvt Limited, 8th edition, New Delhi. **(For unit 5)**

Reference Books	
1	Granger, C. W. J., and Newbold, P. (1984): Forecasting Econometric Time Series, Second Edition, Academic Press Inc., NY.
2	Anderson, T.W., (1971): The Statistical Analysis of Time Series, John Wiley & Sons, NY. (Latest Edition: 1994: Wiley Interscience)
3	Adke, S. R., and Manjunath, S. A. (1984): An Introduction to Finite Markov Processes, Wiley Eastern, New Delhi.
4	Parzen, E. (1962): Stochastic Processes, Holden-Day, Oakland, CA. (Latest Edition: 2015: Dover Books on Mathematics, Dover Publications).
5	Box, G.E.P., Jenkins, G.M., Reinsel, G.C and Ljung, G.M. (2015). Time Series Analysis: Forecasting and Control, 5th edition, John-Wiley & Sons, New Jersey

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=34 Paper: P-10. Stochastic Processes and Time Series Analysis - ISI, Kolkata
2	https://nptel.ac.in/courses/111/103/111103022/ Stochastic Processes – IIT Guwahati
3	https://nptel.ac.in/courses/111/102/111102098/ Introduction and Motivation for studying Stochastic Processes – IIT Delhi
4	https://ocw.mit.edu/courses/mathematics/18-445-introduction-to-stochastic-processes-spring-2015/lecture-notes/
5	https://www.stat.auckland.ac.nz/~fewster/325/notes/325book.pdf

Course Designed By: Dr. R. Muthukrishnan

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	L	M	M
CO2	S	S	M	L	S	M	S	L	M	M
CO3	S	S	M	L	S	M	S	L	M	M
CO4	S	S	M	L	S	S	S	L	S	S
CO5	S	S	M	L	S	S	S	L	S	S

*S-Strong; M-Medium; L-Low

Course Code	21S43B	TITLE OF THE COURSE	L	T	P	C
Core		Biostatistics and Survival Analysis	4	1	-	4
Pre-requisite		Basics of distribution theory and regression analysis	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Initiate the awareness of Biostatistics and its need.
2. Make the students have a clear understanding of special kinds of various statistical tools used in biostatistics.
3. Be knowledgeable about the potential applications of these tools.

Expected Course Outcomes

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

1	Understand the concepts and statistical tools used in Biostatistics.	K2
2	Effectively apply these tools on solving the biological problems occurring in real life.	K3
3	Analyze the given biostatistical data as per the objectives of the problem.	K4
4	Interpret the outcomes of the analyses meaningfully.	K5
5	Create research problems of his own and able to proceed with them.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Clinical Trials	12 hours

Introduction to Biostatistics – Various types of studies - Ethics - Measures of disease frequency and disease burden. Clinical Trials - Goals of Clinical Trials - Phases of Clinical Trials - Classification of Clinical Trials - Randomization: Fixed Allocation, Simple, Blocked, Stratified, Baseline Adaptive and Response Adaptive - Blinding: Single, Double and Triple - Designs for Clinical Trials: Parallel Groups Design, Cluster Randomization Designs, Crossover Designs.

Unit:2	Multiple Regression and Logistic Regression	12 hours

Multiple Regression – Assumptions – uses – Estimation and interpretation of coefficients – Testing the regression coefficients – Coefficient of determination – Testing model adequacy. Logistic regression: Introduction – Logistic regression model – relative risk – logit – odds ratio – properties of odds ratio – the relationship between the odds ratio and relative risk – Maximum Likelihood estimates and interpretation of coefficients – Test for coefficients - Test of overall regression and goodness of fit using Maximum Likelihood technique – Deviance statistics, Wald test, LR test and score test.

Unit:3	Survival Analysis	12 hours

Introduction to Survival analysis - terminology and functions of survival analysis - goals - Basic data layout - Censoring-different types of censoring - Parametric survival models based on basic life time distributions - Exponential, Weibull, Gamma, Gompertz-Makeham, log-logistic and log-normal distributions - General method for incorporating covariates in parametric models.

Unit:4	Survival Models	12 hours

Kaplan-Meier's method - general features and assumptions - Log rank test for two groups, several

groups - alternatives to log rank test: Wilcoxon, Tarone-Ware, Peto-Prentice and Fleming-Harrington tests - Cox PH model and its features - ML estimation of the Cox PH model-Hazard Ratio - Adjusted survival curves-Cox likelihood.		
Unit:5	**Types of Cox Regression Models**	**12 hours**
Evaluating the proportional Hazards Assumptions - Overview - graphical approach - log-log plots - Observed versus expected plots- time-dependent covariates - Stratified Cox Procedure - hazard function - Extension of the Cox PH model - hazard ratio formula - extended Cox likelihood - An overview of Proportional odds model..		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Chow, S. C., and Liu, J. P. (2004). Design and Analysis of Clinical Trials: Concepts and Methodologies, Second Edition, Wiley – Interscience, John Wiley & Sons, NJ.
2	Friedman, l. M., Furberg, C. D., and DeMets, D. L. (2010), Fundamentals of Clinical Trials, Fourth edition, Springer – Verlag, NY.
3	Van Belle, G., Fisher, L. D., Heagerty, P. J., and Lumley, T. (2004). Bio-Statistics - A Methodology for the Health Science, Second Edition, Wiley, NY.
4	Daniel, W. W. and Chad L. Cross(2018). Bio-Statistics: A foundation for analysis in the Health Sciences, Eleventh Edition, John Wiley & Sons, NY.
5	Kleinbaum, D. G., and Klein, M. (2012): Logistic regression: A Self-Learning Text, Third Edition, Springer – Verlag, NY.
6	Kleinbaum, D. G., and Klein, M. (2012): Survival Analysis: A Self-Learning Text, Third Edition, Springer – Verlag, NY.
Reference Books	
1	Hosmer, Jr. D. W., Lemeshow, S., and Sturdivant, R. X. (2013). Applied Logistic Regression, Third Edition, John Wiley & Sons, Inc., NY.
2	Lee, E. T., and Wang, J. W. (2013). Statistical Methods for Survival Data Analysis, Fourth Edition, Wiley, NY.
3	Rossi, R. J. (2010). Applied Biostatistics for Health Sciences, John Wiley & Sons, Inc., NY
4	Klein, J. P. and Moeschberger, M. L. (2003). Survival Analysis: Techniques for Censored and Truncated Data, Second Edition, Springer – Verlag, NY.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	Prof.Shamik Sen, Department of Bioscience and Bioengineering, IIT Bombay, “Introduction to Biostatistics”, NPTEL. [https://swayam.gov.in/nd1_noc20_bt28/preview]
2	Dr.Felix Bast, Central University of Punjab, Bathinda, 2020, “Biostatistics and Mathematical Biology”, (NPTEL). [https://swayam.gov.in/nd2_cec20_ma05/preview]
3	www.healthknowledge.org.uk
Course Designed By: Dr. R. Jaisankar	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	M	S	S	S	S	M	L
CO2	S	S	L	M	S	S	S	S	M	L
CO3	S	S	L	S	S	S	S	S	S	L
CO4	S	S	L	S	S	S	S	S	S	L
CO5	S	S	L	M	S	S	S	S	M	L

*S-Strong; M-Medium; L-Low


Elective
Courses

Course Code	21S23E	TITLE OF THE COURSE	L	T	P	C
Elective		Operations Research	4	1	-	4
Pre-requisite		Basic knowledge in operations research	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the importance and concepts of optimization
2. Obtain the optimal solution for both linear and non-linear problem
3. Form and address solution to any real time optimization problem

Expected Course Outcomes

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

1	Form and Solve the linear programming problem	K4
2	Solve the integer programming problem	K3
3	Understand and evaluate the non-linear programming problem	K5
4	Design and develop inventory problem	K6
5	Explore and address the queueing problem	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Linear Programming	12 hours

Review of linear programming problems – Simplex algorithm – Use of artificial variables - Two-phase method and Big-M method - Degeneracy in LPP. Duality – Interpretation of duality - Dual Simplex Method - Simple problems.

Unit:2	Integer and Dynamic Programming	12 hours

Integer programming problem (IPP) – Pure and mixed integer programming problems - Gomory's constraints and cutting plane algorithm - Mixed IPP – Branch and Bound technique. Dynamic programming problem (DPP) - Principle of optimality – Recursive equation approach Characteristics of DPP.

Unit:3	Non-linear Programming	12 hours

Non-Linear Programming (NLPP): Formulation of NLPP - Constrained optimization problems – Graphical solution - Kuhn-Tucker conditions. Quadratic Programming: Wolf's and Beale's methods

Unit:4	Inventory Control	12 hours

Analytic structure of Inventory Problems, Concept of economic order quantity, its sensitivity analysis and extensions allowing quantity discounts and shortages, Deterministic and probabilistic inventory models - Models with random demand, and static risk models - Multi-item deterministic inventory problems.

Unit:5	Queueing Theory and Network Analysis	12 hours

Queueing systems, queueing models, classification of models - M/M/1, M/M/C and M/C/1 queues and their steady state solutions, Waiting Time Distributions for M/M/1 and M/M/C Models. Network scheduling by PERT/CPM, PERT: Basic components, determination of flows and critical path.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Hillier, F. S. and Leiberman, G. J. (1990). Introduction to Operations Research, Fifth Edition, McGraw-Hill, NY.
2	Kanti Swarup, Gupta, P. K., and Man Mohan. (2017). Operations Research, Nineteenth Edition, Sultan Chand & Sons, New Delhi.
3	Taha, H. A. (1982). Operations Research: An Introduction, Third Edition, McMillan Publishing Co., Inc., London.
4	Sharma, S. D. (2017). Operations Research: Theory, Methods and Applications, Kedar Nath, Ra Nath and Co, Meerut.

Reference Books	
1	Saaty, T. L. (1961). Elements of Queuing Theory, McGraw-Hill Co., NY.
2	Wagner, H. M. (1980). Principles of Operations Research with Application to Managerial Decisions, Second Edition, Prentice Hall India Learning Private Limited, New Delhi.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd2_cec20_ma10/preview
2	https://swayam.gov.in/nd1_noc19_ma29/preview
3	https://nptel.ac.in/courses/112/106/112106131/
4	https://nptel.ac.in/courses/112/106/112106134/

Course Designed By: Dr. K. M. Sakthivel / Dr. S. Jayalakshmi

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	L	L	M
CO2	S	S	M	L	S	M	S	L	L	M
CO3	S	S	L	L	S	M	S	L	L	M
CO4	S	S	M	L	S	M	S	L	L	M
CO5	S	S	S	L	S	M	S	L	L	M

*S-Strong; M-Medium; L-Low

Course Code	21S33E	TITLE OF THE COURSE	L	T	P	C
Elective		Official Statistics	4	1	-	4
Pre-requisite		Basic notions of health, social and economic sectors	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the functioning of government and policies.
2. Promote human resource development in the official statistics and encourage research and development in theoretical and applied statistics.
3. Execute the data handling tasks in various government records

Expected Course Outcomes

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

1	Understand the fundamentals of measurement in official statistics	K1
2	Evaluate the methods for data collection, analysis and interpretation of health, social and economic.	K2
3	Use appropriate methods for presenting and preparing commentaries on official statistics.	K3,K4
4	Execute the tasks in agricultural and economic statistics	K5
5	Overcome the limitations that arises from measurement and processes of statistical production.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Statistical System in India	12 hours

Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO). Organization of large scale sample surveys. General and special data dissemination systems.

Unit:2	Official Statistics	12 hours

Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

Unit:3	Agricultural and Social Statistics	12 hours

System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects**.** Statistics related to industries, foreign trade - Balance of payment - Inflation - Social statistics.

Unit:4	Index Numbers	12 hours

Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses.

Unit:5	National Income	12 hours

National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India. Measurement of income inequality: Gini’s coefficient, Lorenz curves, Application of Pareto and Lognormal as income distribution.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2	C. S. O. (1990). Basic Statistics Relating to the Indian Economy.
3	C.S.O. (1995). Statistical System in India.
4	C. S. O. (1999). Guide to Official Statistics.
5	Mukhopadhyay, P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
Reference Books	
1	Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.
2	Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.
3	Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
4	Panse, V. G. (1964). Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.classcentral.com/course/swayam-macro-economics-19942
2	https://www.classcentral.com/course/swayam-economics-of-health-and-health-care-14023
Course Designed By: Dr. S. Jayalakshmi	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	L	S	M	M	L	L	L
CO2	S	S	L	L	S	M	M	L	L	L
CO3	S	S	L	L	S	M	M	L	L	L
CO4	S	S	L	L	S	M	M	L	L	L
CO5	S	S	L	L	S	M	M	L	L	L

*S-Strong; M-Medium; L-Low

Course Code	21S43E	TITLE OF THE COURSE	L	T	P	C
Elective		Data Mining and Big Data	4	1	-	4
Pre-requisite		Data, Data Structure and Data Source	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the role of separate database for decision making.
2. Learn the core ideas of data mining techniques in different case studies.
3. Inculcate the concept learning and Machine learning theory.

Expected Course Outcomes

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

1	Get knowledge about database and their structure in social media	K1
2	Gain knowledge over the importance of KDD and Data Mining	K2
3	Apply data mining techniques in real world scenario.	K3
4	Explore the analyze of computational aspects in KDD Environment.	K4,K5
5	Develop a case studies on a different applications of data mining and Big data.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Database and Data Visualization	12 hours

Introduction to Data - Growth in Data - Database - Data understanding and preparation - Structured, Semi structured and Unstructured data - Data Models - Data Warehouse - Operational data - Data Process - Data Visualization - Structure Query Language - Applications.

Unit:2	Knowledge Discovery Process	12 hours

Introduction to Data Mining – Definition - An expanding universe of data production factor – data mining verses query tools – data mining in marketing – practical applications. Learning: – self learning – machine learning– concept learning - decision support system – integration with data mining – client / server data warehousing – multi processing machine – cost justification.

Unit:3	Knowledge Discovery Environment	12 hours

Knowledge discovery process and KDD Environment: Introduction – data selection – cleaning – enrichment – coding – data mining and its techniques – reporting - ten golden rules.

Unit:4	Machine Learning	12 hours

Introduction to Classification, Prediction and Clustering - Decision Tree induction - Information Gain - Gini Index - Bayesian classification - Naive Baye's classifier - Linear and Non-Linear regression - Logistic regression - Partitioning Clustering - Hierarchical Clustering - Distance Measure - Density based clustering - Text Mining - Web Mining - Case studies.

Unit:5	Big Data Science	12 hours

Big data: What and Why — data science - convergence of key trends - structured, semi structured and unstructured data – industry examples of big data – Web analytics - big data and marketing – fraud and big data - risk and big data – credit risk management –big data and healthcare - Case studies.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Books for Study	
1	Adriaans, P., and Zantinge, D. (1996). Data Mining, First Edition, Addison Wesley Professional, London
2	Agneswaran, V. S. (2014). Big Data Analytics Beyond Hadoop, First Edition, Pearson FT Press.
3	Gupta, G. K. (2014). Introduction to Data Mining with Case Studies, Third Edition, PHI Learning Private Limited, New Delhi.

Reference Books	
1	Delmater, R., and Hancock, M. (2001). Data Mining Explained, Digital Press, MA.
2	Hand, D., Mannila, H., and Smyth, P. (2001). Principles of Data Mining, MIT Press, London.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd1_noc20_cs92/preview
2	https://swayam.gov.in/nd2_cec19_cs01/preview
3	https://nptel.ac.in/courses/106/105/106105174/

Course Designed By: Dr. V. Kaviyarasu

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	S	S	S	S	S
CO2	S	S	L	S	S	S	S	S	S	S
CO3	S	S	L	S	M	S	S	S	M	M
CO4	S	S	L	S	M	M	S	S	M	M
CO5	S	S	L	S	M	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Course Code	21S23E	TITLE OF THE COURSE	L	T	P	C
Elective		Robust Statistics	4	1	-	4
Pre-requisite		Sampling, Distribution, Estimation, Testing of Hypotheses, Design of Experiments, Multivariate Statistics	Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are to:

1. Know various assumptions and limitations of existing statistical procedures
2. Impart knowledge on normality assumption and outlier detection
3. Understand the basics of robust statistics in the context of measures of location and scale
4. Inculcate various robust statistics under univariate, multivariate and regression procedures
5. Impart basic knowledge on data depth

Expected Course Outcomes:

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

1	Visualize the data by conventional and modern methods	K1-K4
2	Compute various statistical measures by using robust methods	K1-K5
3	Fit a model by applying suitable conventional / robust procedures	K1-K6
4	Make inferences about population parameters based on random samples.	K3-K6
5	Solve real life problems by applying suitable conventional / robust statistical procedures.	K3-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Introduction	12 hours

History of Normal Distribution – Normal curve - problems with assuming normality - detecting outliers – basic idea of robust statistics - tools for judging robustness –qualitative, quantitative, and infinitesimal robust ness - influence function, breakdown point, maximum asymptotic bias.

Unit:2	Measure of location and scale	12 hours

Measures of location and scale – quantiles - trimmed means – winsorized mean – M-estimates of location - dispersion estimates – median absolute deviation - M-estimates of scale – properties of M-estimates – influence function, breakdown point, maximum bias, and asymptotic normality – outlier detection methods - concept of L-estimates and R-estimates.

Unit:3	Statistical Inference	12 hours

Confidence interval and tests - student's t and non-normality - basic bootstrap methods – percentile method – bootstrap t method — inferences about the population trimmed mean – inferences based on M-estimates.

Unit:4	Linear Regression	12 hours

Review of Least Square method – Least Median of Squares – Least Trimmed Squares - Regression M-estimates – robust tests for linear hypothesis – robust test using M-estimates – regression quantiles – equvariance property of regression estimate.

Unit:5	Multivariate Statistics	12 hours

Visualization of multivariate data – Outlier detection methods – Robust measures of location vector and scatter matrix – Multivariate M-estimators of location and scatter – High breakdown estimators of multivariate location and scatter - Minimum Volume Ellipsoid estimator –

Minimum Covariance Determinant estimator – affine equivariance property of multivariate estimators - Mahalanobis distance – Robust distance - Concept of data depth.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Text Book(s)	
1	Huber (1981). Robust Statistics, Wiley
2	Jana Jureckova and Jan Picek (2006). Robust Statistical Methods with R, Chapman & Hall/CRC
3	Wilcox, R.R. (2010). Fundamentals of Modern Statistical Methods, Springer.
4	Wilcox, R.R. (2017). Introduction to Robust Estimation and Hypothesis Testing, Elsevier.
Reference Books	
1	Wilcox(2009). Basic Statistics, Oxford University Press.
2	Rohatgi, V. K. (1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NY.
3	Montgomery, D.C., Peck, E.A. and Vining, G.G. (2011). Introduction to linear regression analysis, Wiley
4	Shevylyakov, G.L.and H.Oja (2016). Robust Correlation: Theory and Applications, Wiley
5	Tiku, M.L. and Akkaya, A.D. (2004). Robust estimation and hypothesis testing, New Age International (P) Limited.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	http://www.stat.rutgers.edu/home/dtyler/ShortCourse.pdf
2	http://cmstatistics.org/CMStatistics2015/docs/WinterCourseAR_Regression.pdf?20180201194816
3	https://cseweb.ucsd.edu/~slovett/workshops/robust-statistics-2019/slides/donoho-univariate.pdf
4	https://cseweb.ucsd.edu/~slovett/workshops/robust-statistics-2019/slides/donoho-multivariate.pdf
5	https://cseweb.ucsd.edu/~slovett/workshops/robust-statistics-2019/slides/donoho-regression.pdf
Course Designed By: Dr. R. Muthukrishnan	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	S	S	M	S
CO2	S	S	M	S	S	M	S	S	M	S
CO3	S	S	M	S	S	M	S	S	M	S
CO4	S	S	M	M	S	M	S	S	M	S
CO5	S	S	M	S	S	M	S	S	M	S

*S-Strong; M-Medium; L-Low

Course code	21S33E	TITLE OF THE COURSE	L	T	P	C
Elective		Machine Learning using Python	4	1	-	4
Pre-requisite		Knowledge in Basic Programming and Multivariate Analysis	Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are to:

1. Comfortably Perform basics operations in Python
2. Understand machine learning concepts
3. Explore and execute the machine learning concepts for real time data using Python

Expected Course Outcomes:

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

1	Perform basic operations and concepts in Python	K3
2	Understand and use the essential modules in Python	K3
3	Evaluate the scope and opportunities of machine learning	K5
4	Gain knowledge and hands-on training in machine learning techniques	K5
5	explore program skills for machine learning techniques	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit: 1	**Basics of Python**	**12 hours**
Type of variables, data types, lists, control statements, functions, classes, files and exceptions.		
Unit:2	**Essential Modules in Python**	**12 hours**
Jupyter Notebook, Numpy, Scipy, Matplotlib, Pandas, mglearn		
Unit:3	**Supervised Learning**	**12 hours**
Classification and Regression, k-Nearest Neighbors,k-Nearest Neighbors, Decision Trees, Neural Networks		
Unit:4	**Unsupervised Learning -1**	**12 hours**
Preprocessing and Scaling, Scaling training, Dimensionality Reduction, Feature Extraction, and Manifold Learning		
Unit:5	**Unsupervised Learning -2**	**12 hours**
Clustering: k- Means clustering, Agglomerative Clustering, DBSCAN		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture Hours	**62 hours**

Text Book(s)

1	Introduction to Machine Learning with Python – A Guide for Data Scientists by Andreas C. Muller & Sarah Guido(2017), O'Reilly
2	Machine Learning in Python : Essential Techniques for Predictive Analysis by Micheal Bowles (2015), Wiley
3	Python Crash Course : A hands-on, Project- Based Introduction to Programming by Eric

	Matthes(2016), no starch press
Reference Books	
1	Python for Probability, Statistics and Machine Learning (second edition) (2019) by Jose Unpingco, Springer
2	Practical Statistics for Data Scientists(second edition)(2020) by Peter Bruce, Andrew Bruce & Peter Gedeck, O'Reilly
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd1_noc20_cs29/preview
2	https://swayam.gov.in/nd1_noc19_cs59/preview
3	https://nptel.ac.in/courses/106/106/106106202/
Course Designed By: Dr. K.M.Sakthivel	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	M	S	S	S	M	M
CO2	S	S	M	S	M	S	S	S	M	M
CO3	S	S	M	S	M	S	S	S	M	M
CO4	S	S	M	S	M	S	S	S	M	M
CO5	S	S	M	S	M	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Course Code	21S43E	TITLE OF THE COURSE	L	T	P	C
Elective		Demography and Vital Statistics	4	1	-	4
Pre-requisite		Fundamentals of data and data source	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Learn the core idea of Demographic and Vital Statistical data.
2. Acquire the knowledge of Mortality and Fertility Rate in India.
3. Understand the basics in Life Table, Population projection and Migration.

Expected Course Outcomes

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

1	Learn the basics in Birth, Death and other vital statistics.	K1
2	Provide the basic knowledge in Measurements of Population.	K2
3	Explore the importance of life table and its types.	K3
4	Analyze the concepts of Migration and its importance.	K4
5	Understand the core idea of population projection and their estimation.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Demographic Data	12 hours

Introduction to Demography and vital statistics - Sources Uses and Methods of demographic Data. Population Theories: Errors in demographic data, uses of Balancing equation and Chandrasekharan - Deming formula - Adjustment of age data - use of Myer and UN indices - Population composition and Pyramid.

Unit:2	Measurement of Mortality	12 hours

Measurement of population - Rates and Ratios of vital events - Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates - Direct and Indirect method of Standardization.

Unit:3	Life Tables	12 hours

Stationary and Stable population - Lotka and Dublin's Model - Central Mortality Rates - Force of Mortality. Life Tables: Assumption, description, construction of Life Tables and Uses of Life Tables - Makehams and Gompertz Curve - National and UN Model life table - Abridged life table.

Unit:4	Measurement of Fertility	12 hours

Measurements of Fertility: Nuptiality and Fertility - Crude Birth Rate (CBR) - General Fertility Rate (GFR) - Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase - Pearl's Vital Index - Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Unit:5	Population Projection and Migration	12 hours

Population estimation and Projection – Basic concepts – Growth and Change – Methods of Projection –Exponential and Logistic curve. Migration: Internal and International Migration - Net migration, International and Postcensal estimates - Decennial population Census in India.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Books for Study	
1	Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, Ninth Edition, World Press, India.
2	Gupta, S. C., and Kapoor, V. K. (2016). Fundamentals of Applied Statistics, Sultan Chand & Sons Private Limited, New Delhi.
3	Mishra, B. D. (1980). An Introduction to the Study of Population, South Asian Publishers Pvt. Ltd., New Delhi.
4	Mukhopadhyay, P. (2011): Applied Statistics, Second Edition, Books and Allied (P) Ltd., India.

Reference Books	
1	Barclay, G. W. (1958). Techniques of Population Analysis, John Wiley and Sons, New York.
2	Biswas, S. (1988). Stochastic Processes in Demography & Application, Wiley Eastern Ltd., India

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/109/104/109104045/
2	https://swayam.gov.in/nd1_noc19_hs39/preview
3	https://nptel.ac.in/courses/109/104/109104150/

Course Designed By: Dr. V. Kaviyarasu

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	L	S	M	S	M	L	L
CO2	S	M	M	M	S	M	S	M	M	M
CO3	S	M	M	M	S	M	S	M	M	M
CO4	S	M	M	L	S	M	S	M	L	L
CO5	S	M	M	L	S	M	S	M	L	L

*S-Strong; M-Medium; L-Low

Course Code	21S43E	TITLE OF THE COURSE	L	T	P	C
Elective		Computer Simulation and Modeling	4	1	-	4
Pre-requisite		Basics in statistical methods and data analysis	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Learn the concept of simultion.
2. Acquire knowledge in simulation modeling.
3. Understand the performance of input and output data analyses

Expected Course Outcomes

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

1	Generate random numbers from a specific probability distribution	K1- K6
2	Simulate the data from an appropriate probability model	K1 -K6
3	Perform input and output data analysis.	K1 - K6
4	Identify the areas of application of simulation.	K1 - K6
5	Construct models using the simulated data	K1 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Introduction to Simulation	12 hours

Advantages and Disadvantages of Simulation - Areas of Application - System environment - Components of a system - Types of models - Discrete-event system simulation - Steps in a Simulation Study – Examples for simulation - Programming Languages for simulation: FORTRAN, GPSS, SIMAN, SIMSCRIPT, SLAM and MODSIM III.

Unit:2	Statistical Models in Simulation	12 hours

Discrete and continuous probability distributions – Poisson, uniform, exponential, triangular, gamma and normal distributions. Empirical continuous distributions. Simulation of Manufacturing and Material Handling System: Modeling of manufacturing system - Issues in Simulating Manufacturing and Material Handling system - Simulations and Languages for Manufacturing and Material handling system.

Unit:3	Random Numbers Generation	12 hours

Random number generation: Properties of random numbers - Generation of pseudo-random numbers - Techniques for generating random numbers: Inverse transformation techniques.

Unit:4	Input Data Analysis	12 hours

Data collection – Identification of distribution with data - Parameter estimation - Goodness-of fit tests - Chi-square test - Kolmogorov - Smirnov test - Selecting input models without Data. Model Building: Verification and validation - Verification of simulation models - Calibration and validation of models: Face validity - Validation of model assumptions.

Unit:5	Output Data Analysis	12 hours

Stochastic Nature of Output Data - Types of simulation with respect their estimation - Output analysis for terminating simulation - Output analysis for steady-state simulations. Comparison and evaluation of alternative system designs. Comparison of two system designs - Comparison of

several systems designs - Statistical models for estimating the effect of design alternatives – Meta modeling.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Books for Study	
1	Deo, N. (1983): System Simulation with Digital Computer. Prentice Hall of India (Digitized 2007)
2	Gardon, G. (1992): System Simulation, Second Edition. Prentice Hall of India.
3	Jerry Banks, John S. Carson, II and Barry L. Nelson. (1995). Discrete - Event System Simulation, Second Edition. Prentice Hall
4	Law, A.M. (2007). Simulation Modeling and Analysis (Fourth Edition). McGraw Hill Education.
5	Ross, S. M. (2006). Simulation, Fourth Edition, Elsevier Academic Press, Burlington, US.
6	Alexopoulos, C., and Kim, S. H. (2002). Output Data Analysis for Simulations, Proceedings of the 2002 Winter Simulation Conference (E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, Eds.)
7	Garrido, J. M. (2009). Simulation Output Analysis, Object Oriented Simulation, pp. 405 – 409, Springer.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://cs.wmich.edu/alfuqaha/Spring10/cs6910/lectures/Chapter1.pdf
2	https://www.solver.com/simulation-tutorial-introduction
3	https://cs.wmich.edu/alfuqaha/Spring10/cs6910/lectures/Chapter5.pdf
4	http://www.cs.bilkent.edu.tr/~cagatay/cs503/_M&S_03_Input_Data_Analysis.pdf
5	https://www.usna.edu/Users/math/uhan/sa421/2013s/lessons/26.pdf
6	https://www.uni-due.de/imperia/md/content/tul/download/ews2014_2015_sl02_im_output_analysis.pdf
Course Designed By: Dr. R. Vijayaraghavan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	M	M	M	M	L	M
CO2	S	S	L	S	M	M	M	M	L	M
CO3	S	S	L	S	M	M	M	M	L	M
CO4	S	S	L	S	M	M	M	M	L	M
CO5	S	S	L	S	M	M	M	M	L	M

*S-Strong; M-Medium; L-Low

Course Code	21S43E	TITLE OF THE COURSE	L	T	P	C
Elective		Applied Regression Analysis	4	1	-	4
Pre-requisite		Fundamentals of Linear Regression, Correlation and their Properties	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Understand the notions of regression model building.
2. Impart application of regression models in various domains.
3. Instruct the methodology to test assumptions and conditions involved in regression models

Expected Course Outcomes

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

1	Identify mature of regression models	K1,K2
2	Construct linear and non-linear regression models	K2,K3
3	Test model assumptions and conditions	K3,K4
4	Identify appropriate test statistic and carryout tests of significance	K3.K5
5	Build logistic regression and generalized linear models	K2,K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Simple Regression Models and Properties	12 hours

Simple regression models with one independent variable, assumptions, estimation of parameters, standard error of estimator, testing the significance of regression coefficients, standard error of prediction. Testing of hypotheses about parallelism, equality of intercepts, congruence. Extrapolation, optimal choice of independent variable.

Unit:2	Tests for Assumptions	12 hours

Diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X. Inverse regression.

Unit:3	Multiple Regression Models and Properties	12 hours

Multiple regression: Standard Gauss Markov Setup. Least square (LS) estimation, Error and estimation spaces. Variance - Covariance of LS estimators. Estimation of error variance, case with correlated observations. LS estimation with restriction on parameters. Simultaneous estimation of linear parametric functions.

Unit:4	Non-linear Regression Models	12 hours

Non-linear regression: Linearization transforms, their use & limitations, examination of non-linearity initial estimates, iterative procedures for NLS grid search, Newton-Raphson, steepest descent, Marquardt's methods. Logistic Regression: Logic transform, ML estimation, Tests of hypotheses, Wald test, LR test, score test, test for overall regression.

Unit:5	Logistic Regression and GLM	12 hours

Multiple logistic regressions, forward, backward method. Interpretation of parameters relation with categorical data analysis. Generalized Linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian and gamma.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Books for Study	
1	Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, Third Edition, John Wiley and Sons.
2	Montgomary, D. C., Peck, E. A., and Vining, G. G. (2012). Introduction to Linear Regression Analysis, Fifth Edition, John Wiley & Sons, NY.
Reference Books	
1	Hosmer, D.W., Lemeshow, S., and Sturdivant, R. X. (2013). Applied Logistic Regression, Third Edition, John Wiley & Sons, NY.
2	Seber, G.E.F. and Wild, C.J. (2003). Nonlinear Regression, John Wiley & Sons, NY.
3	Neter, J., Wasserman, W., and Kutner, M.H. (1989). Applied Linear Statistical Models, Second Edition, Irwin, IL.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://ncss-wpengine.netdna-ssl.com/wp-content/themes/ncss/pdf/Procedures/NCSS/Multiple_Regression.pdf
2	https://nptel.ac.in/courses/111/104/111104098/
3	http://people.sabanciuniv.edu/berrin/cs512/lectures/10x-logistic-regression-new.pdf
4	https://nhorton.people.amherst.edu/ips9/IPS_09_Ch14.pdf
5	https://online.stat.psu.edu/stat504/node/149/
6	https://online.stat.psu.edu/stat504/node/171/
Course Designed By: Dr. R. Vijayaraghavan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	M	M	S	S	M	M
CO2	S	S	M	S	M	M	S	S	M	M
CO3	S	S	M	S	M	L	S	S	M	M
CO4	S	S	M	S	M	L	S	S	M	M
CO5	S	S	M	S	M	L	S	S	M	M

*S-Strong; M-Medium; L-Low


Practical

Course code	21S2P1	TITLE OF THE COURSE	L	T	P	C
Core: Practical		Programming Lab I: Object Oriented Programming with C++	-	1	4	4
Pre-requisite		Knowledge in Coding and Statistical Computation	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Impart knowledge on statistical computation using C++ programming
2. Instill coding knowledge into practice
3. Provide training in writing codes in C++ for statistical computation

Expected Course Outcomes

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

1	Write codes for computing statistical measures	K1 - K4
2	Write codes for matrix operations and generating random numbers	K2 - K4
3	Write codes for measures of multivariate normal distribution	K2 - K4
4	Write codes for constructing process control charts and draw curves	K1 - K3
5		K1 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit: 1	Statistical Measures	15 hours

Measures of Central Tendency, Dispersion, Skewness and Kurtosis. Simple, Partial, Multiple Correlation Coefficients, Regression coefficients and least squares estimates

Unit: 2	Matrices and Random Number Generation	15 hours

Smallest and largest element of a given array of numbers, Sorting of numbers, Matrix operations (Algebraic operations: addition, subtraction and multiplication of matrices, verification of properties, inverse of a given matrix). Generating random numbers using standard discrete and continuous distributions, computation of probability and cumulative probabilities of a given distribution.

Unit: 3	Statistical Inference	15 hours

Computation of unbiased estimates of population total, mean and variance under simple random sampling with/without replacement, and verification of properties. Computation of confidence limits for mean, variance and ratio of variances based on samples from a normal population for given critical values of χ^2, t, F and Z statistics.

Unit: 4	Measures of Multivariate Distribution and Quality Control	15 hours

Computation of sample mean vector and covariance matrix of multivariate normal population, and computation of T^2 and D^2 statistics. Computation of control limits of control charts for variables and attributes, computation of acceptance probabilities for single sampling plan and construction of OC, ATI and AOQ curves.

Unit: 5	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

	Total lecture hours	**62 hours**
Text and Reference Books		
1	Johnson, R. A., and Wichern, D. W. (2013). Applied Multivariate Statistical Analysis Sixth Edition, Pearson New International Edition.	
2	Goon, A. M., Gupta, M. K., and Dasgupta, B. (1989). An Outline of Statistical Theory-Vol.II, World Press, Calcutta.	
3	Montgomery, D. C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://nptel.ac.in/content/syllabus_pdf/111104073.pdf	
2	http://www.nptelvideos.in/2012/12/applied-multivariate-analysis.html	
3	https://nptel.ac.in/courses/111/102/111102112/	
4	https://nptel.ac.in/courses/112/107/112107259/	
Course Designed by: Dr. S. Gandhiya Vendhan / Dr. R. Vijayaraghavan		

Note

The maximum marks for continuous internal assessment and end semester University examination for Programming Lab I shall be fixed as 50 and 50, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of two questions from each of the four units with internal choice in Section A and two questions from the four units with internal choice in Section B. A candidate shall attend all the questions, each of which shall carry 10 marks. The examination shall be conducted at the end of Semester II. Problems relating to the topics specified in Unit I to IV which will be taught in Semester I and Semester II shall form the basis for setting the question paper.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	M	S	S	S	M	M
CO2	S	S	L	S	M	S	S	S	M	M
CO3	S	S	L	S	M	S	S	S	M	M
CO4	S	S	L	S	M	S	S	S	M	M
CO5	S	S	L	S	M	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Course code	21S3P2	TITLE OF THE COURSE	L	T	P	C
Core: Practical		Statistical Software Practical using SPSS and MINITAB	-	1	4	4
Pre-requisite		Knowledge in Statistical Methods	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Provide intensive training in statistical computation using software
2. Impart knowledge in handling statistical data for analysis
3. Instill the students to familiarize with the application of statistical tools

Expected Course Outcomes

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

1	Use the software for various applications	K1-K6
2	Draw statistical graphs, charts and diagrams	K1-K6
3	Compute statistical measures using software	K1-K6
4	Perform statistical data analysis	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit: 1	Descriptive Statistics and Generating Random Samples	15 hours

Classification, diagrams, graphical representation of data and descriptive statistical measures. Calculation of probabilities under various distributions and generating random samples from probability distributions

Unit: 2	Regression Analysis, Interval Estimation and Parametric Tests	15 hours

Correlation and regression: Simple, partial and multiple correlation coefficients, simple linear and multiple regression, curve fitting, time series and forecasting models. Confidence intervals for mean, variance and proportions, tests of significance based on normal, t, chi-square, F and Z statistics.

Unit: 3	Non-parametric Tests and Design of Experiments	15 hours

Run, sign and median tests, test based on Kruskal – Wallis statistics, Freedman's test. One way ANOVA-two way ANOVA-factorial designs– Multiple comparison tests

Unit: 4	Multivariate Analysis and Statistical Quality Control	15 hours

Principal component analysis, factor analysis, cluster analysis and discriminant analysis. Statistical quality control charts – Determination of parameters for constructing basic control charts, such as $\overline{X}$, R, S, p and c charts.

Unit: 5	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

Total lecture hours	62 hours

Reference Books

1	Landau, S., and Everitt, B.S. (2004). A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC Press, New York
2	Almquist, Y. B., Ashir, S., and Brännström, L. A Guide to SPSS: The Basics, Version 1.0.1, Stockholm University, Sweden.
3	Evans, M. (2009). MINITAB Manual, W.H. Freeman and Company, New York.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/110/107/110107113/
2	https://nptel.ac.in/courses/110/105/110105060/
3	https://nptel.ac.in/courses/111/104/111104098/
Course Designed By: Dr. R. Vijayaraghavan	

Note

The maximum marks for continuous internal assessment and end semester University examination for Statistical Software Practical shall be fixed as 50 and 50, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of two questions from each of the four units with internal choice in Section A and two questions from the four units with internal choice in Section B. A candidate shall attend all the questions, each of which shall carry 10 marks. The examination shall be conducted at the end of Semester II. Problems relating to the topics specified in Unit I to IV which will be taught using statistical software namely SPSS and MINITAB shall form the basis for setting the question paper:

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	M	S	S	M	M
CO2	S	S	L	S	S	M	S	S	M	M
CO3	S	S	L	S	S	M	S	S	M	M
CO4	S	S	L	S	S	M	S	S	M	M
CO5	S	S	L	S	S	M	S	S	M	M

*S-Strong; M-Medium; L-Low

Course code	21S4P3	TITLE OF THE COURSE	L	T	P	C
Core: Practical		Programming Lab II: Computational Statistics	-	1	4	4
Pre-requisite		Knowledge in Statistical Methods	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Impart knowledge on statistical computation using real data sets
2. Instill knowledge to generate random samples
3. Develop skills in analyzing survival daya

Expected Course Outcomes

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

1	Draw charts for data visualization	K1 - K4
2	Generate random numbers using simulation	K2 - K4
3	Draw resamples using specific procedures	K2 - K4
4	Fit regression equations and perform correlation analysis	K1 - K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit: 1	**Data Visualization**	**15 hours**

Introduction to R. Data visualization, ggplot2, Visualizing data distributions, Distribution function, Histogram, Box plots, Quantile - quantile plots, Normal distribution.

Unit: 2	**Random Numbers Generation, Simulation, Resampling**	**15 hours**

Generating random numbers from standard discrete and continuous distributions. Simulation, Monte Carlo techniques, Resampling methods, Jackknife and bootstrap methods.

Unit: 3	**Regression and Correlation Analysis**	**15 hours**

Linear regression, Multiple linear regression, Simple, partial and multiple correlation coefficients, Linear models and Measurement error models.

Unit:4	**Polynomial Regression, Cox Regression, Survival Analysis**	**15 hours**

Quadratic regression, Cox regression, Survival Analysis, Survival function, Hazard function, Kaplan – Mayer estimates, Log-rank test.

Unit: 5	**Contemporary Issues**	**2 hours**

Expert lectures, online seminars – webinars

Total lecture hours	**62 hours**

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://rafalab.github.io/dsbook/reshaping-data.html
2	https://rafalab.github.io/dsbook/data-visualization-principles.html
3	https://www.kaggle.com/learn/data-visualization
4	https://liavas.net/courses/math422/files/Simulation_modeling.pdf
5	https://www.solver.com/simulation-random-number-generators
6	https://nptel.ac.in/content/storage2/courses/104101002/downloads/lecture-notes/module3/chapter28.pdf
10	https://www.iiap.res.in/astrostat/School10/LecFiles/JBabu_JackknifeBootstrap_notes.pdf
11	https://statisticsbyjim.com/hypothesis-testing/bootstrapping/
12	http://people.bu.edu/aimcinto/jackknife.pdf
13	https://www.math.wustl.edu/~sawyer/handouts/Jackknife.pdf

14	https://socialsciences.mcmaster.ca/jfox/Courses/soc761/survival-analysis.pdf
15	https://www.datacamp.com/community/tutorials/survival-analysis-R
Course Designed By: Dr. R. Vijayaraghavan / Dr. R. Muthukrishnan	

Note

The maximum marks for continuous internal assessment and end semester University examination for Programming Lab II shall be fixed as 50 and 50, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of two questions from each of the four units with internal choice in Section A and two questions from the four units with internal choice in Section B. A candidate shall attend all the questions, each of which shall carry 10 marks. The examination shall be conducted at the end of Semester IV. The topics on computational and graphical approaches for solving statistical problems specified in Unit I to IV will be covered in this practical oriented paper and shall form the basis for setting the question paper.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	M	S	S	M	S
CO2	S	S	L	S	S	M	S	S	M	S
CO3	S	S	L	S	S	M	S	S	M	S
CO4	S	S	L	S	S	M	S	S	M	S
CO5	S	S	L	S	S	M	S	S	M	S

*S-Strong; M-Medium; L-Low

Course code	21S4P4	TITLE OF THE COURSE	L	T	P	C
Core: Practical		Statistical Software Practical using R	-	1	4	4
Pre-requisite		Knowledge in Statistical Methods	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Perform basic operations and functions in R Programming
2. Eexecute code for statistical methods using build-in functions
3. Write customized program for mathematical and statistical problems

Expected Course Outcomes

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

1	Perform the basic operations of R Language	K3
2	Use appropriate plots, Charts and diagrams for all kinds of statistical data	K3
3	Perform statistical test procedures using R software	K4
4	Write programming codes for the methods in Statistical quality control	K3
5	Write and execute programming codes for multivariate analysis	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit: 1	Basic Operations and Descriptive Statistics	15 hours

Operations on vectors and matrices, Creating and manipulating data frames. Charts, Plots, Diagrams and Graphs, Descriptive Statistics, Correlation coefficient – Pearson's, Spearman and Kendall's Tau. Fitting simple linear and multiple linear regressions

Unit: 2	Parametric Tests	14 hours

t test , Paired t test and independent t test, F test, Chi- Square test, One way and two way ANOVA.

Mann whitney u test, Kruskal wallis test, Kolmogorov smirnov test, Spearmann rank correlation chi square test

Unit: 4	Statistical Quality Control and Multivariate Analysis	17 hours

X bar Chart and R – Chart, X bar Chart and S – Chart, C Chart, P Chart, np Chart, U chart, Drawing OC curves for Single and Double Sampling Plans for Attributes.

Canonical Correlation, Principal component Analysis, Factor Analysis , Cluster Analysis, Discriminant Analysis

Unit: 5	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

	Total lecture hours	62 hours

Text Book(s)

1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, New Delhi.
2. Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer
3. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.

Reference Books

1. De Vries, A., and Meys, J. (2016). R For Dummies, Second Edition, John Wiley & Sons Private Ltd, NY.
2. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.

3	Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall/CRC Press.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd1_noc19_ma33/preview
2	https://swayam.gov.in/nd2_aic20_sp35/preview
3	https://nptel.ac.in/courses/111/104/111104100/
Course Designed By: Dr. K.M.Sakthivel	

Note

The maximum marks for continuous internal assessment and end semester University examination for Statistical Software Practical shall be fixed as 50 and 50, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of two questions from each of the four units with internal choice in Section A and two questions from the four units with internal choice in Section B. A candidate shall attend all the questions, each of which shall carry 10 marks. The examination shall be conducted at the end of Semester IV. The aim of this paper is to utilize theoretical knowledge gained and to develop computational and technical skills for real life applications emphasizing the importance of R programming. Problems relating to the topics specified in Units I to IV shall form the basis for setting the question paper.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	S	S	S	M	M
CO2	S	S	L	S	S	S	S	S	M	M
CO3	S	S	L	S	S	S	S	S	M	M
CO4	S	S	L	S	S	S	S	S	M	M
CO5	S	S	L	S	S	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Course code	21S4PV	TITLE OF THE COURSE	L	T	P	C
Core		Project and Viva - Voce	4	1	-	-
Pre-requisite		Knowledge in statistical theory and methods	Syllabus Version		2023 -24	

All the admitted candidates shall have to carry out a project/dissertation work during the fourth semester under the supervision of the faculty of the Department of Statistics in the University. Candidates shall have to submit three copies of the report of the project/dissertation work at the end of the fourth semester at least two weeks before the last working day and shall have to appear for a viva-voce examination. The report shall be evaluated and viva-voce examination shall be conducted jointly by an External Examiner and the Project Guide. The maximum marks for the project/dissertation report and viva – voce examination shall be fixed as 100, which is split with the following components:

Internal Assessment Marks by the Project/Dissertation Guide	:	50 marks
Evaluation of Project/Dissertation Report jointly by the External Examiner and the Guide	:	30 marks
Conduct of Viva-Voce Examination jointly by the External Examiner and the Guide	:	20 marks


Supportive
Courses

Course Code		TITLE OF THE COURSE	L	T	P	C
Supportive		Descriptive Statistics	2	1	-	2
Pre-requisite		Basic mathematical computations	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Introduce the basics of statistics
2. Instil knowledge to compute statistical measures for analysing data
3. Instruct the basic theory and applications of probability

Expected Course Outcomes

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

1	Understand the theory and applications of basic statistics	K1-K6
2	Compute statistical measures for decision making	K1-K6
3	Solve problems on basic probability	K2-K6
4	Perform correlation and regression analysis	K1-K6
5	Make interpretations of results from the derived results	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Statistics and Statistical Data	6 hours

Origin-Scope-Functions, limitations, uses and Misuses of statistics. Classification and Tabulation of data, Diagrammatic and graphic representation of data.

Unit:2	Basic Statistical Measures	6 hours

Measure of Central tendency–Measures of Dispersion-relative measures of dispersion-Skewness and Kurtosis-Lorenz's curve.

Unit:3	Basic Notions of Probability	6 hours

Elementary Probability space-Statistical probability Axiomatic approach to probability-Finitely additive and countable additive probability functions-Addition and multiplication theorems-Conditional probability-Bayes theorem-Simple problems.

Unit:4	Random Variables and Probability Functions	6 hours

Random variables-Discrete and continuous random variables-Distribution function and probability density function of a random variable-Expectation of a random variable-Addition and product theorems- Evaluation of standard measures of location, dispersion, Skewness and Kurtosis.

Unit:5	Correlation and Regression	6 hours

Simple linear correlation and regression-Regression equations-their properties spearman's Rank correlation Co-efficient.

Unit:6	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

	Total Lecture hours	32 hours

Books for Study

1	Goyal, J. K., and Sharma, J. N. (2014), Mathematical Statistics, Krishna Prakashan Private

	Limited, Meerut.
2	Gupta, S. P. (2012). Statistical Methods, Sultan Chand & Sons, New Delhi.
3	Gupta, S C., and Kapoor, V. K. (2018). Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand & Sons, New Delhi.
Reference Books	
1	Goon, A. M., Gupta, M. K., and Das Gupta, B. (2013). Fundamentals of Statistics, Vol.1, World Press Private Ltd, Calcutta.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/105/111105041/
2	https://nptel.ac.in/courses/111/106/111106112/
Course Designed By: Dr. R. Vijayaraghavan	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	M	M	M	L	L
CO2	S	S	M	L	M	M	M	M	L	L
CO3	S	S	M	L	M	M	M	M	L	L
CO4	S	S	M	L	M	M	M	M	L	L
CO5	S	S	M	L	M	M	M	M	L	L

*S-Strong; M-Medium; L-Low

Course Code	TITLE OF THE COURSE	L	T	P	C
Supportive	Statistical Methods for Biologists	2	1	-	2
Pre-requisite	Basic mathematical computations	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Introduce the basics of biostatistics
2. Instil knowledge to compute statistical measures for analysing data
3. Instruct the applications of statistical methods for biological problems

Expected Course Outcomes

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

1	Understand the theory and applications of basic statistics	K1-K6
2	Compute statistical measures for decision making	K2-K3
3	Formulate hypotheses and perform statistical analysis for biological problems	K1-K6
4	Perform analysis of variance for experimental designs	K1-K6
5	Make interpretations of results from the derived results	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Statistical Data, Classification and Tabulation	6 hours

Nature of Biological and Clinical experiments of data-Classification and tabulation of data-Diagrammatic representation of data- Histogram and frequency curves

Unit:2	Basic Measures of Statistics	6 hours

Measures of Central tendency-Mean, Median, Mode, Geometric mean, Harmonic Mean- Measures of deviation – Range, Mean deviation, Quartile and standard deviation – Measures of Skewness and Kurtosis.

Unit:3	Correlation and Regression	6 hours

Correlation : Rank Correlation – Multiple and Partial Correlation – Regression – Regression equations for biological problems.

Unit:4	Basic Sampling Methods	6 hours

Basic concepts of sampling – Simple random sample – Stratified sample – systematic sample – cluster sample. Test of significance based on large sample – Mean, Variance and Proportions.

Unit:5	Analysis of Variance and Basic Experimental Designs	6 hours

Analysis of variance –One way and Two way classifications – Completely Randomized blocks – Randomized Block design and Latin Square Design (Simple problems based on biological data)

Unit:6	Contemporary Issues	2 hours

Expert lectures, online seminars – webinars

Total Lecture hours **32 hours**

Books for Study

1. Lewis, A. E. (1984). Biostatistics, Van Nostrand Reinhold Publications.
2. Campbell, R. C. (1967): Statistics for Biologists, University Press, Cambridge, UK.

3	Kapur, J. N., and Saxena, H. C. (1986). Mathematical Statistics, S. Chand & Co., Ltd., New Delhi.
Reference Books	
1	Pagano, M., and Gauvrean, K. (2018). Principles of Biostatistics, Second Edition, Chapman and Hall/CRC Press, NY.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/102/106/102106051/
2	https://nptel.ac.in/courses/102/101/102101056/
Course Designed By: Dr. R. Jaisankar	

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	M	M	M	M	S
CO2	S	S	M	L	M	M	M	M	M	S
CO3	S	S	M	L	M	M	M	M	M	S
CO4	S	S	M	L	M	M	M	M	M	S
CO5	S	S	M	L	M	M	M	M	M	S

*S-Strong; M-Medium; L-Low

Course Code		TITLE OF THE COURSE	L	T	P	C
Supportive		Elements of Operations Research	2	1	-	2
Pre-requisite		Basic understanding of computations	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Introduce the managerial decision making methods
2. Inculcate knowledge in formulating optimization problems
3. Develop skills in solving optimization problems

Expected Course Outcomes

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

1	Understand the theory of elements of operations research	K2
2	Learn optimization techniques for solving decision making problems	K2
3	Formulate the optimization problems	K1-K6,
4	Learn inventory management through problems	K2-K6
5	Construct network diagram and perform network analysis	K2-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**Linear Programming**	**6 hours**

Linear Programming Problem – Graphical Method – General Problem of Linear Programming – Simplex Method – Phase I and Phase II Problems – Transportation and Assignment Problems.

Unit:2	**Replacement Theoryy**	**6 hours**

Replacement theory: Replacement of Items that deteriorate – Replacement of items that fail completely – Individual and group replacement policy.

Unit:3	**Sequencing Problems**	**6 hours**

Sequencing Theory – Processing ‘n’ jobs through 2 machines – Processing ‘n’ jobs through 3 machines – Processing ‘n’ jobs through ‘m’ machines.

Unit:4	**Network Analysis**	**6 hours**

Network Theory – Introduction to Network – Determination and flow for Critical Path Method – Project Evaluation Review Techniques and its differences.

Unit:5	**Basics of Inventory Theory**	**6 hours**

Inventory Theory – Meaning of Inventory – Factors involved in Inventory – Economic Models with and without shortages.

Unit:6	**Contemporary Issues**	**2 hours**

Expert lectures, online seminars – webinars

Total Lecture hours	**32 hours**

Books for Study

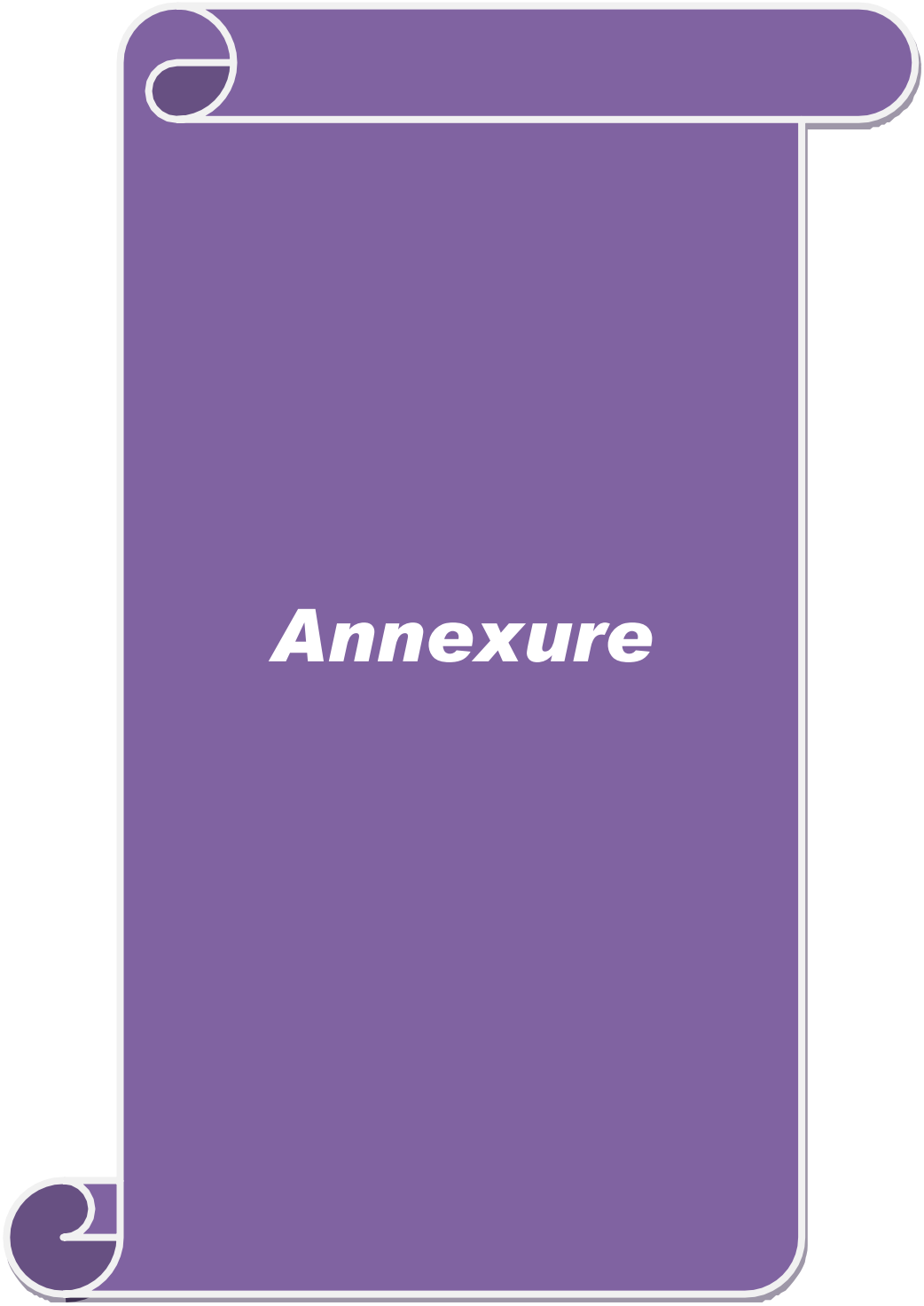
1	Kanti Swarup, Gupta, P. K., and Man Mohan. (2017). Operations Research, Nineteenth Edition, Sultan Chand & Sons, New Delhi.
2	Sharma, S. D. (2017). Operations Research: Theory, Methods and Applications, Kedar Nath, Ram Nath and Co, Meerut.

Reference Books	
1	Taha, H. A. (1982). Operations Research: An Introduction, 3rd Edition, McMillan Publishing Co., Inc., London.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/111/107/111107128/
2	https://nptel.ac.in/courses/112/106/112106134/
3	https://onlinecourses.swayam2.ac.in/cec20_ma10/preview
Course designed by: Dr. K. Pradeepa Veerakumari	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	L	M	M	M	L	M	M
CO2	S	S	M	L	M	M	M	L	M	M
CO3	S	S	M	L	M	M	M	L	M	M
CO4	S	S	M	L	M	M	M	L	M	M
CO5	S	S	M	L	M	M	M	L	M	M

*S-Strong; M-Medium; L-Low


Annexure

BHARATHIAR UNIVERSITY, COIMBATORE - 641 046

BRANCH II - STATISTICS

M.Sc., Statistics / M.Sc. Statistics (with Computer Applications)

(Choice Based Credit System)

(For the candidates admitted during the academic year 2023 – 2024 and onwards)

Objective of the Course

The course aims to instill and inspire the domain knowledge on theoretical and applied aspects of Statistics in a broader spectrum. It intends to impart awareness on the importance of the conceptual framework of statistics across diversified fields and to afford practical training on the applications of statistical methods for carrying out analysis of data using sophisticated statistical software like SAS, SYSTAT, SPSS, etc., and using the programming knowledge in R and C++. The course curriculum has been designed in such a way to cater the needs of the stakeholders to get placements in industries and institutions on successful completion of the course and to provide them ample skill and opportunities to meet the challenges at the national level competitive examinations like CSIR NET in Mathematical Sciences, SET, Indian Statistical Service (ISS) of UPSC, etc.

Eligibility Criteria for Admission

A candidate who has acquired a degree in B.Sc., Statistics or B.Sc., Mathematics with Statistics as an allied / ancillary subject or as one of the subjects or B. Sc., in Mathematics with Computer Applications having Statistics as one of subjects shall be permitted to join M. Sc., STATISTICS course.

A candidate who has acquired a degree in B.Sc., Statistics or B.Sc., Mathematics with Statistics as an allied / ancillary subject or as one of the subjects or B. Sc., Mathematics with Computer Applications having Statistics as one of subjects or B.Sc., in Computer Science with Statistics as one of the subjects or B.C.A., with Statistics as one of the subjects shall be permitted to join M. Sc., STATISTICS with (Computer Applications) course

Duration of the Course

The duration of the M. Sc., STATISTICS / M. Sc., STATISTICS with Computer Applications course is two years which comprise of four semesters. A candidate who has been admitted to the course shall appear all the four semester examinations during the course of study. On successful completion of all the examinations, he / she shall qualify himself/herself for the award of the degree in M.Sc., STATISTICS or M. Sc., STATISTICS (with Computer Applications).

Pattern of Choice Based Credit System

The course of study shall be based on the pattern of Choice Based Credit System (CBCS) with continuous internal assessment and comprehensive external assessment. The comprehensive external assessment shall be done at the end semester University examination. The odd semester shall begin in July and the even semester shall begin in December. Each candidate shall earn a minimum of 100 credits, which include non-scholastic courses, viz., one online SWAYAM/MOOC course of 2 credits, two value added courses each with 2

credits and two job oriented courses each with 2 credits. The non-scholastic courses shall not be considered for computing CGPA (Cumulative Grade Point Average). The break-up of total credits for the programme shall be as given under:

Core Papers – Theory	13 x 4 Credits = 52 Credits
Core Papers – Practical	04 x 4 Credits = 16 Credits
Elective Papers	03 x 4 Credits = 12 Credits
Core: Project/Dissertation	01 x 4 Credits = 04 Credits
Supportive Papers	02 x 3 Credits = 06 Credits
SWAYAM/MOOC Online Course	01 x 2 Credits = 02 Credits
Value Added Courses	02 x 2 Credits = 04 Credits
Job Oriented Courses	02 x 2 Credits = 04 Credits

Components for Internal Assessment

Tests, assignments, seminars and attendance shall be the components for continuous internal assessment. A maximum of 25 marks shall be allotted under continuous internal assessment in each theory paper offered by the Department. The distribution of marks is as given under:

Marks for Tests : 15

Marks for Assignments / Seminar : 05 (Average of Assignment and Seminar Marks)

Attendance : 05

Distribution of Marks for Attendance

90% and above	: 5 Marks
Between 85% and 90%	: 4 Marks
Between 80% and 85%	: 3 Marks
Between 75% and 80%	: 2 Marks
Between 70% and 75%	: 1 Mark

Distribution of Continuous Internal Assessment Marks for Core - Practical Paper

Record Work	: 25 Marks
Test	: 10 Marks
Attendance	: 05 Marks

Award of Degree

A candidate who secures a minimum of 50% of marks in the continuous internal assessment as well as in the end semester University examination and also a minimum of 50% of marks in aggregate comprising both continuous internal assessment and end semester University examination in each paper shall be declared to have passed the course for the award of the degree in M.Sc., Statistics or M.Sc., Statistics (with Computer Applications).

A candidate who secures a minimum of 7.5 out of 10 CGPA (Cumulative Grade Point Average) and above in aggregate comprising both continuous internal assessment and end semester University examination shall be declared to have passed the examination in FIRST CLASS WITH DISTINCTION, if the candidate has passed all the examination prescribed for the course in the first appearance.

A candidate who secures a minimum of 6.0 out of 10 CGPA and above comprising both continuous internal assessment and end semester University examination in aggregate shall be declared to have passed the examination in FIRST CLASS.

A candidate who clears all the papers prescribed for the course in the FIRST APPEARANCE shall be eligible for Ranking/Distinction.

Pattern of Question Paper – (for core - theory and elective subjects)

The question paper for each of the core and elective papers shall consist of three sections. While Section A shall contain 10 objective type questions, Section B and Section C shall contain questions of descriptive nature. Internal choice (either / or type) shall be given in Section B and Section C. In Section A, there shall be two questions each with four multiple choices from each of the five units. In Sections B and C, there shall be one question with internal choice (either/or type) from each of the five units. The composition of the question paper shall be as given below:

Time: Three Hours Max. Marks: 75

Section A – (10 x 1 = 10)
Answer *All* the questions
Each question carries *one* mark

Choose the correct answer

Q. No.1. – Q. No. 10 - Objective questions with four multiple choices

Section B – (5 x 5 = 25)
Answer all the questions
Each question carries *five* marks

Q. No. 11 – Q. No. 15 - Questions with internal choices (either (a) or (b) type)

Section C – (5 x 8 = 40)
Answer all the questions
Each question carries *eight* marks

Q. No. 15 – Q. No. 20 - Questions with internal choices (either (a) or (b) type

Pattern of Question Paper – (for core – practical subjects)

The question paper for each of the core - practical papers (Statistics Practical I and II, Programming Lab I and II, Statistical Software Practical using SPSS and MINITAB, and Statistical Software Practical using R shall consist of four questions with internal choice. The maximum marks for each of the practical papers shall be 60. A candidate shall attend all the four questions, each of which shall carry 15 marks. The composition of the question paper shall be as given below:

Time: Three Hours Max. Marks: 60

Answer all the questions
Each question carries *fifteen* marks

Q. No. 1 – Q. No. 4 - Questions with internal choices (either (a) or (b) type)

Pattern of Question Paper – (for supportive subject)

The question paper for each of the supportive papers shall consist of three sections. While Section A shall contain 5 objective type questions, Section B and Section C shall contain questions of descriptive nature. Internal choice (either / or type) shall be given in Section B and Section C. In Section A, there shall be one question each with four multiple choices from each of the five units. In Sections B, there shall be one question with internal choice (either/or type) from each of the five units and in Section C, there shall be three questions with internal choice (either/or type from all the five units. The composition of the question paper shall be as follows:

Time: Two Hours Max. Marks: 38

Section A – (5 x 1 = 5)
Answer *All* the questions
Each question carries *one* mark

Q. No.1. – Q. No. 5 - Objective questions with four multiple choices

Section B – (5 x 3 = 15)
Answer all the questions
Each question carries *three* marks

Q. No. 6 – Q. No. 10 - Questions with internal choices (either (a) or (b) type)

Section C – (3 x 6 = 18)
Answer all the questions
Each question carries *six* marks

Q. No. 11 – Q. No. 13 - Questions with internal choices (either (a) or (b) type)

M. Sc., Statistics with Computer Applications

Syllabus
(with effect from 2023 – 24)

Program Code: STAB

DEPARTMENT OF STATISTICS
Bharathiar University
(A State University, Accredited with "A^{++}" Grade by NAAC and
21th Rank among Indian Universities by MHRD-NIRF)
Coimbatore 641 046, INDIA

BHARATHIAR UNIVERSITY, COIMBATORE 641 046
DEPARTMENT OF STATISTICS

MISSION

The Department of Statistics aims to instill and inspire the domain knowledge on theoretical and applied aspects of Statistics in a broader spectrum. It intends to impart awareness on the importance of the conceptual framework of statistics across diversified fields and to afford practical training on the applications of statistical methods for carrying out analysis of data using sophisticated statistical software. The curriculum of post-graduate programme of the Department is designed in such a way to cater the needs of the stakeholders to get placements in industries and institutions on successful completion of the course and to provide them ample skill and opportunities to meet the challenges at the national level competitive examinations. The departments strive to enhance its potentials and capabilities to provide good quality education in statistics by acquiring recognition of the funding agencies.

BHARATHIAR UNIVERSITY, COIMBATORE 641 046

BRANCH II - STATISTICS

Course Title: M.Sc. (Statistics with Computer Applications) | Course Code: STAB
(For the candidates admitted during 2023 - 2024 and onwards)

List of Core/Elective/Supportive Subjects to be offered

CORE Subjects

1. Real Analysis and Linear Algebra
2. Measure and Probability Theory
3. Distribution Theory
1. Sampling Theory and Methods
2. Object Oriented Programming with C++
3. Statistical Estimation Theory
4. Multivariate Statistical Analysis
5. Statistical Quality Control and Reliability Theory
6. Practical Lab I: Object Oriented Programming with C++
7. Testing Statistical Hypotheses
8. Linear Models and Design of Experiments
9. Programming in R
10. Statistical Software Practical using SPSS and MINITAB
11. Stochastic Processes
12. Biostatistics and Survival Analysis
13. Practical Lab II: Computational Statistics
14. Statistical Software Practical using R
15. Project & VIVA-VOCE

ELECTIVE Subjects

1. Operations Research
2. Official Statistics
3. Data Mining and Big Data
4. Robust Statistics
5. Machine Learning Using Python
6. Demography and Vital Statistics
7. Computer Simulation and Modeling
8. Applied Regression Analysis

SUPPORTIVE Subjects (for students of other departments)

1. Descriptive Statistics
2. Statistical Methods for Biologists
3. Elements of Operations Research

VALUE ADDED COURSES

1. Basics of Biostatistical Analysis
2. Elements of Actuarial Mathematics
3. Data Analysis using STATISTICA
4. Essentials of Data Analytics Capstone

JOB ORIENTED CERTIFICATE COURSES

1. Design & Analysis of Clinical Trials
2. Basics of Six Sigma Tools