KANCHI MAMUNIVAR CENTRE FOR POSTGRADUATE STUDIES

(Autonomous – Reaccredited with "B++" Grade by NAAC)

(A College with potential for Excellence)

LAWSPET, PUDUCHERRY - 605008

M.Sc. – STATISTICS

(Effect From 2019-2020 batch)

KANCHI MAMUNIVAR CENTRE FOR POST GRADUATE STUDIES

(Autonomous)

(A College with Potential for Excellence – Reaccredited with "B++" Grade by NAAC)

Puducherry 605 008

Department of Mathematics

M.Sc. STATISTICS (CBCS)

SEM	CODE	TITLE OF THE PAPER	CREDIT	THEORY HOURS	SEMINAR / Assignment/ Test	TUTORIAL/ CSIR-NET COACHING
I	STAT-101	Probability Theory	4	4	1+1	2 hours per week
	STAT-102	Distribution Theory-I	4	4	1+1	
	STAT-103	Sampling Theory	4	4	1+1	
	STSC-104	Soft core – I	3	3	1+1	
	STSC-105	Soft core – II	3	3	1+1	
II	STAT-206	Distribution Theory-II	4	4	1+1	2 hours per week
	STAT-207	Applied Regression analysis	4	4	1+1	
	STAT-208	Estimation Theory	4	4	1+1	
	STSC-209	Soft core – III	3	3	1+1	
	STSC-210	Soft core – IV **Statistical Lab-1**	3	3	1+1	
III	STAT-INT	INTERNSHIP/MINI PROJECT	3	-	-	2 WEEKS
	STAT-311	Testing of Hypothesis	4	4	1+1	2 hours per week
	STAT-312	Linear Models and Design of Experiments	4	4	1+1	
	STAT-313	Stochastic Processes	4	4	1+1	
	STSC-314	Soft core – V	3	3	1+1	
	STSC-315	Soft core - VI **Statistical Lab-II (SPSS)**	3	3	1+1	
IV	STAT-416	Multi Variate Analysis	4	4	1+1	2 hours per week
	STAT-417	Optimization Techniques	4	4	1+1	
	STAT-418	Statistics using R	4	4	1+1	
	STSC-419	Soft core – VII	3	3	1+1	
	STSC-420	Soft core – VIII	3	3	1+1	

Credits for 12 Hard core papers = 12*4 =48 credits

Credits for 8 soft core papers = 8 * 3 =24 credits

LIST OF HARDCORE PAPERS

SLNO	SUBJECT CODE	TITLE OF THE PAPER
1	STAT101	Probability theory
2	STAT102	Distribution Theory-I
3	STAT103	Sampling Theory
4	STAT206	Distribution Theory-II
5	STAT207	Applied Regression Analysis
6	STAT208	Estimation Theory
7	STAT311	Testing of Hypothesis
8	STAT312	Linear Models and Design of experiments
9	STAT313	Stochastic Processes
10	STAT416	Multi Variate Analysis
11	STAT417	Optimization Techniques
12	STAT418	Statistics using R

LIST OF SOFT CORE PAPERS

SLNO	TITLE OF THE PAPER
1	Numerical Methods
2	Queueing theory
3	Measure Theory
4	Ordinary Differential Equations and Laplace Transform
5	Difference Equations And z-Transform
6	Real Analysis
7	Statistical Quality Control
8	Time series analysis
9	Reliability and survival analysis
10	Data warehousing and Data mining
11	Categorical data Analysis
12	Statistical Lab – I
13	Statistical LAB - II
14	Fundamentals of Statistics(other departments)
15	Python Programming

QUESTION PATTERN FOR M.Sc. Statistics

Each paper will have 100 marks with CIA(40 marks) and End semester examination(60 marks)

CIA

The CIA component of 40 marks shall have the following split-up

Best 2 tests out of 3 tests	15 marks
Mid-Semester examination	15 marks
Seminar/Assignment	10 Marks

External examination

Question Paper Pattern

Part A consists of 10 questions and each question carries 1 mark

Choose not less than two questions from each unit. (10x1 = 10)

Part B consists of 5 Questions of internal choice type (5X4=20)

Choose questions compulsorily from each unit.

Part C consists of 5 questions and answers any three (3X10=30).

Choose Five questions from four units. Do not omit any unit.

INTERNSHIP/MINI PROJECT

a) Report submission and evaluation	60 marks
b) Viva – voce examination	40 marks
	Total : 100 marks

KANCHI MAMUNIVAR CENTRE FOR POST GRADUATE STUDIES
(Autonomous) PUDUCHERRY-605008.
DEPARTMENT OF STATISTICS
M.Sc. STATISTICS(CBCS)
(From 2019-20 Batch Onwards)
SCHEME OF EXAMINATIONS

SEM	CODE	TITLE OF THE PAPER	Duration of the examination	Marks		
			Hours	IA	UM	TOTAL
I	STAT-101	Probability Theory	3	40	60	100
	STAT-102	Distribution Theory-I	3	40	60	100
	STAT-103	Sampling Theory	3	40	60	100
	STSC-104	Soft core – I	3	40	60	100
	STSC-105	Soft core – II	3	40	60	100
II	STAT-206	Distribution Theory-II	3	40	60	100
	STAT-207	Applied Regression analysis	3	40	60	100
	STAT-208	Estimation Theory	3	40	60	100
	STSC-209	Soft core – III	3	40	60	100
	STSC-210	Soft core – IV **Statistical Lab-1**	3	40	60	100
III	STAT-INT	INTERNSHIP/MINI PROJECT	Report submission and evaluation 60 External Viva-voce 40			100
	STAT-311	Testing of Hypothesis	3	40	60	100
	STAT-312	Linear Models and Design of Experiments	3	40	60	100
	STAT-313	Stochastic Processes	3	40	60	100
	STSC-314	Soft core – V	3	40	60	100
	STSC-315	Soft core - VI **Statistical Lab-II (SPSS)**	3	40	60	100
IV	STAT-416	Multi Variate Analysis	3	40	60	100
	STAT-417	Optimization Techniques	3	40	60	100
	STAT-418	Statistics using R	3	40	60	100
	STSC-419	Soft core – VII	3	40	60	100
	STSC-420	Soft core – VIII	3	40	60	100

STAT- 101: PROBABILITY THEORY **CREDIT 4**

Unit I

Probability measures – Conditional probability – Random variables – Univariate distribution functions – Expectations – Conditional expectations – Jointly distributed random variables – Independent random variables – Borel-Cantelli lemma – Kolmogorov Zero – one law-Borel theorem

Unit II

Convergence of random variables – Almost sure, in law, in probability and in r^{th} mean and their interrelations – Characteristic functions – Inversion formula

Unit III

Bochner's theorem – Convergence distribution functions and characteristic functions – Convergence of moments – Helly compactness theorem, Helly-Bray theorem – Continuity theorem

Unit IV

The law of large numbers – Weak law of large numbers – Kolmogorov strong law of large numbers – The Glivenco-Cantelli theorem – Central limit theorems – Lindeberg-Levy theorem – Liapounov's theorem and Lindeberg – Feller theorems

BOOKS FOR STUDY

1. Bhat, B.R. (1981): Modern Probability Theory, Wiley Eastern Ltd.,
2. Debera, G. (1987) : Measure Theory and Integration, Wiley Eastern Ltd.
3. Tucker, H.G. (1967): A Graduate Course in Probability, Academic Press, New York.

BOOKS FOR REFERENCE

1. Loeve, M. (1955): Probability Theory, D. Van Nosatrand Co, Inc.
2. Munroe M.E. (1965): Measure and Integration, Addison & Wesley.

STAT - 102:DISTRIBUTION THEORY-I **CREDITS: 4**

Unit I: Univariate Discrete Distributions

Special features, probability mass function, distribution function, Characteristic function, statistical properties, special cases among statistical measures, inter relationships with the other distributions of Discrete Uniform, Binomial, Poisson, Geometric, Hypergeometric, Negative Binomial, Power Series distributions.

Unit II: Univariate Continuous Distributions:

Special features, probability density function, distribution function, Characteristic function, statistical properties, special cases among statistical measures, inter relationships with the other distributions of Triangular, Rectangular, Exponential, Normal, Log Normal, Cauchy, Pareto, Rayleigh Distributions

Unit III: Bivariate Probability Distributions

Special features, joint probability mass/density functions, distribution function, Characteristic function, statistical properties, special cases among statistical measures, inter relationships with the other distributions of Bivariate Binomial, Bivariate Poisson, Bivariate Normal, Bivariate Exponential Distributions

Unit-IV: Truncated Probability Distributions:

Special features, joint probability mass/density functions, distribution function, Characteristic function, statistical properties, special cases among statistical measures, inter relationships with the other distributions of Truncated Binomial, Truncated Poisson, Truncated Normal, Truncated Exponential Distributions

Books for Study

1. Mood M., Graybill F.A. and BoesD.C.(2001) : Introduction to the Theory of Statistics, Tata McGraw-Hill, New Delhi.
2. Johnson, N.L,Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, Vol.1 &2, Wiley Series in Probabilty and Statistics.
3. Johnson, N.L , Kemp A.W. &Kotz, S. (1994): Univariate Discrete Distributions, Wiley Series in Probabilty and Statistics
4. David H. A. and NagarajaH.N.(2003): Order Statistics, 3/e, John Wiley & Sons.

Books for Reference

1. Rao C. R.,(1973): Linear Statistical Inference and its Applications, Wiley Eastern Ltd, New Delhi.
2. Dudewicz, E.J and Mishra, S.N(1980): Mathematical Statistics, John Wiley, NY.
3. Kocherlakota S and KocherlakotaK(1992): Bivariate Discrete distributions, M. Dekker.
4. Balakrishnan N and Lai C.D.(2009): Continuous Bivariate Distributions, Springer.
5. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
6. ParimalMukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.

STAT – 103 :SAMPLING THEORY **CREDIT 4**

Unit I

Review of SRSWR and SRSWOR – Stratified Random Sampling and systematic Sampling-estimation of population mean and variance.Varying Probability sampling: cumulative total method and Lahiri's method – Estimation in pps sampling with replacement, pps sampling without replacement, General selection procedures, Narian's scheme of sampling selection and Sen-Midzona method- Ordered estimator; Des Raj unordered estimators: Horvitz –Thompson estimator and Murthy's estimator.

Unit II

Ratio estimates and their properties for simple Random and Stratified Random sampling- Ratio estimator and Multivariate ratio estimator – Regression estimator-Regression estimates with pre assigned "b" – sample estimate of variance – Bias - Regression estimators in stratified sampling-Multivariate Regression estimator.

Unit III

Cluster sampling: Equal cluster sampling- Estimators of mean and variance, optimum cluster size, Unequal cluster sampling – Estimators of mean and variance, varying probability clusters sampling – Two stage sampling - variance of the estimated mean – Three stage sampling – variance of the estimated mean.

Unit IV

Multiphase sampling: Double sampling for stratification – Optimum allocation – Estimated variance in Double sampling for stratification. Sources of errors in Surveys – Mathematical model for the effects of call-backs and the errors of measurement – Interpenetrating sub sampling method.

BOOKS FOR STUDY:

1. Cochran, W.G (1977): Sampling Techniques, Wiley Eastern Ltd,.(Chapter 6 for Unit I, Chapter 7 for Unit II and Chapter 13 for Unit IV)
2. Singh, D and Choudhary, F.S (1986): Theory and Analysis of Sampling Survey Designs, Wiley Eastern Ltd,. (Chapter 5 for Unit I and Chapter 8 for Unit III)

BOOKS FOR REFERENCE:

1. Desraj and Chandok (1998): Sampling Theory, Narosa Publications, New Delhi
2. Kish,L(1995): Survey Sampling, John Wiley and Sons.
3. Murthy, M.N (1979): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
4. Sharon L Lohr (1999): Sampling: Design and Analysis, Duxbary Press.
5. Sukhatme et al (1984): Sampling Theory of Surveys with applications, Iowa state University press and IARS.

STAT - 206 – DISTRIBUTION THEORY-II CREDITS: 4

Unit I: Multivariate Normal Distribution
Special features, joint probability density function, distribution function, Characteristic function, statistical properties, special cases among statistical measures, inter relationships with the other distributions of Multivariate Normal Distribution and Wishart's Distributions.

Unit II: Life Time Probability Distributions:
Special features, probability density function, distribution function, Characteristic function, statistical properties, special cases among statistical measures, inter relationships with the other distributions of One and Two parameter Gamma, One and Two parameter Beta, Weibull, and Lognormal Distributions.

Unit III: Sampling Distributions
Special features, joint probability mass/density functions, distribution function, Characteristic function, statistical properties, special cases among statistical measures, Applications, Inter relationships with the other distributions of Chi-square, Student's-t, Fisher's-t, Snedecor's –F, Gaussian's-Z Distributions

Unit-IV: Order Statistics Probability Distributions
Order statistics, their distributions and properties- Joint and marginal distributions of order statistics - Distribution of range and mid range - Extreme values and their asymptotic distributions

Books for Study

1. Mood M., Graybill F.A. and BoesD.C.(2001) : Introduction to the Theory of Statistics, Tata McGraw-Hill, New Delhi.
2. Johnson, N.L,Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, Vol.1 &2, Wiley Series in Probabilty and Statistics.
3. Johnson, N.L , Kemp A.W. &Kotz, S. (1994): Univariate Discrete Distributions, Wiley Series in Probabilty and Statistics
4. David H. A. and NagarajaH.N.(2003): Order Statistics, 3/e, John Wiley & Sons.

Books for Reference

1. Rao C. R.,(1973): Linear Statistical Inference and its Applications, Wiley Eastern Ltd, New Delhi.
2. Dudewicz, E.J and Mishra, S.N(1980): Mathematical Statistics, John Wiley, NY.
3. Kocherlakota S and KocherlakotaK(1992): Bivariate Discrete distributions, M. Dekker.
4. Balakrishnan N and Lai C.D.(2009): Continuous Bivariate Distributions, Springer.
5. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
6. ParimalMukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.

STAT – 207 : APPLIED REGRESSION ANALYSIS CREDITS 4

UNIT 1

K- Variable Linear regression models: Assumptions of the Linear model, Ordinary Least Square estimators (OLS). Inference about regression parameters, Residual Plots, diagnostics and remedial measures.

UNIT 2

Auto – Correlation: Source, effects and deletion, test for auto correlation (Durbin – Watson test), Estimation under auto correlated disturbance (Two step procedure) Heteroscedasticity : Meaning causes and test for Heteroscedasticity (Breusch –pagan test), estimation under Heteroscedasticity .

UNIT 3

Multicollinearity: Meaning, causes and effects of multicollinearity , detection of Multicollinearity : using simple and partial correlation, Remedies.

UNIT 4

Standard statistical measures for Time Series analysis: Absolute measures- Mean absolute error, Mean error, Mean square error. Relative measures – Percentage error, Mean percentage error, Mean absolute percentage error – Smoothing methods – Single exponential smoothing. Double exponential smoothing (Holt method).

(Only Theoretical Questions to be asked)

BOOKS FOR STUDY

1. Montgomery. D.C.,Peck , E.A.and vining , G.G. (2003): Introduction to Linear regression analysis , third edition, John Wiley and Sons , Inc .
2. Draper, N.R. and Smith, H. (2000): Appiled Regression Analysis, 2nd edition, John Wiley & Sons.

BOOKS FOR REFERENCE

1. Chattergee S. and Betram price (1977): Regression Analysis by Examples, John Wiley & Sons.
2. George E. P. BOX and Gwilym M. Jenkins (1976): Time Series Analysis – Forecasting and Control, Holdne – Day Inc.
3. Johnston J. (1984): Econometric Methods. (3rd Edition), McGraw Hill International Book Company, New Delhi.
4. Singh, Parashar and Singh (1997): Econometrics and Mathematics Economics (1st Edition), S. Chand & Co, New Delhi.

STAT – 208 : ESTIMATION THEORYCREDITS 4

UNIT I

Parametric point estimation – properties of estimates–Consistency–weak consistency, consistency in the rth mean, strong consistency, Fisher's consistency and interrelated theorems. Sufficient condition for consistency, unbiasedness–sufficient statistics-Factorization theorem, Distributions admitting sufficient statistic, procedure for finding minimal sufficient statistic.

UNITII

Methods of estimation–method of moments, methods of maximum likelihood and the small sample properties. Large sample properties of MLE – Consistency, Asymptotic normality, asymptotic efficiency. Interval estimation–Fundamental notions of interval estimation, shortest confidence intervals; Constructions of shortest confidence intervals.

UNIT III

The information inequality–Cramer–Rao (CR) inequality, Kiefer-Chapman-Robbins (KCR) inequality, CR inequality, Bhattacharya inequality; Minimum variance bound estimator, Invariant (equivarient) estimators (concept only).

UNIT IV

Uniformly minimum variance unbiased estimators (UMUE), A necessary and sufficient condition for an unbiased estimator to be a UMVUE; Completeness and Boundedly completeness; Relation between complete statistic and minimal sufficient statistic; Boundedly complete but not complete ;Rao-Blackwell Theorem, Lehmann-Scheffes theorem.

(Only Theoretical Questions to be asked)

Books for study

1. Goon, A.M. Gupta M.K. and Das Gupta B.C.(1980): An outline of statistical theory, Vol II, The world press, Calcutta.
2. Lehmann E.I., (1983): Theory of point estimation Wiley Eastern.
3. Rohatgi, V.K. (1986): Statistical Inference, Wiley Eastern.
4. Mood, A.M, Graybill, F.A., and Bose D.C. (1974): Introduction to Theory of Statistics, McGraw-Hill.

Books for Reference

1. Rao. C.R. (1998): Linear Statistical Inference and its applications, Wiley Eastern.

STAT - 311 : TESTING STATISTICAL HYPOTHESIS CREDITS 4

Unit I

Randomized and non-randomized tests. The Neymann-Pearson fundamental lemma, Most Powerful tests, uniformly most powerful test, uniformly most powerful test for distributions with monotone likelihood ratio, a generalization of fundamental lemma.

Unit II

Unbiasedness for hypothesis testing, uniformly most powerful unbiased tests, unbiased tests for one parameter exponential family, similar regions and complete sufficient statistics, tests with Neymann structure, uniformly most powerful similar tests, locally most powerful tests. Invariant test-maximal invariance, uniformly most powerful invariant tests, likelihood Ratio test, Consistent tests.

Unit III

One sample non-parametric tests- Kolmogorov-Smirnov test, sign test, Wilcoxn Signed Rank test, Test for randomness. Two sample non-parametric tests, Kolmogorov smirnov test, Wald-Wolfowitz run test, Mann-Whitney U test, Median test. K-sample test-Kurskal-Wallis test, Friedman test.

Unit IV

Sequential test – Basic structure of sequential tests – sequential probability ratio test (SPRT). Power and expected sample size of SPRT. Optimum Properties of SPRT.

(Only Theoretical Questions to be asked)

BOOKS FOR STUDY

1. Goon.A.M. Gupta, M.K.Das Gupta (1980): An Outline of Statistical Theory (Vol.II) The World Press Calcutta.
2. Lehmann, E.L.(1983):Testing Statistical Hypothesis, Wiley Eastern.
3. Rohatgi, V.K. (1986): an Introduction to probability theory and mathematical statistics, Wiley Eastern, New Delhi.

BOOKS FOR REFERENCES

1. Abraham Wald (1959): Sequential Analysis, John Wiley & Sons.
2. Rao. C.R. (1998): Linear Statistical Inference and its Application, John Wiley, Second Edition.

STAT – 312: LINEAR MODEL AND DESIGN OF EXPERIMENTS CREDITS 4

UNIT –I

Basic Principles of Experimentation – Experimental Error – Review of CRD & RBD - LSD – Applications – Layout of LSD – Advantages and Disadvantages of LSD – Statistical Analysis of LSD – Least Square Estimates of parameters – Multiple comparison methods – Least Significant Difference method – DMRT and Tukey's Test.

UNIT –II

Factorial experiments – Introduction – 2^2 factorial Design – Statistical Analysis of 2^2 factorial Design – Yates method of computing 2^2 factorial totals. 2^3 Factorial Experiment – Model Description - Statistical Analysis of 2^3 factorial Design- Yates method of computing 2^3 factorial totals – 3^2 Factorial Experiment - Confounding – Partial confounding and complete Confounding.

UNIT – III

Split Plot Design – Introduction – model description – Statistical Analysis – Advantages and Disadvantages. - Analysis of Covariance with one Concomitant variable – model – Least Square Estimates for parameters – Estimation of variance – Statistical analysis in CRD & RBD.

UNIT –IV

Incomplete Block Designs – Introduction – Balanced Incomplete Block Designs – Parametric Relationships – Symmetric BIBD – Statistical Analysis of Balanced Incomplete Block Designs (Intra Block only) - Partial BIBD.

Text Books:

1. S.C. Gupta and V.K. Kapoor : Fundamental of Applied Statistics – Sultan Chand & Sons, Fourth Edition, 2015.
2. R. Panneer Selvam : Design And Analysis of Experiments, Prentice Hall.
3. M.N. Das and N.P. Giri : Design and Analysis of Experiments, New Age International, 2nd Edtion, 2008.

Reference Books:

1. W.G. Cochran and G.M. Cox: Experimental Designs – John Wiley.
2. Montgomery : Design and Analysis of Experiments, John Wiley & Sons (p) Ltd.. 5th Edition 2009.
3. Angela Dean and Daniel Voss : Design and Analysis of Experiments, Springer.

STAT 313 – STOCHASTIC PROCESSES **CREDITS: 4**

Unit I

Definition and classification – Markov chain– Examples (Random walk, Gambler's ruin problem)- Transition Probability Matrices - Higher Transition Probabilities -Bernoulli Trails - classification of states and chains - theorems and problems; Basic limit theorem of renewal theory.

Unit II

Overview- postulates- probability mass function -Properties - inter related probability distributions- Generalization- Arrival process, Departure Process, Pure Birth(Yule-Furry) process, Birth and Death Processes, Birth-Death and Migrations processes Chapman Kolmogorov Equations- Compound Poisson Process - Transition density matrix and Poisson Process.

Unit III

Weiner Process: Brownian Motion, Joint probabilities, Wiener process, Differential equations, Kolmogorov equations, First passage time distribution; Branching Process: properties of generating functions of branching processes, Probability of Ultimate extinction, Distribution of Total number of Progeny, Age dependent Branching process

Unit IV

Renewal processes: Definition, examples and relationships between terms – renewal interval, delayed recurrent event, Renewal Processes in continuous time, Renewal Function and renewal density, renewal equation, renewal theorems – Study of residual life time process

Books for Study

1. Karlin, S and Taylor, H.M(1975): A First Course in Stochastic Processes, Academic Press, New York.
2. Medhi,J (2009): Stochastic Processes, 3/e, New age International.
3. Bhat B.R.(2004): Stochastic Models: Analysis and Applications, New Age Publications

Books for Reference

1. Bhattacharya and Waymire, E.C. (1992): Stochastic Process with Applications John Wiley and sons.
2. Jones,P.W and Smith,P(2001): Stochastic Processes: An Introduction, Arnold Press.
3. Cinlar, E(1975): Introduction to Stochastic Processes, Prentice-Hall Inc., New Jersey.
4. Cox, D.R and Miller, H.D(1983) : Theory of Stochastic Processes – Chapman and Hall, London,Third Edition
5. Ross S.M (1983): Stochastic Process, Wiley. 6. G. Grimmett and D. Stirzaker (2001): Probability and Random Processes, 3/e, OUP Oxford.

STAT – 416: MULTIVARIATE STATISTICAL ANALYSIS **Credits 4**

Unit I

Multivariate Normal distribution: Properties – Marginal and conditional distributions. The Moment generation function and moments. Distribution of linear combinations- Distribution of the exponent term of the Multivariate normal distribution – Partial and multiple correlation co-efficients – The Maximum Likelihood estimation of the parameters of Multivariate Normal and their sampling distributions – Inference concerning the mean vector when covariance matrix is known. Distribution of correlation coefficient when population correlation coefficient is equal to zero – Distribution of Regression coefficients.

Unit II

Hotelling-T^2 distribution: Applications – Derivation of generalized T^2 statistic and its distribution – Uses of T^2 statistics – optimum properties of T^2 statistic – Mahalanobis-D^2 Statistic and its distribution – Relation between T^2 and D^2. Generalised variance – Wishart distribution and its properties.

Unit III

Principal components: Definition – Maximum likelihood estimates of the Principal components and their variances. Factor Analysis: The Mathematical model – Estimation of Factor Loadings – Varimax rotation – Numerical solution of the estimating equations – testing Goodness of Fit of the Factor model. Canonical Correlation: Estimation of Canonical correlation and variates.

Unit IV

Discrimination and Classification – Fisher's method – Classification into one of two populations (known and unknown distributions) – Classification into one of several populations – Optimality of classification rules. Cluster Analysis: Similarity measure, Hierarchical and K-means clustering.

(Only theoretical questions to be asked)

BOOKS FOR STUDY

1. Anderson, T.W.(2003): An Introduction to Multivariate Statistical Analysis, Wiley Easter Ltd.
2. Rao, C.R.(2001): Linear Statistical Inference and it Applications, Wiley Eastern Ltd.
3. Richard A. Johnson and D.W. Wichern (2007): Applied Multivariate Statistical Analysis, Prentice-Hall of India, New Delhi.

BOOKS FOR REFERENCE

1. Morrison. F. (1990): Multivariate Statistical Methods, McGraw Hill Book Co.
2. Everitt,B.S&Dunn,G (2001) Applied Multivariate Data Analysis, 2nd Edition, Arnold publishers, London

STAT 417 – OPTIMIZATION TECHNIQUES **CREDITS: 4**

Unit I

Mathematical Programming - Solving of LPP by graphical method - Linear Programming Problem (LPP)–Simplex, Big M and Two Phase methods – Revised simplex method – Solving LPP using Duality - Dual Simplex method

Unit-II

Post Optimality and Sensitivity Analysis–Variation in cost vector and requirement vector– Addition and deletion of single variable and single constraint - Integer Programming Problem (IPP) - Gomory's cutting plane algorithm– Mixed IPP – Branch and Bound technique

Unit III

Dynamic programming problem (DPP) - Bellman's principle of optimality - General formulation - computation methods and application of DPP - Solving LPP through DPP approach

Unit IV

Non Linear Programming: Constrained and Unconstrained Problems of Maxima and minima, Constraints in the form of equations (Lagrangian Method) and in equations (KuhnTucker conditions), Quadratic programming: Beale's and wolf's methods simplex method for quadratic programming.

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Text Books

1. Hillier FS and LibermannGJ(2002):IntroductiontoOperationsResearch,7 th Edition, McGraw Hill
2. KantiSwarup,P.K.GuptaandManMohan(2004):OperationsResearch,SultanChand and Sons, New Delhi.
3. Gross D, ShortleJ.F. , Thompson J.M. and Harris C.M. (2011): Fundamentals of Queuing Theory, John Wiley & Sons

Reference Books

1.Sinha SM(2006):Mathematical Programming: Theory and Methods, Elsevier Publications.
2. Devi Prasad (2015), Operations Research, Narosa Publishing House
3. Kapoor V.K.(2008):Operations Research, 8/e,SultanChand&Sons
4. Sharma .S.D(1999): Operation Research , Kedar Nath RamNath& Co., Meerut.
5. HamdyA.Taha(1987):Operations Research – An Introduction, 4 /e, Prentice Hall of India, PrivateLtd,NewDelhi.
6. Sujit K. Bose (2012), Operations Research Methods, 2/e, Narosa Publishing House
7. K. Chandrasekhara Rao and Shanti Lata Misra (2012), Operations Research, Narosa Publishing House

STAT – 418 PROGRAMMING IN R CREDITS 4

UNIT I

R language Essentials: Expressions and Objects, Assignments, Creating Vectors, Vectorized arithmetic, Creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection; examples.

UNITII

R Programming; conditional Statements – if and if else; loops-for, while, do-while; functions-built-in and user defined; Data entry – reading from text file, data editor; examples.

UNITIII

Descriptive Statistics and Graphics; Obtaining summary statistics; generating tables; Bar plots, pie charts, Box plots, Histogram; exercises. Correlation and Regression.

UNIT IV

One and two sample tests for mean and variance- One way and two way ANOVA, CRD, RBD, LSD, 2^2, 2^3, 3^2 factorial design.

BOOKS FOR STUDY

1. Michael J.Crawley (2007), The R Book, John Wiley and Sons Ltd.
2. Peter Dalgaard (2008), Introductory Statistics with R, 2^{nd} edition, Springer.

LAB EXERCISES:

1. Bar and Pie charts, Box plots for single and multiple groups.Checking Normality using Histogram and Q-Q plot.
2. Finding of measures, Dispersion.
3. Correlation coefficient –Person's ,Spearman and Kendall's Tau.
4. Fitting simple linear and multiple linear regressions.
5. One sample and two sample t test.
6. One way and two way ANOVA
7. CRD, RBD, LSD, 2^2, 2^3, 3^2 factorial design.

NUMERICAL METHODS **CREDITS 3**

UNIT- I: ALGEBRAIC AND TRANSCEDENTALTAL EQUATIONS

Bi section Method – Iterative methods – False Position Method – Newton Raphson Method – Horner's Method

UNIT – II: Simultaneous Linear Algebraic equations

Gauss Elimination Method – Gauss Jordan method – Methods of Factorizations - Gauss Jacobi Method – Gauss Seidel Method

UNIT – III: Interpolation

First order finite differences – Higher order finite differences – Difference Tables – Backward differences – Gregory Newton forward formula – Backward interpolation formula

UNIT – IV: Interpolation with unequal intervals

Newton's interpolation formula for unequal intervals – Lagrange's Interpolation formula – Inverse interpolation

Book for study

1. Numerical methods in science and technology by Dr. M.K.Venkatraman ,National Publishing company

Book for Reference

1. Numerical methods by Singaravelu, Meenakshi agency

QUEUEING THEORY **CREDITS 3**

UNIT-1

Structure of queueing system – classification of queueing model - Single server queueing model with infinite capacity – Derivation of steady state probability distribution –Derivation of performance system measures - problems

UNIT-II

Single server queueing model with finite capacity – Derivation of steady state probability distribution – Derivation of performance system measures - problems

UNIT-III

Multi server queueing model with infinite capacity – Derivation of steady state probability distribution – Derivation of performance system measures - problems

UNIT-IV

Multi server queueing model with finite capacity – Derivation of steady state probability distribution – Derivation of performance system measures - problems

Book for study

1. **Operations research theory and Applications by J.K.Sharma**

REFERENCE BOOKS:

1. S.D.Sharma, Operations Research, Kedarnath,14th edition
2. P.R. Vittal, Introduction to Operations Research, Margham Publications, Chennai, 2nd Edition.
3. P.K. Gupta, D.S. Hira, Problems in Operations Research, Principles and Solutions, S. Chand & Company Ltd., New Delhi.
4. R. Pannerselvam, Operations Research,Prentice Hall of India, 2nd Edition, 2006
5. S.D.Sharma, Operations Research, Kedarnath,14th edition

MEASURE THEORY **CREDITS 3**

UNIT I

Algebra of sets-Countable sets – field –monotonic field-monotonic class-field generated by a class of subsets-Borel sets- Borel field.

UNIT II

Set functions – countably additive set functions – finitely additive set functions. Measure functions. Properties of measure functions – Outer measure functions – Extension measure –completion of a measure function (concepts only).

UNIT III

Lebesque measure and its properties. Lebesque-Stieltjes measure-examples. Measurable functions-Borel measurable functions –Approximation theorem.

UNIT IV

Measure integration – Properties of integrals – sequence of Measurable functions – mode of convergence of measurable functions – monotone and dominated convergence theorems.

BOOKS FOR STUDY

1. De Barra, G. (1991) Measure theory and Integration, Wiley Eastern Ltd.,

BOOKS FOR REFERENCE

2. Basu, A.K. (1999) Measure theory and Probability, PHI.

3. Ash, R.B. (2000) Probability & Measure Theory, 2nd Edition, Academic

Press.

4. Royden, H.L. (1968) Real Analysis, 2nd Edition, Macmillan.

5. Burrill.W. (1972) Measure Integration and Probability, Academic Press,

ORDINARY DIFFERENTIAL EQUATIONS AND LAPLACE TRANSFORMS

CREDITS 3

UNIT I

Linear Differential equations with constant co-efficients - Linear differential equations with variable coefficients.

UNIT II

Method of Variation of parameters – Simultaneous Linear differential equations with constant coefficients

UNIT III

Laplace transform – basic properties – transforms of derivatives and integrals functions – derivatives and integrals of transforms – transforms of step function – and impulse functions – transforms of periodic functions

UNIT IV

Inverse Laplace transforms – convolution theorem – initial and final value theorem – solution of linear ODE of second order with constant coefficients using Laplace transform.

Prescribed Text

1. Calculus III S.Narayanan and T.K. Manicavachagom Pillay ,
2. Engineering Mathematics – II Dr. M.B.K. Moorthy

Recommended books

1. Introductory course in Differential equations ,D.A.Murray, Orient Longman (1967)
2. Advance Engineering Mathematics , Erwin Kreyzsig, Wiley India Edition (2010)
3. Engineering Mathematics ,M.K.Venkataraman, National Publishing

DIFFERENCE EQUATIONS and Z- TRANSFORMATION CREDITS 3

UNIT 1 : Difference Operator

Difference operator – Definition of difference operator **Δ** and shift operator E -Properties of **Δ** - Formula for differences of particular functions - The falling factorial power and Binomial coefficient - Summation – General properties of indefinite sums - Generating function and approximate summation - Bernoulli polynomials and Bernoulli numbers - Properties of Bernoulli polynomials - Euler summation formula.

UNIT 2 : Linear difference Equations

First order equation – General results for linear equations – A linear equation of n^{th} order - Characterization of general solution of a linear equation of n^{th}order - The matrix of Casorati - Role of Casoratian in the study of linear difference equations - Solving linear equations

UNIT 3 : Z- Transform

Z-Transform – Definition of Z-transform of a sequence - Exponentially bounded sequence - Linearity theorem – Shifting theorem - Initial and final value theorem – Convolution theorem - Solution of Volterra summation equation - Solution of Fredholm equation - Eigen pair - Properties of eigen pairs.

UNIT 4 : Stability Theory

Initial value problems for linear system – Cayley Hamilton theorem - The Putzer algorithm -

TEXT BOOK:

Walter G Kelley & Allan C. Peterson : "Difference equations ", Academic press- second edition, 2001.

SECTIONS:

2.3 , 3.1 – 3.4, 3.7, 4.1

REFERENCE BOOKS:

1. Dr. Sudhir, K.Pundir and Dr.RimplePundir - Difference equations - UGC model curriculum.

2. Ronald E. Mickens - Difference equation - Theory and application - Chapman and Hall , Second edition, London 1990.

REAL ANALYSIS **CREDITS 3**

UNIT-1: SETS AND FUNCTIONS

Sets and elements – Operations on sets – Functions – Real valued functions – Equivalence – Countability – Real numbers – Least Upper bound

UNIT-II

Definition of sequence and subsequence – Limit of a sequence – Convergent sequence – Divergent sequence – Bounded sequence – Monotone sequence – Operations of convergent sequence – Operations on Divergent sequence –Cauchy sequence

UNIT-III

Limit of a function on real line – Metric Spaces – Limits in Metric spaces

UNIT-IV

Functions continuous at a point on real line – Reformulation – Functions continuous on a metric space – Open sets – Closed sets – Discontinuous functions on R

Book for study

1. Methods of real analysis – Richard R Goldberg

STATISTICAL QUALITY CONTROL **CREDITS 3**

Unit I

Modified control charts for mean – CUSUM chart – technique of V-mask – Weighted moving average charts – multivariate control charts – Hotelling's T^2 control charts and economic design of X-bar chart

Unit II

Process capability analysis: Meaning, estimation technique for capability of a process – Capability indices: Process capability ratios C_p; C_{pk}, C_{pm},C_{mk}, C_{pc} – Process capability analysis using a control chart – Process capability analysis using design of experiments

Unit III

Acceptance sampling – terminologies – Attribute sampling plan by attributes – Single sampling plan and double sampling plan – OC, ASN, AOQ, AOQL and ATI curves – Acceptance sampling variables for process parameter – Sequential plans for process parameter **(σ known and unknown) – Sampling variables for proportion non-conforming – X method, K method.**

Unit IV

Double specification limits – M-method, Double sampling by variables – MILSTD – 414 Tables – Continuous Samppling plan – CSP-1, CSP-2, CSP-3, Wald and Wolfowitz SP-A and SP-B

BOOKS FOR STUDY

1. Douglas C. Montgomery (2009): Introduction to Statistical Quality control, 6/e, John Wiley and Sons, New York
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis
3. Oakland, J.S.(1989): "Total Quality Management", Buttrworth-Hcinemann Ltd., Oxford

BOOKS FOR REFERENCE

1. Mittage, H.J and Rinne, H(1993): Statistical Methods of Quality Assurance, Chapmann Hall, London, UK
2. Zeiri (1991): "Total Quality Management for Engineers", Wood Head Publishers.
3. Juran J.M and Frank M. Gryna Jr. (1982): "Quality planning and analysis"' TMH, India

TIME SERIES ANALYSIS **CREDITS 3**

UNIT I

Exploratory Time Series Analysis: Forecasting trend and seasonality based on smoothing. Methods of Exponential and moving average smoothing; Types and implications of interventions; Outliers, additive and innovational outliers, procedure for detecting outliers.

UNIT II

Stationary Stochastic models: weak and strong stationarity, Deseasonalising and detrending an observed time series, Auto-covariance, autocorrelation function (ACF), partial autocorrelation function (PACF) and their properties, conditions for stationarity and invertibility.

UNIT III

Models for Time Series: Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods.

UNIT IV

Spectral analysis and decomposition: Spectral analysis of weakly stationary process, Periodogram and Correlogram analysis, Spectral decomposition of weakly AR process and representation as a one-side MA process- necessary and sufficient conditions, implication in prediction problems.

Text Books:

1. Nicholas T. Thomopoulos, 1980, Applied Forecasting Methods, Prentice Hall
2. BoxGEP, JenkinsGMandReinselGC(2004):TimeSeries Analysis-Forecasting and Control, Pearson Education.
3. BrockwellPJandDavisRA(2002): Introduction to Timeseriesand Forecasting, Springer.
4. Montgomery D C and Johnson L A (1977): Forecasting and Time Series analysis, McGraw Hill.

Reference Books:

1. ChatfieldC(1996):TheAnalysisofTimeSeries:TheoryandPractice,fifthedition, Chapman and Hall.
2. NachaneD.M.(2006):Economics:TheoreticalFoundations and Empirical;Perspective, Oxford University press
3. Diggle, P.J Time Series: A Bio-statistical Introduction, Oxford University press (1990).
4. Hamilton, J., 1994 Time Series Analysis, Princeton University Press.
5. Harvey, A.C., 1993, Time Series Models, MIT Press.
6. Kendall, Sir Maurice and Ord J K (1990): Time Series, Edward Arnold.
7. Tsay, R., 2002, Analysis of Financial Time Series, Wiley Series.

DATA WAREHOUSING AND DATA MINING

UNIT -I

INTRODUCTION- Why Data Mining-What is Data Mining-What Kinds of Data Can Be Mined-What Kinds of Patterns Can Be Mined-Which Technologies Are Used-What Kinds of Applications Are Targeted- Major Issues in Data Mining- Relation To Statistics, Databases- Data Mining Functionalities-Steps In Data Mining Process-Architecture of A Typical Data Mining Systems-Classification Of Data Mining Systems - Overview Of Data Mining Techniques.

UNIT – II

DATA WAREHOUSING AND ONLINE ANALYTICAL PROCESSING - Data Warehouse: Basic Concepts-Data Warehouse Modeling: Data Cube and OLAP-Data Warehouse Design and Usage-Data Warehouse Implementation-Data Generalization by Attribute-Oriented Induction.

UNIT – III

DATA PREPROCESSING AND MINING FREQUENT PATTERNS - Data Preprocessing: An Overview-Data Cleaning, Data Integration, Data Reduction- Data Transformation.
Data Mining Frequent Patterns, Associations, and correlations: Basic Concepts-Frequent Itemset Mining Methods.

UNIT – IV

CLASSIFICATION & CLUSTERING – Classification: Basic Concepts- Decision Tree Induction-Bayes Classification Methods- Rule-Based Classification-Cluster Analysis: What is Cluster Analysis? Partitioning Methods-Hierarchical Methods. **DATA MINING TRENDS AND RESEARCH FRONTIERS**-Data Mining Applications-Data Mining and Society-Data Mining Trends.

TEXT BOOK:

1. Jiawei Han, Micheline Kamber, Jian Pei, "Data Mining-Concepts and Techniques", -Third Edition, Morgan Kaufmann Publishers, 2012.

REFERENCE BOOKS:

1. Ralph Kimball, "The Data Warehouse Life Cycle Toolkit", John Wiley & Sons Inc., 1998.
2. Sean Kelly, "Data Warehousing In Action", John Wiley & Sons Inc., 1997.

3. Alex Berson, Stephen J. Smith, “Data Warehousing, Data Mining, & OLAP”, Tata McGraw- Hill, 2004.
4. Usama M.Fayyad, Gregory Piatetsky - Shapiro, Padhrai Smyth And Ramasamy Uthurusamy, "Advances In Knowledge Discovery And Data Mining", The M.I.T Press, 1996.
5. W. H. Inmon Building the Data Warehouse Wiley Computer Publishing Third Edition, 2002.

CATEGORICAL DATA ANANYSIS **CREDITS – 3**

UNIT -1

Categorical response data probability structure of Contingency Tables – Sensitivity and Specificity – Independence of Categorical Varaibles - Poison , Binomial and Multinomial sampling - Comparing two proportions – Relative Risk , Odds Ratio – Partial Association in Stratified 2 X 2 Tables – Conditional and Marginal odds ratio – Marginal and Conditional Independence – Homogenous Association Interval estimation of odds ratio and relative risk – Standard errors with delta method – Delta method applied to Sample Logit and Log Odds Ratio

UNIT – 2

Introduction to Generalized Linear Models : Components of Generalized Linear Model , Binomial Logit Model , Poisson Loglinear Model , DEViance, linearity Probability Model, Logistic Regression Model, Probit and Inverse CDF Link Function, GLM for counts , Inference for GLM, Deviance and Goodness of fit, Deviance for poisson and Binomial models.

UNIT –3

Logistic regression – Interpreting ß co-efficient and odds ratio – Testing ß and constructing confidence interval for ß single predictor model – checking model fit – Models with categorical predictors – Multiple logistic regression – model fit using Likelihood ratio test – likelihood equation – Asymptotic covariance matrix of parameters.

UNIT-4

Log linear models for two-way tables – saturated model- models for independence and interaction in three-way tables – inference for log linear model – Chi-squared goodness of fit tests – Conditional association – Relation between log linear and logit models – Generalized log linear model – Likelihood equations for log linear models.

(Only Theoretical Questions to be asked)

BOOKS FOR STUDY:

1. Alan Agresti , (2002) : Categorical Data Ananlysis , Wiley Interscience , John Wiley & Sons
2. David W. Hosmer Jr, Stanley Lemeshow (1999): Appiled Survival Analysis , John Wiley & Sons , INC

BOOKS FOR REFERENCE:

1. Radhakrishna Rao , " Linear Statistical Inference and its Applications " Wiley - Interscience 2ed / 2001/ISBN: 0471218758.

Reliability and survival analysis

Unit I

Introduction to Reliability and its needs; Structural properties of coherent system: components and systems, coherent structures, representation of coherent systems in terms of paths and cuts, relevant & irrelevant structure; Modules of coherent systems; Reliability of a coherent systems; Reliability importance of components; Bounds on System Reliability.

Unit II

Life Distributions: Concept of distribution function, hazard function, Reliability function, MTTF, Bathtub failure rate; loss of memory property of Exponential distribution - parametric families of some common life distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation of parameters in these models.

Unit II

Estimation of survival function Actuarial Estimator, Kaplan- Meier Estimator, Estimation under the assumption of IFR / DFR . Tests of exponentiality against non- parametric classesTotal time on test, Despande test.

Unit IV

Two sample problem- Gehan test, Log rank test. Mantel Haenszel test, Tarone Ware tests. Introduction to Semi- parametric regression for failure rate, Cox's proportional hazards(PH) model with one and several covariates and estimation problems in Cox's PH Model. Rank test for the regression coefficients

Books for Study:

1. Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley
2. Miller, R.G. (1981) : Survival analysis (John Wiley).
3. Cox, D.R. and Oakes, D. (1984) : Analysis of Survival Data, Chapman and Hall, NewYork.
4. Elisha T Lee, John Wenyu Wang and Timothy Wenyu Patt(2003): Statistical Methods for Survival data Analysis, 3/e, Wiley Inter Science.
5. Barlow, R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing; Rinehart and Winston.

STATISTICAL LABORATORY – I (CREDITS 3)

I. Estimation Theory

1. MLE and Standard error of ML estimators.
2. MLE for truncated distribution.
3. Method of moments.
4. Interval estimation: Confidence interval for mean, difference of means
5. Interval estimation - variance and ratio of variances.

II. Distribution I and II

1. Fitting of Discrete Distributions
2. Fitting of Continuous Distributions

III. Applied Regression Analysis

1. Linear Regression
2. Multiple Regression

STATISTICAL LABORATORY – II (CREDITS 3)

(USING SPSS)

Testing of Hypothesis

1. Large Sample Tests: Means, Variances and Proportions
2. Test based on Chi-square distribution: Population variance, testing the goodness of fit, independence of attributed
3. Test based on t-distribution: Single mean, Difference of means, Paired t test, Correlation coefficient
4. Test based on F-distribution: Equality of two population variance
5. Non-parametric tests – Sign test, Wilcoxon test, Mann-Whitney U test, Median test, Run test, Kolmogorov –Smirnov one sample test.

Design of Experiments

1. One way classification and Two way classification Model
2. Completely Randomised Design and Multiple Comparison Methods
3. Latin Square Design and L.S.D. with one or two missing values
4. 2^2, $2^{3 \text{ and }} 3^2$FactorialDesign
5. Balanced Incomplete Block Design (BIBD)

FUNDAMENDALS OF STATISTICS
(OTHER DEPARTMENTS)

UNIT-1

Classification - Frequency distribution – formation of Frequency tables – Tabulation of data – Diagrammatic presentation - Ogive

UNIT-II

Measures of Central tendency – Arithmetic mean – Geometric mean – Harmonic mean – Median – Mode - Quartiles

UNIT-III
Measures of dispersion – Mean deviation – Quartile deviation – Standard deviation – Co-efficient of variations

UNIT-IV
Correlation – Pearson's co-efficient of correlation – rank correlation – fitting a straight line

Book for study

1. Statistics by R.S.N. Pillai and V. Bagavathi

PYTHON PROGRAMMING

UNIT – I

Introduction to Python Programming - values and types -variables, Keywords, Operators, and Expressions, Input-Output, Indentation - Control Flow- if, if-elif-else, for, while break, continue, pass - Lists – Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences - Functions – Anonymous Functions - Fruitful Functions.

UNIT – II

Object-Oriented Programming OOP in Python: Classes, ' self-variable', Methods, Constructor Method, Inheritance, Overriding Methods, Data hiding – Exceptions Handling – NumPy: Introduction - Data Types - Array Attributes - Array Creation Routines - Indexing & Slicing – Broadcasting - Array Manipulation - Binary Operators - String Functions - Mathematical Functions - Arithmetic Operations - Statistical Functions.

UNIT – III

Python Pandas : Introduction - Data Structures: Series, DataFrames, Panels - Basic Functionality - Descriptive Statistics - Function Application - Reindexing – Iteration – Sorting - Working with Text Data -Options & Customization - Indexing & Selecting Data - Statistical Functions - Window Functions - Aggregations - Missing Data - GroupBy - Merging/Joining - Concatenation - Date Functionality – Timedelta - Categorical Data - Visualization - IO Tools.

UNIT – IV

Matplotlib: data visualization: Basic plots - Scatter (2D) plots – Seaborn: Boxplot, Violin plot (distribution), Pairwise scatter plots -Time series - NumPy with Matplotlib - NumPy: Histogram Using Matplotlib .

Reference Books

1. Introduction to Computation and Programming using Python, by John Guttag, PHI Publisher, Revised and Expanded version.
2. Fundamentals of Python first Programmes by Kenneth A Lambert, Copyrighted material Course Technology Inc. 1st edition (6th February 2009)
3. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython ,2nd edition, Wes McKinney,O'Reilly Media (2017)
3. Statistics and Machine Learning in Python, Release 0.3 beta by Edouard Duchesnay, Tommy Löfstedt, Feki Younes, 2019.