INTEGRATED M.Sc. PROGRAMME IN BASIC SCIENCES - STATISTICS

Syllabus (III Semester - X Semester)

Semester III-Core Course-1
IST3CR01-Probability Distributions

Hours per week –5
Number of credits - 4

Text books:

1. **Gupta, S.C. and Kapoor, V.K. (2014). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.**
2. **Ross. S. (2010). A First Course in Probability, (8th ed.), Pearson Education, Inc.**

Module 1: Mathematical Expectations and generating functions

Mathematical Expectation, Expectation of a function of a random variable, Addition theorem of expectation, multiplication theorem of expectation. Expectation of a linear combination of random variables, covariance, correlation coefficient, variance of a linear combination of random variables, conditional expectation and conditional variance, moment generating functions, cumulants, characteristic function.

(23L)

Module 2: Discrete probability distributions

Discrete uniform distribution, Bernoulli distribution, Binomial distribution, Poisson distribution, Negative binomial distribution, Geometric distribution (including lack of memory property), Hypergeometric distribution and their properties (mean, variance, mode, mgf, additive property), Fitting of Binomial and Poisson Distributions, Applications.

(22L)

Module 3: Continuous probability distributions

Rectangular distribution, Exponential distribution (including lack of memory property), Weibull distribution, Gamma distribution, Beta distribution of first kind, Beta distribution of second kind, and their properties (mean, variance, mode, mgf, additive property), Laplace, Logistic and Cauchy distributions. Applications. (22L)

Module 4: Normal distribution and Limit theorems

Normal distribution and its properties (mean, variance, mode, mgf, additive property), Normal distribution as a limiting form of Binomial distribution and Poisson distribution. Fitting of normal distributions. Standard normal distribution, Estimation of probabilities using standard normal tables, Log-normal distribution, applications. Chebychev's inequality and weak law of large numbers-Bernoulli's and Chebychev's form, Central Limit Theorem, Lindberg Levy and Liapounoff's forms of CLT, The strong law of large numbers, other inequalities,(problems based on above topics), Applications. (23L)

References Books:

1. Goon A. M., Gupta M. K., and Dasgupta B. (2005). Fundamentals of Statistics, Vol. II, 8th edition, World Press, Kolkata.

2. Hogg R. V., McKean J. W., and Craig A. T. (2014). Introduction to Mathematical Statistics, 6th edition, Pearson Education Inc.

3. Rohatgi, V.K. and Saleh, A.K.MD.E. (2015). An Introduction to Probability and Statistics, (3rd ed.), John Wiley & Sons Inc.

4. R.S.N. Pillai, Bagavathi (2010). STATISTICS- Theory and Practice, S. Chand publications.

5. Medhi J. (2006). Statistical Methods, 2nd edition, New Age International Publishers.

Semester III-Core Course -2
IST3CR02-Estimation Theory

Hours per week – 5
Number of credits - 4

Textbooks:

1. **Gupta S. C. and Kapoor V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sultan Chand and Sons.**
2. **Miller I. and Miller M. (2014) John E. Freund's Mathematical Statistics with applications, 8th edition, Pearson Education Limited**

Module 1: Sampling distributions

Concept of random sample, parameter and statistic, standard error, sampling distribution of a statistic, sampling distribution of the sample mean and sample variance. The Chi-square, t, and F distributions and statistics following these distributions and their applications. Relation among Normal, Chi-square, t and F distributions, order statistics, the theory in practice. (22L)

Module 2: Point estimation

Point estimation - introduction, Characteristics of estimators-Unbiasedness, Efficiency, Consistency, Sufficiency. Robustness. MSE of an estimator, Cramer-Rao inequality and its application, Minimum variance unbiased estimator, Rao – Blackwell Theorem. Completeness property of an estimator.
(23L)

Module 3: Methods of estimation

The method of moments, the method of maximum likelihood, properties of maximum likelihood estimators (statement only), Method of minimum variance, Method of least squares, Bayesian estimation, the theory in practice. (22L)

Module 4: Interval Estimation

Basic concepts of interval estimation, confidence interval, degree of confidence (confidence coefficient). The estimation of means, the estimation of differences between means, the estimation of proportion, the estimation of differences between proportions, the estimation of variances, the estimation of ratio of two variances, the estimation of correlation coefficient, the estimation of regression coefficients, the theory in practice.
(23L)

Reference books:

1. Casella, G and Berger, R.L. (2002) Statistical Inference, 2nd edition, Thomson Learning.
2. Hogg, R. V., McKean, J. W., and Craig, A. T. (2014). Introduction to

Mathematical Statistics, 6th edition, Pearson Education Inc.

4 Mukhopadhyay, P. (1996). Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta

5. Rohatgi, V.K. and Saleh, A.K.MD.E. (2015). An Introduction to Probability and Statistics, (3rd ed.), John Wiley & Sons Inc.

Semester III -Core course -3

IST3CR03-Statistical Computing using Excel/R– II

Hours per week – 5
Number of credits - 4

Type of questions

1. Plotting scatter diagrams
2. Calculation of correlation co-efficient from bivariate data
3. Calculation of rank correlation co-efficient from qualitative data
4. Fitting of straight line, parabola, exponential and polynomial by least square method
5. Fitting regression lines
6. Construction of index numbers
7. Measurement of trend and seasonal variations
8. Problem based on Bayes' theorem
9. Computation of partial and multiple correlation from data for 3 and 4 variables
10. Finding the equation of regression plane and forecasting when there are 3 or 4 variables
11. Fitting of binomial and Poisson distributions and computation of probabilities
12. Fitting of normal distribution and computation of probabilities
13. Approximation of binomial and Poisson probabilities using Central limit theorem (normal approach)
14. Lognormal parameter estimation and computation of probabilities
15. Generation of discrete and continuous random variables
16. Checking unbiasedness using samples and computation of Uniformly Minimum Variance Unbiased Estimators
17. Estimation of parameters using maximum likelihood method
18. Estimation of parameters using method of moments
19. Computation of Minimum Variance Bound Estimators
20. Computation of interval estimates of mean, difference of mean, proportions, difference of proportions, variances and ratio of variances

Semester IV - Core Course-1
IST4CR02-Introduction to Sampling Theory

Hours per week – 5
Number of credits - 4

Textbooks:

1. **Cochran, W.G. (2007). Sampling Techniques, (3rd ed.), John Wiley and Sons.**
2. **Parimal Mukhopadhyay (2015). Theory and Methods of Survey Sampling, (2nd ed.) Prentice-Hall of India.**

Module 1: Basic Concepts

Sample survey, some uses of sample surveys, principal steps in a sample survey, the role of sampling theory. Complete enumeration versus sampling, sampling and non sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey Different non random sampling techniques- Judgement sampling, convenient sampling, quota sampling.
(20L)

Module 2: Simple Random Sampling

Simple random sampling with and without replacement, definition and procedure of selecting a sample, estimation of the population mean and population total, variances of these estimates and estimates of their variances, confidence interval for population mean, simple random sampling for attributes, determination of the sample size. Comparison between srswr and srswor.
(23L)

Module 3: Stratified Random Sampling

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional, Neyman and optimum allocations and their comparison with simple random sampling.

(22L)

Module 4: Systematic and Cluster Sampling

Systematic Sampling: Technique Linear and circular systematic sampling, estimates of the population mean and population total, variances of these estimates. Comparison of systematic sampling with simple random sampling and stratified sampling in the presence of linear trend. Cluster sampling- clusters with equal sizes –estimation of population mean and total – their variances and estimates of the variances. (25L)

Reference Books:

1. Gupta,S.C. and. Kapoor,V.K .(2014) *Fundamentals of Applied Statistics*, Sultan Chand & Co. New Delhi.
2. http://mospi.nic.in
3. Singh,D. and Choudhary,F.S.(2013) *Theory and Analysis of sample survey Designs*, New Age International Publishers.
4. Sampath,S.(2005) *Sampling Theory and Methods*,(2nd ed.), Alpha Science International Limited.

Semester IV - Core Course-2
IST4CR03-Testing of Hypothesis

Hours per week – 5
Number of credits -4

Textbook :

1. **Gupta, S.C. and Kapoor, V.K. (2014), Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.**

Module 1: Neyman Pearson Methodology of Testing

Concept of testing of hypothesis, simple and composite hypotheses, null and alternative hypotheses, type I and type II errors, critical region, level of significance and power of the test. Steps in solving testing of hypothesis problem, Optimum test under different situations- Most powerful tests (MP Test), Uniformly most powerful test (UMP Test), Neyman Pearson Lemma (statement only), p-value. (25L)

Module 2: Tests based on Standard normal and Student's t distribution

Tests for means and equality of means (when population SD known and unknown), Tests for proportion and equality of proportions. Paired t test, Test for correlation coefficient and regression coefficients. (22L)

Module 3: Tests based on Chi square and F distribution.

Test for population variance, equality of variances, Test for goodness of fit, Test for independence of attributes, Test for homogeneity, One way ANOVA.
(18L)

Module 4: Non-Parametric Tests (All Tests as Techniques Only)

Basic ideas, advantages and disadvantages of Non parametric tests, Sign test, Wilcoxon signed rank test, Median test, Mann Whitney U test, Kruskal Wallis test and test for randomness (run test). Kolmogorov - Smirnov test.
(25L)

Reference Books:

1. Hogg, R.V., McKean, J.W. and Craig, A.T.(2014). *Introduction to Mathematical Statistics,* (7th ed.), Pearson Education Publication.
2. Gibbons J.D.(1992). *Nonparametric Statistics: An Introduction,* Sage Publications.
3. Spiegel, M.R. and Stephens L.J. (2014). *Statistics*, (5thed.), Schaum's outlines, McGraw-Hill Education..
4. Rohatgi, V.K. and Saleh, A.K.MD.E.(2015). *An Introduction to Probability and Statistics,* (3rd ed.), John Wiley & Sons Inc.

5. Mood A.M., Graybill F.A. and Boes D.C (2001). *Introduction to the Theory of Statistics*, (3rd ed.), McGraw Hill Education (India) Private Limited
6. John E Freund, Mathematical Statistics (6th edn), Pearson Edn, NewDelhi

Semester V-Core Course-1

IST5CR01-Real Analysis I

Hours per week – 5
Number of credits -4

Textbook :

1. **Robert G Bartle,Donald R. Sherbert(2010), Introduction to Real Analysis(Forth edition), John Wiley & sons ,Inc**

Module 1: Preliminaries

Sets and functions: Set, Subset, Proper subset, Empty set, Disjoint sets, Equality of sets, Set operations, Cartesian product, functions, domain and range of functions, direct image and inverse image, Special type of functions –injective, surjective, bijective. Inverse functions, Composition of functions. Problem based on these topics
(20L)

Module 2: Real Number system:
Mathematical induction, finite and infinite sets, Uniqueness theorem, Countable and uncountable sets, algebraic and order properties of real number, Arithmetic –Geometric mean inequality, Bernoulli inequality, absolute value, Cauchy, triangle inequality, Completeness property, suprema & infima, Archimedean property, Density theorem, nested interval and nested interval property. (25L)

Module 3: Sequences:
Definition of sequences of real numbers, the limit of a sequence, uniqueness of limit, limit theorems, Squeeze theorem, convergence of sequence, Monotone sequence,monotone convergence theorem, subsequence and Bolzano-Weierstrass theorem, Divergence criteria, limit superior and limit inferior, Cauchy sequence and Cauchy convergent criterion, Infinite series and its convergence, Ratio test and Root test. (25L)

Module 4: Continuous functions:
Definition, Boundedness theorem, Maximum minimum theorem, Location of roots theorem, Intermediate value theorem, uniform continuity, tagged partition, Differentiation, Interior extremum theorem, Rolle's theorem, Mean value theorem, Taylor's theorem.
(20L)

Reference books:

1. S.C. and Savitha Arora, Real Analysis, New Age International
2. Bali, N.P (2009). *Real Analysis*, Laxmi Publications (P) Ltd, New Delhi.
3. Shanti Narayan and Raisinghania, M.D. (2014).*Elements of Real Analysis*,(17^{th} ed.), S.Chand & Company, New Delhi
4. C. and Savitha Arora, Real Analysis, New Age International
5. Bali, N.P (2009). *Real Analysis*, Laxmi Publications (P) Ltd, New Delhi.

6. Shanti Narayan and Raisinghania, M.D. (2014).*Elements of Real Analysis*,(17^{th} ed.), S.Chand & Company, New Delhi

Semester V-Core Course-2

IST5CR02-Operations Research

Hours per week – 5
Number of credits - 4

Textbook :

1. **Kanti Swarup, Gupta P.K., Man Mohan (2010): Operations Research, Sultan Chand and Sons, New Delhi.**

Module 1

Origin and Development of OR, Objectives of OR, Modeling and types of models in OR. Linear Programming: Mathematical formulation of LPP, graphical solutions of a L.P.P. Simplex method for solving LPP.
(22L)

Module 2

Artificial Variables-Two phase method, Big M-method, Concept of Duality in L.P.P, Dual simplex method, Sequencing problem, traveling salesmen problems. (20L)

Module 3

General transportation problem. Methods for finding initial basic feasible solutions by North West corner rule, Least cost method and Vogel's approximation method (VAM). MODI method to find the optimal solution. Unbalanced transportation problem and degeneracy (definitions and simple problems only). Assignment problem-Hungarian method to find optimal assignment.
(28L)

Module 4

Inventory models, deterministic inventory models, EOQ models with and without shortages, multi-item deterministic models with one linear constraint, EOQ problem with price breaks. Game theory, PERT and CPM (20L)

Reference books

1. Taha, H.A. (2014). Operations Research, Pearson Education Publication.
2. Gupta R.K. (2010): Operations Research, Krishna Prakashan Media (P) Ltd., Meerut.
3. Bronson, R.and Naadimuthu, G. (1997). Operation Research,Schaum's Outline Series, McGraw-Hill Education.
4. Mittal, S.K.and.Goel, B.S. (1990): Operations Research, Pragati Prakashan, Meerut.

Semester V-Core Course-3
IST5CR03-NumericalAnalysis

Hours per week – 5
Number of credits - 4

Text book:

1. **S. S. Sastry - Introductory Methods of Numerical Analysis, PHI Learning Private Limited Fifth Edition**

Module 1: Solution of Equations

Bisection Method, Method of False Position, Iteration Method, Aitken'sΔ process, Newton–Raphson Method, Generalised Newton's Method and Ramanujan's Method.

(24L)

Module 2: Interpolation

Errors in Polynomial Interpolation, Forward Differences, Backward Differences, Central Differences Symbolic Relations, Difference of a Polynomial and Newton's Formulae for Interpolation. (22L)

Module 3: Fourier Approximations

Fourier series, Fourier transform, Discrete Fourier transform (DFT) and inverse Discrete Fourier transform (IDFT).

(20L)

Module 4 : Numerical Differentiation and Integration

Introduction, numerical differentiation and errors in numerical differentiation. Numerical Integration, Trapezoidal Rule, Simpson's 1/3 Rule, Simpson's 3/8 Rule, Boole's and Weddle's Rules. (24L)

Reference Books

1. Erwin Kreyszig, Advanced Engineering Mathematics, Tenth Edition Wiley New Delhi, 2015.
2. Scarborough : Numerical Mathematical Analysis
3. Francis Shield (Schaum's Series) : Numerical Analysis
4. Hilderbrand : Introduction to Numerical Analysis

Semester V-Core Course-4
IST5CR04-Statistical Quality Control

Hours per week – 5
Number of credits -4

Textbooks:

1. **Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.**
2. **Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.**
3. **Grant E. L. and Leavenworth R. S. (1980) Statistical Quality control, McGraw Hill.**

Module 1

Quality, quality assurance, dimensions of quality, definition of quality control and statistical quality control, Statistical Process Control and product control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts- operation and uses of control charts, probability limits, specification limits, tolerance limits, 3 sigma limits and warning limits. (25L)

Module 2

Control Charts for Variables: X-bar chart, R-chart & s-chart, purpose of the charts, determining the trial control limits, interpretation of control charts. standard out of control pattern on control charts. (21L)

Module 3

Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes, OC, ARL & process capability of control charts. (22L)

Module 4

Acceptance sampling plans for attributes, producer's risk and consumer's risk. Concepts of AQL, LTPD, AOQ, AOQL, ATI and ASN- single, double and multiples sampling plans-OC curves for single and double sampling plans. (22L)

Reference books:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

2. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.

3. Duncan A. J. (1980) Quality control and Industrial Statistics, Irwin Homewood.

4. Schilling E. G. (1982) Acceptance Sampling in Quality Control, Marcel Decker.

Semester V-Core Course-5

IST5CR05-Statistical Computing using Python

Hours per week : 5
Number of credits : 4

Applications of topics covered in Core courses

1. IST1CR02-Basic Statistics
2. IST2CR02-Applied Statistics
3. IST3CR01-Probability Distributions
4. IST3CR02-Estimation Theory
5. IST4CR03-Testing of Hypothesis

Semester VI - Core Course-1
IST6CR01-Real Analysis II

Hours per week – 5
Number of credits -4

Textbook:

1. **Rudin, W., Principles of Mathematical Analysis, (3rd Edn.) Mc. Graw- Hill, 1986.**

Module 1:

Basic Topology - Finite, Countable and Uncountable sets Metric Spaces, Compact Sets, Perfect Sets, Connected Sets. Continuity - Limits of function, Continuous functions, Continuity and compactness, continuity and connectedness, Discontinuities. (23L)

Module 2:

Differentiation-The derivative of a real function, Mean Value theorems, The continuity of Derivatives, L Hospital's Rule, Derivatives of Higher Order, Taylor's Theorem, Differentiation of Vector – valued functions. The Riemann – Stieltjes Integral, - Definition and Existence of the integral, properties of the integral, Integration and Differentiation.
(23L)

Module 3:

Riemann Integration: Partitions and tagged partitions, Definition of Riemann integral , Integrability criteria, integrability of continuous and monotone functions, properties of integrals, first and second fundamental theorems on integral calculus. (22L)

Module 4:

The Riemann – Stieltjes Integral (Continued) - Integration of Vector vector-valued Functions. Sequences and Series of Functions - Discussion of Main problem, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation.

(22L)

Reference Books:

1. S.C. and Savitha Arora, Real Analysis, New Age International
2. L.M. Graves : The theory of functions of a real variable, Tata McGraw-Hill Book Co (1978)
3. M.H. Protter & C.B. Moray : A first course in Real Analysis, Springer Verlag UTM (1977)

4. S.C. Saxena and SM Shah : Introduction to Real Variable Theory, Intext Educational Publishers San Francisco (1972).
5. Hewitt and Stromberg K : Real and Abstract Analysis, Springer Verlag GTM 25 (1975)Reprint
6. S.R. Ghorpade & B.V. Limaye : A course in Calculus and Real Analysis, Springer 2006.
7. Bali, N.P (2009). *Real Analysis*, Laxmi Publications (P) Ltd, New Delhi.
8. Shanti Narayan and Raisinghania, M.D. (2014).*Elements of Real Analysis*,(17th ed.), S.Chand & Company, New Delhi
9. S.C. and Savitha Arora, Real Analysis, New Age International
10. Bali, N.P (2009). *Real Analysis*, Laxmi Publications (P) Ltd, New Delhi.
11. Shanti Narayan and Raisinghania, M.D. (2014).*Elements of Real Analysis*,(17th ed.), S.Chand & Company, New Delhi

Semester VI-Core Course-2

IST6CR02-Complex Analysis

Hours per week: 5

Number of credits : 4

Text book: 1. Brown J.W. and Churchill R.V. (2009) Complex variables and applications (8thedition), The Mc-Grow-Hill companies

Module 1: Complex Numbers

Sum and products, basic algebraic properties, further properties, Vector and moduli, complex conjugates, exponential form, products and powers in exponential form, arguments of products and quotients, Roots of complex numbers, examples.

(20L)

Module 2: Analytic functions and elementary functions

Functions of a complex variable, limits, theorems on limits, continuity, derivatives, differentiation formulas, Cauchy-Riemann equations, polar coordinates, analytic functions, examples, harmonic functions, the exponential function, the logarithmic function, complex exponents, trigonometric functions

(24L)

Module 3: Integrals

Derivatives of functions w(t), definite integrals of functions w(t), contours, contour integrals, some examples, Cauchy-Goursat theorem (without proof), Cauchy integral formula, an extension of the Cauchy integral formula, some consequences of the extension, Liouville's theorem and the fundamental theorem of algebra, maximum modulus principle.

(22L)

Module 4: Series, Residues and poles

Convergence of sequences, convergence of series, Taylor's series (without proof), examples, Laurent's series (without proof), examples, Isolated singular points, residues, Cauchy's residue theorem, three types of isolated singular points, residues at poles, examples, zeros of analytic functions, zeros and poles

(24L)

Reference Books:

1. John M. Howie (2003) Complex Analysis, Springer
2. Lars V. Ahlfors (1979) Complex Analysis – An introduction to the theory of analytic functions of one complex variables (3rd edition), McGraw-Hill education)
3. H.S. Kasana (2013) Complex Variables: Theory and Applications, 2nd edition, PHI learning private limited.
4. Shanti Narayan and Dr. P.K. Mittal (1956)- Theory of functions of a complex variable, S. Chand.

Semester VI-Core Course-3

IST6CR03-Markov Processes and Queueing Models

Hours perweek – 4
Number of credits -3

Module 1

Introduction to stochastic processes:- classification of stochastic processes, wide sense and strict sense stationary processes, processes with stationary independent increments, Markov process, Markov chains- transition probability matrices, Chapman-Kolmogorov equation, computation of higher step transition probabilities. (19L)

Module 2

First passage probabilities, criteria for recurrent and transient states, Communication of states, Reducible and irreducible Markov chains, mean recurrence time, classification of states Stationary distribution and limiting probabilities (18L)

Module 3

Poisson processes, derivation and properties, inter-arrival time distribution and waiting times, birth and death processes, Kolmogorov differential equations, linear growth process with immigration (17L)

Module 4

Basics of Queueing Theory, steady-state solutions of Markovian queues - M/M/1, M/M/s, M/M/∞ models, Queue length, System length, Mean Waiting time, Little's Formula, M/M/1/k queues. M/G/1 and G/M/1 queues and their interarrival as well as waiting time distribution (18L)

Reference Books :

1. Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second Edition, Academic Press, New-York.
2. Medhi J. (2017) Stochastic Processes, Second Edition , Wiley Eastern, New Delhi
3. Ross S.M. (2007) Stochastic Processes. Second Edition, Wiley Eastern, New Delhi
4. Donald Gross , John F. Shortle , James M. Thompson , Carl M. Harris (2012) Fundamentals of Queueing Theory, Edition 4 Wiley Asia

Semester VI - Core Course-4

IST6CR04- Actuarial Statistics

Hours per week – 4
Number of credits-3

Textbook:

1. **Shailaja R. Deshmukh (2009), Actuarial Statistics, an introduction using R, Universities Press (India) Private Limited.**

Module 1: Insurance Business & Future lifetime distribution and life tables

Insurance Business- Introduction, what is actuarial science?, insurance companies as business organisations, concept of risk.Future life time distribution and life tables-Introduction, future lifetime random variable, curate future-lifetime, life tables, assumptions for fractional ages, select and ultimate lifetables

(18L)

Module 2: Actuarial present values of benefit in life insurance products

Introduction, compound interest and discount factor, benefit payable at the moment of death, benefit payable at the end of year of death, relation between A and $\bar{A}$

(17L)

Module 3: Annuities and Premiums

Annuities- Introduction, annuities certain, continuous life annuities, discrete life annuities, life annuities with *m*thly payments Premiums-Introduction, loss at issue random variable, fully continuous premiums, fullydiscrete premiums, true *m*thly payment premiums, gross premiums

(19L)

Module 4: Reserves and multiple life contracts

Reserves-Introduction, fully continuous reserves, fully discrete reserves
Multiple life contracts-Introduction, joint life status, last survivor status (18L)

Reference books

1. Promislow, S.D. (2006) Fundamentals of Actuarial Mathematics, John Wiley
2. Neill, A. (1977) Life contingencies, Heinemann, London
3. Donald D.W.A (1970) Compound Interest and Annuities, Heinemann, London
4. Eric V. Slud (2012) Actuarial Mathematics and Life-table Statistics, Chapman & Hall/CRC

Semester VI -Elective Choice1
IST6EL05- Mathematical Economics

Hours per week – 5
Number of credits-4

Textbooks

1. **Damodar N Gujarati, Sangeeth (2007) Basic Econometrics 5th Ed., McGraw Hill Education Private Ltd.**
2. **Montgomery D.C., Peck E.A. and Vining G.G. (2007) Introduction to Linear Regression Analysis, John Wiley, India.**
3. **Johnston J. (1984) Econometric Methods (Third edition), McGraw Hill, New York**

Module 1

Theory and analysis of consumer behaviour, utility function, Marginal utility analysis, Demand and supply functions, elasticity of demand, equilibrium of market, Cob web model, Cost Function, Marginal analysis of firms.

(20L)

Module 2

Production functions-indifference curve approach, homogeneous functions, Euler's theorem, Marginal rate of substitutions, Cobb-Douglas Production function, CES production function, Input- output analysis, main features of analysis, Leontief's static and dynamic model, limitations and importance of analysis. (25L)

Module 3

Simple linear regression models, Multiple linear regression models, estimation of the model parameters, tests concerning the parameters, Multicollinearity- consequences, Detection, Farrar-Glauber test, remedial measures. Heteroscedasticity- consequences, Detection, tests, remedial measures, Aitken's generalized least square method, Auto-correlation-tests for auto correlation, consequences. (25L)

Module 4

Simultaneous equation models, identification problems, rank and order conditions, methods of estimation- indirect least squares, instrumental variables, least variance ratio and two-stage least squares, FIML- methods.

(20L)

References Books

1. Allen.R.G.D. (2008) Mathematical Analysis For Economists, Aldine Transaction
2. Apte P.G. (1990) Text book of Econometrics, Tata Me Graw Hill.
3. Jeffrey M. Wooldridge (2012) Introductory Econometrics: A Modern Approach 5th Edition, South-Western College Pub.
4. Koutsoyiannis A. (2008) Modern Microeconomics, Second Edition, Macmillan Press Ltd
5. S.P.Singh ,Anil K Parashar, H.P Singh (1999) Econometrics and Mathematical Economics, S.Chand &co.

Semester VI-Elective Choice 2
IST6EL06-Biostatistics

Hours per week – 5
Number ofcredits -4

Recommended Textbooks:

1. **Leon Gordis (2008) Epidemiology,Elsevier Publishers**
2. **Rothman K.J and Greenland S (1998). Modem Epidemiology, Third edition, Lippincott**
3. **Isabel dos Santos Silva (1999) Cancer Epidemiology: Principles and Methods, International Agency for Research on Cancer.**

Module 1

Basic concepts in epidemiology; Measures of Exposures, Types of exposures, Sources of exposures, Measures of outcome; Disease registries, Classification of diseases, Measures of disease frequency: Prevalence, Incidence, Risk, Odds of disease, Incidence time, Incidence rate, Relationship between prevalence, rate and risk, Routine data to measure disease occurrence, cumulative rate, cumulative risk, proportional incidence, Case fatality; Standardization - direct method of Standardization, indirect method of standardization. (22L)

Module 2

Type of study design- Intervention studies, Cohort studies, case-control studies, cross-sectional studies, ecological studies; Relative and absolute measures of effect, Confidence intervals and significance tests for measures of occurrence and effect; Validity and reliability of measures of exposure and outcome: Sensitivity, Specificity, Predictive value method for selecting a positivity criterion, Receiver Operator Characteristic (ROC) curve, Intra and Inter-observer reliability, Kappa measure of agreement. (21L)

Module 3

Case-control studies: Definition of cases, and controls, methods of selecting cases and controls, matching, sample size, power calculations, Basic methods of analysis of grouped data, Basic methods of analysis of matched data. Logistic regression for case-control studies, estimation and interpretation of logistic parameters, matched analysis- estimation of logistic parameters, Categorical data analysis. Cohort studies: Prospective cohort studies: planning and execution, retrospective cohort, nested case-control, case-cohort studies: planning and execution, matching and efficiency in cohort studies, cohort studies –statistical analysis. Longitudinal studies: Design, execution and analysis of longitudinal studies, repeated measurement analysis.

(25L)

Module 4

Sources of bias, Selection bias, measurement bias, misclassification of exposure and outcome, Differential and non-differential exposure and outcome classification, Confounding, Assessment of confounding, Mantel-Haenszel summary measures of effect, Interaction, Mantel-Haenszel method to adjust for several confounders, Confidence intervals

and statistical tests for adjusted relative measures of effect; Excess risk and Attributable risk; Causation and Hill's criteria. (22L)

Reference Books:

1. Penny Web ,Chiris Bain & Sandi Pirozzo (2005).Essential Epidemiology - An Introduction for students & Health Professionals, Cambridge University Press
2. R Bonita, R Beaglehole. T Kjellström, (2006): Basic Epidemiology 2nd Edition.
3. Clayton, D. and Hills, M. (2013). Statistical Methods in Epidemiology, OUP
4. Ahrens W. and Pigcot I.(2005). Handbook of Epidemiology, Springer.

Semester VI

IST6PR06-Mini Project

Hours per week – 2
Number of credits-2

Semester VII -Core Course-1

IST7CR01-Probability Theory

Hours per week – 5
Number of credits -4

Text Books:

1. **Ash R.B. and Doléans-Dade C.A. (2000) Probability and measure theory, Academic Press**
2. **Bhat B.R. (2014) Modern Probability theory (An introductory text book), Fourth edition, New Age International**
3. **Laha R.G and Rohatgi V.K (1979) Probability theory, Wiley.**

Module 1

Finite and countable operations on sets, Sequences and limits of sets, field, Sigma field, minimal sigma field, monotone class, Borel field, finite and sigma finite measures, measure, measurable space ,measure space, Counting measure, Lebesgue measure, Lebesgue Stieltjes measure, Probability measure, monotone and continuity properties of probability measure, Cartheodory Extension theorem (statement only).

(20L)

Module 2

Discrete and Continuous probability spaces and their properties. Conditional probability, multiplication theorem, total probability and Bayes theorem. Independence of events, independence of classes, Independence of random variables, properties, Borel 0-1 criterion, Random variables, vector random variables, properties of random variables, Distribution function and its properties. Jordan decomposition theorem, Correspondence theorem (statement only). (21L)

Module 3

Mathematical expectation, moments and its properties. Basic, Chebychev's, Markov's, Jensen's, Cr, Cauchy-Swartz's, Minkowski's inequalities. Convergence of random variables-convergence almost surely, convergence in probability, convergence in distribution and convergence in rth mean of a sequence of random variables, properties, counter examples and their inter-relationships. Weak and complete convergence of distribution functions. Helly-Bray Lemma and Helly-Bray Theorem (statements only). (24L)

Module 4

Law of large numbers: Weak law of large numbers - Bernoulli, Chebychev, Poisson and Khinchine WLLN, Necessary and sufficient condition for weak law of large numbers.

Strong law of large numbers, Kolmogorov strong law of large numbers for i.i.d random variables. Central limit theorem, Demoivre-Laplace central limit theorem, Lindberg-Levy central limit theorem, Liaponov's central limit theorem, Lindberg-Feller central limit theorem (Without proof), Statement of Multivariate central limit theorem (25L)

Reference Books

1. Basu A.K. (2012). Measure Theory and Probability, Second Edition, PHI Learning Pvt. Ltd, New Delhi.

2. Billingsley P. (2012) Probability and Measure, Anniversary edition, Wiley Eastern Ltd.
3. Loeve M. (1977) Probability Theory, Fourth edition, Springer-Verlag.
4. Rohatgi V.K. and Saleh M. (2015) An introduction to probability and statistics, Third edition, Wiley.
5. Robert G. Bartle (2001), A Modern Theory of Integration, American Mathematical Society (RI)
6. Ash R.B (1972) Real Analysis and Probability, Academic press.
7. Parthasarathy K.R (2005) Introduction to Probability and Measure, Hindustan Book

Semester VII -Core Course-2
IST7CR02-Theory of Bivariate and Multivariate Distributions

Hours per week – 5
Number of credits-4

Textbooks:

1. **Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, John Wiley, New York.**
2. **Johnson, R.A. and Wichern, D.W. (1992). Applied Multivariate Statistical Analysis, 3 rd edn., Prentice- Hall, London.**
3. **Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley, New York.**

Module 1

Bivariate distributions, marginal and conditional distributions, independence, conditional mean and variance. Random vectors and their distributions, expectation and covariance of random vectors and quadratic forms; Characteristic functions in higher dimensions. Multiple regressions and multiple correlation, partial regression and partial correlation (illustrative examples). (22L)

Module 2

Multivariate normal distribution- marginal and conditional distribution, characteristic function, singular normal distribution, additive property, distribution of linear combination of normal random vectors. Characterization of normal distribution based on linear combination of random variables, distribution of quadratic forms, Cochran's theorem (statement only). (25L)

Module 3

Samples from multivariate normal distribution, MLE of mean vector and dispersion matrix. Distribution of sample mean vector, Wishart distribution: definition and properties, analogy with chi-square distribution, characteristic function, additive property, generalized variances, partitioned Wishart matrix, distribution of sample dispersion matrix. (25L)

Module 4

Sampling distribution of multiple correlation coefficient and tests of significance of multiple correlation. Tests of hypothesis about mean vector of multivariate normal distribution, equality of mean vectors of two multivariate normal distributions- Hotelling's T2 and Mahalanobis' D2. (18L)

References:

1. Graybill,F.A. (1961). An Introduction to Linear Statistical Model, Vol 1, Mc Graw Hill, New York.

2. Kendall, M.G. (1958). A Course in Multivariate Analysis, Griffin, London.

3. Rohatji, V.K. and Saleh, A.K.M.E. (2003). An Introduction to Probability Theory and Mathematical Statistics, 2nd edn., John Wiley & Sons, New York.

4. Srivastava, M.S. and Khatri, C.G. (1979). An Introduction to Multivariate Statistics, North Holland.

Semester VII -Core Course-3
IST7CR03-Sampling Theory

Hours per week – 5
Number of credits -4

Textbooks:

1) Cochran W.G (1992): Sampling Techniques, Wiley Eastern, New York.

2) Singh ,D and Chowdhary, F.S. (1999): Theory and Analysis of Sample Survey Designs, Wiley Eastern (New Age International), New Delhi.

Module 1

Official Statistical Systems in India – Role of NSSO and CSO and their activities – For general awareness of students, Census and Sampling methods, Advantages and disadvantages, Principles of sampling theory, Principal steps in a sample survey, probability sampling and non- probability sampling, sampling and non -sampling errors, bias, variance and MSE, simple random sampling with and without replacement - estimation of population mean, total and proportions, estimation of sample size. Properties of the estimators, variance and standard error of the estimators, confidence intervals, determination of the sample size. (25L)

Module 2

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and SRS. Systematic sampling – Linear and Circular, estimation of the mean and its variance, intraclass correlation coefficient, comparison of systematic sampling, SRS and stratified random sampling for a population with a linear trend. (20L)

Module 3

Ratio method of estimation, estimation of population ratio, mean and total, Bias and relative bias of ratio estimator, comparison with SRS estimation. Unbiased ratio type estimators- Hartly- Ross estimator, Regression method of estimation. Comparison of ratio and regression estimators with mean per unit method, Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two- stage cluster sampling with equal and unequal cluster sizes, Multi stage and Multiphase sampling (Basic Concepts), estimation of the population means and its standard error. (25L)

Module 4

Varying probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method and its inclusion probabilities ., estimation of

the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator and its estimated S. E, Des-Raj's ordered estimator, Murthy's unordered estimator (properties of these estimators for n=2 only). Inclusion probability proportional to size Sampling Procedures. (20L)

Reference books

1) Parimal Mukhopadhyay (2009) Theory and Methods of Survey Sampling, Second Edition, PHI Learning (P) Ltd

2) P.V. Sukhatme et.al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.

3) M.N. Murthy (1977) Sampling Theory and Methods, Statistical Publishing Society,

4) Sampath S. C. (2001) Sampling Theory and Methods, Alpha Science International Ltd., India.

5) Thomas Lumley (1969) Complex Surveys. A guide to analysis using R, Wiley eastern Ltd.

6) Desraj (1967) Sampling theory . Tata McGraw Hill, New Delhi 7. MOSPI website.

Semester VII -Core Course-4

IST7CR04 -Statistical Inference I

Hours per week – 5
Number of credits-4

Textbooks:

1) **Rohatgi V.K. and Saleh A.K. (2015) An Introduction to Probability Theory and Mathematical Statistics, Wiley.**

2) **Berger J.O. (1993) Statistical Decision Theory and Bayesian Analysis, Third**

3) **Casella, G and Berger, R.L (2007) Statistical Inference, Second Edition, Cengage Learning.**

4) **Kale B. K. (2005) A First Course on Parametric Inference, Alpha Science International Edition, Springer**

Module 1

Point estimation - Criteria for estimators - unbiasedness, consistency, strong and weak consistency , efficiency, sufficiency, minimal sufficiency, likelihood equivalence, Fisher-Neyman factorization theorem , completeness, bounded completeness, Exponential family of distributions, ancillary statistics, Basu's theorem

(20L)

Module 2

UMVUE and their characterization, BLUE, Rao-Black well theorem, Lehmann-Scheffe theorem, Fisher information measure and its properties, Fisher information matrix , Lower bound to the variance of an unbiased estimator, Cramer-Rao inequality, Chapman-Robbins inequality, Bhattacharyya's bounds, Efficiency, minimum variance (25L)

Module 3

Methods of estimation: method of moments, method of maximum likelihood & their properties, Cramer- Huzurbazar theorem, Fisher's scoring method, method of minimum chisquare and method of modified minimum chi-square, I nterval estimation - Pivotal method of construction, Shortest confidence intervals and their construction. (25L)

Module 4

Basic elements of Bayesian inference, Loss function and risk function , Standard loss functions, Prior-Posterior analysis, Bayes Theorem, Bayes risk, Bayes principle, Bayes estimators, Minimax estimators. (20L)

Reference books

1) Hogg R. V. and Craig A. T. (2013) Introduction to Mathematical Statistics, Pearson
2) Lehmann E.L. (1983) Theory of point estimation – Wiley, New York.
3) Lindgren B.W (1976) Statistical Decision Theory (3rd Edition), Collier Macmillian, New York.
4) Mukhopadhay,P (1999) Mathematical Statistics, New Central Book Agency Pvt. Ltd
5) Rao C.R (2009) Linear Statistical Inference and its Applications, John Wiley, New York.
6) Srivastava, A.K, Khan , A.Hand Srivastava , N (2014) Statistical Inference Theory of Estimation , PHI Learning Pvt. Ltd., New Delhi

Semester VII Core Course-5

IST7CR05-Design and Analysis of Experiments

Hours per week – 5
Number ofcredits -4

Textbooks:

1) **Das M.N. and Giri N.C. (1994) Design and analysis of experiments, Wiley Eastern Ltd.**

2) **Joshi D.D. (1987) Linear estimation and Design of Experiments, Wiley Eastern.**

Module 1

Analysis of variance- one-way, two-way classifications with equal and unequal number of observations per cell, three-way classification models, Fixed effects and Random effects models. (20L)

Module 2

Planning of experiments: Basic principles of experimental design, Uniformity trials, Completely randomized design (CRD), Randomized block design (RBD), Latin square design (LSD), Analysis of experiments with missing observations., Graeco-Latin square designs, Analysis of covariance (ANACOVA), ANACOVA with one concomitant variable in CRD and RBD (25 L)

Module 3

Incomplete block design: Balanced incomplete block design (BIBD); Incidence Matrix, parametric relations; Analysis of BIBD with recovery of Intra-block information, Basic ideas of partially balanced incomplete block design (PBIBD), Basics of Lattice designs. (22 L)

Module 4

Factorial experiments, 2^n and 3^n factorial experiments, Analysis of 2^2 , 2^3 and 3^2 factorial experiments, Total Confounding in 2^n designs in 2^p blocks ,Partial Confounding in 2^n designs in 2^p blocks, Confounding of more than one effect in a single replication, Split plot experiments (RBD), Strip plot design (outline only) (23 L)

Reference Books

1) Agarwal B.L (2010) Theory and Analysis of Experimental Designs, CBS Publishers & Distributers

2) Dean A. and Voss D. (1999) Design and Analysis of Experiments, Springer

Texts in Statistics

3) Dey A. (1986) Theory of Block Designs, Wiley Eastern, New Delhi.

4) Gomez K.A. and Gomez A.A. (1984) Statistical Procedures for Agricultural Research, Wiley.

5) Kempthrone O (1952) Design and Analysis of Experiments, Wiley Eastern, New York

6) Montgomery C.D. (2012) Design and Analysis of Experiments, John Wiley, New York

Semester VIII -Core Course 1
IST8CR01-Statistical Inference II

Hours per week – 5
Number ofcredits -4

Textbooks:

1. **Rohatgi V.K. (1976) An Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, New York.**
2. **Gibbons J.K. (1971) Non-Parametric Statistical Inference, McGraw Hill.**

Module 1

Basic concepts in statistical hypotheses testing-simple and composite hypothesis, critical regions, Type- I and Type-II errors, significance level, p-value and power of a test; Neyman-Pearson lemma and its applications; Construction of tests using NP lemma- Most powerful test, uniformly most powerful test; Monotone Likelihood ratio and testing with MLR property; Testing in one-parameter exponential families-one sided hypothesis, Unbiased and Uniformly Most Powerful Unbiased tests for different two-sided hypothesis; Extension of these results to Pitman family when only upper or lower end depends on the parameters. (24 L)

Module 2

Similar regions tests, Neymann structure tests, Likelihood ratio (LR) criterion and its properties, LR tests for testing equality of means and variances of several normal populations. Testing in multi-parameter exponential families-tests with Neyman structure, UMP and UMPU similar size-tests; Confidence sets, UMA and UMAU confidence sets, Construction of UMA and UMAU confidence sets using UMP and UMPU tests respectively. (21 L)

Module 3

Sequential probability ratio tests (SPRT), Properties of SPRT, Determination of the boundary constants. Construction of sequential probability ratio tests, Wald's fundamental identity, Operating characteristic (OC) function and Average sample number (ASN) functions for Normal Binomial, Bernoulli's, Poisson and exponential distribution. (22 L)

Module 4

Non-parametric tests-- Sign test, Chi-square tests, Kolmogorov-Smirnov one sample and two samples tests, Median test, Wilcoxon Signed Rank test, Mann- Whitney U-test, Test for Randomness, Runs up and runs down test, Wald–Wolfowitz run test for equality of distributions, 4.3 Kruskall–Wallis one-way analysis of variance, Friedman's two-way analysis of variance, Power and asymptotic relative efficiency. (23 L)

References Books

1. Casella G. and Berger R.L. (2002) Statistical Inference, Second Edition Duxbury, Australia.

2. Lehman E.L. (1998) Testing of Statistical Hypothesis. John Wiley, New York.

3. Wald A. (1947) Sequential Analysis, Wiley, Doves, New York.

4. Parimal Mukhopadhyay (2006): Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata. 27

5. Siegel S. and Castellan Jr. N. J. (1988) Non-parametric Statistics for the Behavioural Sciences, McGraw Hill, New York.

6. Rao C.R. (1973) Linear Statistical Inference and its Applications, Wiley.

Semester VIII Core Course-2
IST8CR02-Stochastic Processes

Hours perweek – 5
Number ofcredits -4

Textbooks:

1. **Karlin S. and Taylor H.M. (1975) A First Course in Stochastic Processes, Second Edition, Academic Press, New-York.**
2. **Medhi J. (2017) Stochastic Processes, Second Edition , Wiley Eastern, New Delhi**
3. **Ross S.M. (2007) Stochastic Processes. Second Edition, Wiley Eastern, New Delhi**

Module 1

Markov chains and classification of states**,** Mean ergodic theorem, basic limit theorem of Markov chains (statement only), stationary distributions, limiting probabilities and absorption probabilities. Random walk, gambler's ruin problem; ultimate ruin probabilities, random walk approximation of Brownian motion and diffusion process, Galton-Watson branching process, generating function relations, mean and variance functions, extinction probabilities, criteria for extinction, distribution of total progeny size. (28L)

Module 2

Continuous time Markov chains, Poisson processes, properties, inter-arrival time distribution pure birth processes and the Yule processes, birth and death processes, Kolmogorov forward and backward differential equations, linear growth process with immigration, steady-state solutions of Markovian queues - M/M/1, M/M/s, M/M/∞ models. (25 L)

Module 3

Renewal processes - concepts, examples, Poisson process viewed as a renewal process, renewal equation, elementary renewal theorem, Key renewal theorem (statement only), applications, delayed renewal processes. (20L)

Module 4

Time series modeling, Autocorrelation function (ACF), partial auto correlation function (PACF), correlogram, AR, MA, ARMA, ARIMA Models, Yule- Walker equations, Box-Jenkins Model fitting and diagnostics. (17 L)

Reference Books

1. Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting Second edition, Springer-Verlag.
2. Feller W. (1968) Introduction to Probability Theory and its Applications, Vols. I & II, John Wiley, New York.
3. Cinlar E. (1975) Introduction to Stochastic Processes, Prentice Hall, New Jersey.
4. Basu A.K. (2003) Introduction to Stochastic Processes, Narosa, New-Delhi.
5. Bhat U.N. and Miller G. (2003) Elements of Applied Stochastic Processes. (Third edition), John Wiley, New York.

Semester VIII Core Course-3
IST8CR03-Advanced Multivariate Analysis

Hours per week –5
Number of credits-4

Textbooks:

1. **Anderson T. W. (2003) An Introduction to Multivariate Statistical Analysis, Third edition, John Wiley.**
2. **Rencher, A. C. (1995) Methods of Multivariate Analysis. John Wiley.**
3. **Seber G. F. (1983) Multivariate Observations, John Wiley.**

Module 1

Notion of likelihood ratio tests, Hotelling's T^2 and Mahalanobis D^2 statistics-Their properties, interrelationships, Null distributions (one sample and two sample cases), Testing equality of mean vectors of two independent multivariate normal populations with same dispersion matrix, Problem of symmetry, Multivariate Fisher-Behren's problem. (24 L)

Module 2

Dimension Reduction methods: Principal component Analysis-Method of extraction-Properties, associated tests, Factor Analysis-Orthogonal Model-Estimation of factor loadings, Canonical variates and canonical correlation, uses, estimation and computation, Hotelling's iterative procedure, Profile analysis and associated tests. (23 L)

Module 3

Classification problems: Discriminant Analysis-Baye's procedure, Classification into one of the two populations (Normal distribution only), Classification into several populations (Normal distribution only), Fishers linear discriminant function and its associated tests, Cluster Analysis: Similarity measures, Hierarchical and non-hierarchical methods. (23 L)

Module 4

Multivariate General linear models-MANOVA (one way and two way), Wilk's lamda, Rao's U, Pillai's trace, Hotelling- Lawley trace, Roy's Maximum Root Statistics(Concepts only), Tests-Independence of sets of variates, Equality of dispersion matrices, Sphericity test. (20 L)

Reference Books

1) Bryan, F.J (2004) Multivariate Statistical Methods: A Primer, Third Edition, Chapman & Hall..

2) Everitt, B and Hothorn, T. (2011) An introduction to Applied Multivariate Analysis with R, Springer

3) Johnson R.A. and Wichern D.W. (2007) Applied Multivariate Statistical Analysis. Sixth Edition, Pearson

4) Johnson D.E (1998): Applied Multivariate methods for Data Analysts, Duxbury press Publishing company

5) Kachigan, S.K. (1991) Multivariate Statistical Analysis: A Conceptual Introduction, Hawthorne Academic

6) Kshirasagar, A.M. (1972) Multivariate Analysis, Marcel-Dekker.

7) Morrison, D. F. (1990) Multivariate Statistical Methods, Second Edition, McGraw Hill Education.

8) Rao C.R (2009) Linear Statistical Inference and its Applications, John Wiley, New York.

9) Srivastava M.S and Khatri C.G (2002): Methods of Multivariate Statistics, John Wiley & sons, N.Y

Semester VIII Core Course-4
IST8CR04- Data Analytics Using R

Hours per week – 5
Number of credits-4

Module 1

Introduction to data, statistical problems and related data analysis. Concept of population, sample and statistical inference through examples. Summarization of univariate data; graphical methods, measures of location, spread, skewness and kurtosis; Empirical cumulative distribution function. Analysis of discrete and continuous data: Fitting some standard discrete and continuous probability distributions. Goodness of fit: Pearson's Chi-square test, Kolmogorov-Smirnov test. Q-Q and P-P Plots.

(25L)

Module 2

Test for one sample, two sample and its extensions: test for mean, median and proportions.
Simple and multiple regressions, logistics and Poisson regression.
Applied Multivariate techniques: Principal components analysis and Factor Analysis.

(20L)

Module 3

Simulating discrete and continuous distributions; Inverse transform method, acceptance rejections sampling, transformations, sum and mixture, Resampling techniques; Jack-knife, bootstrap, bootstrap confidence interval and cross- validation techniques. (25L)

Module 4

Introduction to Markov chain Monte Carlo (MCMC) methods and applications of MCMC method in statistics; Metropolis Hasting algorithm., Random walk, Gibs sampler.
Missing data technique; EM algorithm.

(20 L)

Textbooks

1. Rizzo, M. L. (2019). *Statistical computing with R*. CRC Press.
2. Faraway, J. J. (2016). *Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models*. CRC press.
3. McLachlan, G. J., & Krishnan, T. (2007). *The EM algorithm and extensions* (Vol. 382). John Wiley & Sons.
4. Johnson, R. A., & Wichern, D. W. (2014). *Applied multivariate statistical analysis* (Vol. 6).London, UK:: Pearson.

Semester VIII ElectiveChoice 1

IST8EL05-Reliability Theory

Hours per week – 5

Number of credits – 4

Text books :

1. **Barlow R.E. and Proschan F. (1975) Statistical Theory of Reliability and Life Testing, Holt Rinehart and Winston, New York.**
2. **Sinha S. K. (1986) Reliability and Life Testing, Wiley Eastern, New Delhi.**
3. **Lai C.D and Xie M. (2006) Stochastic ageing and dependence in reliability, New York. Springer.**

Module 1

Components and systems, coherent systems, reliability of coherent systems, cuts and paths, series and parallel system, k-out-of-n systems, Bounds on System Reliability, Basic reliability concepts: Reliability function, Failure rate, mean residual life, Mean time to failure in the univariate cases and their inter-relationships. Study of some common life time models: Exponential, Weibull, Lognormal, Pareto, Gamma, Makeham, Rayleigh distributions. (25 L)

Module 2

Characterization of life distribution based on failure rate and mean residual life function, Bath tub (BT) failure rate distributions and Upside down failure rate distributions(UBT) **,** Reliability concepts in the discrete time. (Basic concepts only), Reliability systems with independent and dependent components. (20 L)

Module 3

Notions of ageing: IFR,IFRA,DMRL,NBU,NBUE,HNBUE and their Mutual implications , and respective duals, TTT transforms and characterization of ageing classes. Reliability concepts in discrete set up, Notion of ageing based on failure rate and mean residual life, NBU, NBUE, HNBUE classes and their duals, Interrelationships. (23L)

Module 4

Reliability estimation using Maximum Likelihood method : Exponential, Weibull and Gamma distributions based on censored and non-censored samples**,** Non-parametric method for estimating reliability function and variance of the estimator using Kaplan-Meier (Product limit estimator) method. (22L)

Reference Books

1. Lawless, J.F. (1982, 2003) Statistical Models and Methods for Lifetime Data. John Wiley and Sons, Inc., New York.
2. Meeker, W.Q. and L.A. Escobar (1998) Statistical Methods for Reliability Data, John Wiley & Sons, New York.
3. Rao S.S. (1992) Reliability-based design, McGraw Hill, New York.
4. Zacks, S. (1992). Introduction to Reliability Analysis. Springer-Verlag, U.S.A

Semester VIII Elective Choice 2
IST8EL06-Survival Analysis

Hours per week – 5
Number of credits – 4

Text book:

1. **Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York,**

Module 1

Basic Quantities and Models - Survival function, Hazard function, Mean residual life function and Median life, Common Parametric Models for Survival Data; Censoring and Truncation - Right Censoring, Left or Interval Censoring, Truncation, Likelihood Construction for Censored and Truncated Data (20L)

Module 2

Nonparametric Estimation of a Survivor Function and Quantiles**,** The Product-Limit Estimator, Nelson-Aalen Estimator, Interval Estimation of Survival Probabilities or Quantiles, Asymptotic Properties of Estimators, Descriptive and Diagnostic Plots, Plots Involving Survivor or Cumulative Hazard Functions, Classic Probability Plots, Estimation of Hazard or Density Functions. (22L)

Module 3

Semi-parametric Proportional Hazards Regression with Fixed Covariates - Coding Covariates, Partial Likelihoods for Distinct-Event Time Data, Partial Likelihoods when Ties are present, Local Tests, Discretizing a Continuous Covariate, Model Building using the Proportional Hazards Model, Estimation for the Survival Function; Introduction to Time-Dependent Covariates; Regression Diagnostics :- Cox-Snell Residuals for assessing thefit of a Cox Model, Graphical Checks of the Proportional Hazards Assumption, Deviance Residuals, Checking the Influence of Individual Observations (28L)

Module 4

Inference for Parametric Regression Models - Exponential, Gamma and Weibull Distributions, Nonparametric procedure for comparison of survival function, Competing risk models – Basic Characteristics and Model Specification. (20L)

Reference Books

1. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons
2. Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc.
3. Hosmer Jr. D.W and Lemeshow S (1999) Applied Survival Analysis - Regression Modelling of Time to event Data, John Wiley & Sons. Inc. 3. Nelson. W (1982) Applied Life Data Analysis.
4. Miller, R.G. (1981) Survival Analysis, John Wiley.

Semester IX Core Course-1
IST9CR01-Time Series Analysis & Forecasting

Hours per week –5
Number of credits-4

Textbooks:

1. **Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting Second Edition, Springer-Verlag.**
2. **Box G.E.P, Jenkins G.M. and Reinsel G.C. (2008) Time Series Analysis: Forecasting and Control, Fourth Edition, Wiley.**
3. **Abraham B. and Ledolter J.C. (2005) Statistical Methods for Forecasting, Second Edition Wiley.**

Module 1: Basics on Times Series

Concepts of time series – Components of time series – Additive and multiplicative models for the analysis of time series - Measurement of trend by (i) Graphic method, (ii) Semi Average method, (iii) Method of Curve Fitting by principle of least squares, (iv) Method of Moving Averages, Measurement of Seasonal Variations by (i) Method of simple average, (ii) Ratio- to-trend method, (iii) Ratio-to-Moving Average Method, (iv) Link Relatives method. Measurement of Cyclic variations by residual approach. Random Component of a time series –Variate difference method. Simple Exponential Smoothing, Holt's exponential smoothing, Holt-Winter's exponential smoothing. (25L)

Module 2

Time series as a discrete parameter stochastic process, Auto-covariance and auto-correlation functions, Partial Auto-correlation function and their properties, Stationary processes, Wold representation of linear stationary processes, Detailed study of the Box - Jenkins linear time series models: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average models. (25L)

Module 3

Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes. Choice of AR and MA periods, Forecasting using ARIMA models, Residual analysis and diagnostic checking. Forecasting of future values. Non-Gaussian Time Series Modeling- exponential, gamma and Laplace stationary marginal distributions. (20L)

Module 4

Spectral density of a stationary time series and its elementary properties, Periodogram, Spectral density of AR, MA, ARMA processs. Seasonal ARIMA models, Introduction to ARCH and GARCH models and their applications; non-linear time series models, bilinear models; Multivariate Time Series Analysis and Vector Auto-regression. (20L)

Reference Books

1. Cryer, J. D. and Chan, K. (2008). Time Series Analysis with Applications in R, Second Edition, Springer-Verlag.
2. Shumway, R. H. and Stoffer, D. S. (2011) Time Series Analysis and Its Applications with R Examples, Third Edition, Springer-Verlag.

Semester IX Core Course-2
IST9CR02-Regression Analysis and Econometrics

Hours per week – 5
Number of credits-4

Textbooks :

1. **Montgomery, D.C ; Peck, E.A, Vining, G.G (2003). Introduction to Linear Regression Analysis, John Wiley & Sons**
2. **John O. Rawlings, Sastry G. Pantula, David A. Dickey (1998) Applied Regression Analysis, Second Edition, Springer.**
3. **Damodar N Gujarati, Sangeeth (2007) Basic Econometrics 5th Ed., McGraw Hill Education Private Ltd.**
4. **Johnston J. (1984) Econometric Methods (Third edition), McGraw Hill, New York.**

Module 1

Simple linear regression, assumptions, principle of least squares**,** ordinary, partial and multiple correlation coefficients and their tests, multiple regression, least square estimators, MLEs of parameters, coefficients of determination, tests for regression coefficients, model adequacy checking**,** Residual analysis and residual plots (23L)

Module 2

Tests for departure from assumptions, fitness of the model, normality, homogeneity of variances, detection of outliers and remedies, Diagnostics for Leverage and influence. transformations for variance stabilization, Linearization, power transformations, Transformation on regressor, Generalized least squares and Weighted least squares. (23L)

Module 3

Demand and supply functions, elasticity of demand, equilibrium of market, Cobweb model, Cost Function, Marginal analysis of firms, production functions- elasticity of production, homogeneous functions, indifference curves, Cobb-Douglas Production function, CES production function, input- output analysis-Open and closed system. (20L)

Module 4

Simple linear regression models, Multiple linear regression models, estimation of the model parameters, tests concerning the parameters, confidence intervals, prediction, use of Dummy variables in regression, Errors in variables, polynomial regression models, step-wise regression, Stochastic regressors, Multicollinearity- consequences, Detection, Farrar-Glauber test, remedial measures. Heteroscedasticity- consequences, Detection, tests, remedial measures, Aitken's generalized least square method, Auto-correlation-tests for auto correlation, consequences, and estimation procedures.

(24L)

Reference books:

1. Searle, S.R. (1971) Linear Models, John Wiley & Sons, Inc.
2. Fox, J. (1984) Linear Statistical Models and Related methods, John Wiley, 3.Christensen, R. (2001) Advanced Linear Modeling,.
4. Bovas Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley & Sons.
5. Bapat R.B. (1999) Linear Algebra and Linear Models, Edition 2, Hindustan Book Agency
6. Allen.R.G.D. (2008) Mathematical Analysis For Economists, Aldine Transaction 7.Apte P.G. (1990) Text book of Econometrics, Tata Me Graw Hill.
8.Jeffrey M. Wooldridge (2012) Introductory Econometrics: A Modern Approach 5th Edition, South-Western College Pub.
9. Koutsoyiannis A. (2008) Modern Microeconomics, Second Edition, Macmillan Press Ltd 10.Kutner M. H, Nachtsheim C.J, Neter J and Li W. (2005), Applied Linear Statistical Model,
Fifth edition. McGraw Hill
11. Theil H. (1982) Introduction to the Theory and Practice of Econometrics, John Wiley.
12. Draper, N. and Smith, H. (1986) Applied Regression Analysis – John Wiley & Sons. 13.Seber, A.F. and Lee, A.J. (2003) Linear Regression Analysis, John Wiley,

Semester IX Core Course-3
IST9CR03-Non-Parametric Inference

Hours per week – 5
Number of credits -4

Module 1

Order Statistics and properties, QQ plot. Empirical distribution function and its properties, Glivenko-Cantelli lemma (statement only), Kaplan-Meier estimator. (20L)

Module 2

Testing for Randomness: Run test, Goodness-of fit test; Kolmogorov-Smirnov test, Cramer-von Mises test, Anderson- Darling test, Chi-square test, Shipiro-Wilk test, Jarque-Bera test, Wald Wolfowitz Run Test. (20L)

Module 3

One sample and paired sample procedure; Sign test, Wilcoxon signed rank test, Two and k samples procedures; Mann-Whitney test, Kruskal-Wallis test, Friedmans test, Measure of association; Kendall Tau, Spearman Rho, Re-sampling techniques; Jackknife and Bootstrap.

(25L)

Module 4

Smoothing, Bias variance trade off, Non-parametric regression, Density estimation; Histogram and Kernel density estimation. Practical using R or Python. (25L)

Reference books:

1. J. D. Gibbons, S. Chakraborti, Nonparametric Statistical Inference, Springer, (2003).
2. L. A. Wasserman, All of Nonparametric Statistics, Springer, (2006).
3. M. Hollander, D. A. Wolfe and E. Chicken, Nonparametric Statistical Methods, John Wiley & Sons, (2013).
4. J. Kloke, J. W. McKean, Nonparametric Statistical Methods Using R, CRC Press, (2015).

Semester IX Core Course-4
IST9CR04-Bayesian Inference

Hours per week – 5

Number of credits – 4

Text books:

1. **Jayanta K. Ghosh, Mohan Delampady, Tapas Samanta (1998) An Introduction to Bayesian Analysis -Theory and Methods, Springer**

Module 1: Bayesian Inference and decision theory

Bayesian inference, advantages of being a Bayesian, paradoxes in Classical Statistics, elements of Bayesian decision theory, improper priors, common problems of Bayesian inference, prediction of a future observation, exchangeability, normative and descriptive aspects of Bayesian analysis, elicitation of probability, objective priors and objective Bayesian Analysis, Exercises (23L)

Module 2: Utility, Prior and Bayesian Robustness

Utility, prior and rational preference, utility and loss, rationality axioms leading to the Bayesian approach, Coherence, Bayesian analysis with subjective prior, Robustness and sensitivity, classes of priors, Posterior Robustness: Measures and techniques, Inherently Robust procedures, Loss robustness, model robustness. Exercises. (23L)

Module 3: Choice of priors for Low-dimensional parameters, Hypothesis testing and model selection

Different methods of construction of objective priors, Exercises P-value and posterior probability of H_0 as measures of evidence against the null, Bounds on Bayes factors and posterior probabilities, Bayesian P-value, Robust Bayesian outlier detection, Non-subjective Bayes factors, Exercises (22L)

Module 4: Bayesian computations

Analytic approximation, The E-M Algorithm, Monte Carlo Sampling, Markov Chain Monte Carlo methods. Exercises (22L)

Reference books

1. Hoff, P.D (2009) A first course in Bayesian Statistical Methods, Springer, New york
2. Lee, P (2004) Bayesian Statistics: an Introduction. Oxford University Press, New York.
3. O'Hagan, A and Forster, J. (2004), Bayesian Inference 2nd ed. Edward Arnold, London
4. Robert C.P. and Casella G. (2004) Monte Carlo Statistical Methods (Second edition). Springer, New York

Semester IX Elective
Choice 1
IST9EL05-Statistical Genetics and Ecology

Hours per week – 5
Number of credits-4

Text Books:

1. **Anil Gore & Sharayu Paranjpe (2001). A Course in Mathematical and Statistical Ecology, Kluwer academic Publishers.**
3 **Lange, K (2002). A Course in Mathematical and Statistical Methods for Genetic Analysis, Springer.**
4 **Falconer D.S.(1991) Introduction to Quantitative Genetics, ELBS Logman group.**

Module 1

Basic biological concepts in genetics, Mendel's law**,** The law of natural selection, mutation and genetic drift, Hardy-Weinberg equilibrium, estimation of allele frequency (dominant/co-dominant cases), Approach to equilibrium for X-linked gene. Non-random mating and inbreeding, phenotypic assortative mating.

(21L)

Module 2

Pedigree data: Elston-Stewart algorithm for calculation of likelihood, Linkage, Genetic mapping, Linkage equilibrium, Partitioning of Chi-square, Detection of linkage and estimation of re-combination fraction, inheritance of quantitative traits. (26L)

Module 3

Introduction to ecology and evolution, population dynamics: single species-Exponential, Logistic and Gompertz models, Leslie matrix model for age and stage Structured population, survivorship curves-Constant, monotone and bath tub shaped hazard rates, Two species: Lotka- Volterra equations, isoclines (24L)

Module 4

Abundance estimation: Capture–recapture, Nearest Neighbour, line transect sampling, indirect methods**.** Ecological Diversity: Species abundance curve, indices of diversity (Simpson's index, Shannon-Wiener index), Game theory in ecology – Evolutionarily stable strategy, its properties**,** simple games such as Hawk-Dove game, Prisoner's dilemma. (20L)

Reference Books:

1. Gardner E.J. & Simmons D. P.(2007) Principles of Genetics, John Wiley & Sons Inc.
2. Lange, K (2002). Mathematical and Statistical Methods for Genetic Analysis, Springer. 3.Robert J Booker (2009) Genetics: Analysis & Principles, McGraw-Hill.
4. Robert H Tamarin, (2001) Principles of Genetics, McGraw-Hill

Semester IX-Elective Choice 2

IST9EL06-Artificial Intelligence and Machine Learning

Hours perweek – 5
Number ofcredits -4

Text books:

1. **Kevin Night and Elaine Rich, Nair B., Artificial Intelligence (SIE), Mc Graw Hill-2008**
2. **Jerome Friedman, Trevor Hastie, and Robert Tibshirani (2008) The Elements of Statistical Learning, Springer**

Module 1: Introduction to AI and Production systems

Introduction to AI-Problem formulation, Problem Definition-Production systems, control strategies, search strategies, Problem characteristics, Production system characteristics-specialised production system-Production solving methods-Problem graphs, Matching, Indexing and Heuristic functions-Hill Climbing-Depth first and Breath first, Constraints satisfaction-Related algorithms, Measure of performance and analysis of search algorithms

(22L)

Module 2: Neural networks, Support vector machines and flexible discriminants

Projection pursuit regression, neural networks, fitting neural networks, Some issues in training neural networks, Bayesian neural nets and the NIPS 2003 challenge. Computational considerations. The support vector classifier, support vector machines, Generalizing Linear discriminant analysis, Flexible discriminant analysis, Penalized discriminant analysis, Mixture discriminant analysis (27L)

Module 3: Prototype methods and Unsupervised learning

Prototype methods, Association rules, Cluster analysis, self-organizing maps, principal components, curves and surfaces, Non-negative matrix factorization, Independent component analysis and exploratory Projection persuit, multidimensional scaling, nonlinear dimension reduction and local multidimensional scaling, the google page rank algorithm. (22L)

Module 4: Ensemble Learning, Random forests

Boosting and regularization paths, learning ensembles, definition of random forests, details of random forests, Analysis of random forests

(18L)

Reference books

1.Christopher M. Bishop (2006) Pattern Recognition and Machine Learning, Springer
2.Richard O. Duda, Peter E. Hart and David G. Stork (2006) Pattern Classification, Second
edition, Wiley
3. Shai Shalev-Shwartz and Shai Ben David (2017) Understanding Machine Learning, Cambridge University Press
4. Tom M. Mitchell (1997) Machine Learning, McGraw-Hill
5. Dan W. Patterson (2007) Introduction to AI and ES, Pearson Education
6. Deepak Khemani (2013) Artificial Intelligence, Tata Mc Graw Hill Education

Semester X

ISTXPR01 Project (Major)

Hours per week – 25
Number of credits-16

ISTXVV02- Comprehensive Viva Voce

Number of credits -4

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INTEGRATED M.Sc. DEGREE PROGRAMME
COMPLEMENTARY (MATHEMATICS) COURSE TO INTEGRATED M.Sc. STATISTICS

THIRD SEMESTER IST3CM04 – MATHEMATICS III
VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND LAPLACE TRANSFORM

Hours per week – 5
Number of credits -4

Text Book:

1. A Text Book of Engineering Mathematics- N.P.Bali, Dr. N. Ch. Narayana Iyengar, Laxmi Publications(P)Ltd.

Module 1: Vector Calculus (25 L)

A quick review of Vector Algebra, Inner Product and Vector Product in R^2 And R^3. Vector and Scalar Functions and Fields, Derivatives, Velocity and Acceleration, Gradient of a Scalar Field; Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.

Text 1: Chapter 8: Sections 8.1 - 8.5, 8.7, 8.9 - 8.11, 8.13 - 8.16.

Module 2: Ordinary Differential Equations of First Order (30L)

Introduction to Differential Equations, Solutions of First Order Differential Equations, Variable Separable, Homogeneous Equations, Equations Reducible to Homogeneous, Linear Differential Equations, Bernoulli's Equations, Exact Equations(Theorem 11.11 Statement only),Equations Reducible to Exact Form.

Text 1: Chapter 11: Sections 11.1,11.4 - 11.12.

Module 3: Partial Differential Equations (20L)

Introduction, Formation of Partial Differential Equations, Linear Partial Differential Equations of the First Order, Lagrange's Equation, and its Working Method.

Text 1: Chapter 16 Sections 16.1 - 16.2, 16.5 - 16.7

Module 4: Laplace Transform (15L)

Introduction, Definition, Linearity Property, Laplace Transform of Some Elementary Functions, Shifting Theorems and the Inverse Laplace Transform.

Text 1: Chapter 18: Section 18.1 - 18.6

Reference Books:

1. Erwin Kreyszig- Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

2. Shanti Narayan , P .K . Mittal :Vector Calculus (S. Chand & Company)

3. Murray : Differential Equations (Macmillan)

INTEGRATED M.Sc. DEGREE PROGRAMME
COMPLEMENTARY (MATHEMATICS) COURSE TO INTEGRATED M.Sc. STATISTICS

FOURTH SEMESTER IST4CM04 MATHEMATICS IV -
LINEAR ALGEBRA, THEORY OF EQUATIONS, SPECIAL FUNCTIONS, NUMERICAL METHODS

Hours per week – 5
Number of credits -4

Text Book:

1. S. Blyth And E. F. Robertson : Basic Linear Algebra, Springer, Second Ed. (2002)
2. A Text Book Of Engineering Mathematics- N.P.Bali, Dr.N.Ch.Narayana Iyengar. Laxmi Publications (P) Ltd.

Module 1: Linear Algebra (30L)

Elementary Matrices, The Process Of Gaussian Elimination, Hermite Or Reduced Row-echelon Matrices. Linear Combinations Of Rows (Columns), Linear Independence Of Columns, Row Equivalent Matrices, Rank Of A Matrix, Column Rank, Normal Form, Consistent Systems Of Equations.

Eigenvalues And Eigenvectors, Characteristic Equation, Algebraic Multiplicities, Eigen Space, Geometric Multiplicities, Eigenvector, Diagonalisation.

Text 1: Chapter 3, Chapter 9.

Module 2: Theory Of Equations (20 L)

Statement Of Fundamental Theorem Of Algebra, Relation Between Roots And Coefficients, Transformation Of Equations, Reciprocal Equations, Descarte's Rule Of Signs And Cardon's Method.

Text 2: Chapter 2 Sections 2.1 - 2.14, 2.16 - 2.18.

.**Module 3: Special Functions (12L)**

Beta And Gamma Functions, Reduction Formula For Gamma function, Relation Between Beta And Gamma Functions, To integrate sinp x cosq x.
Text 2: Chapter 15 Sections 15.1 - 15.7.

Module 4: Numerical Methods (28L)

The forward difference operator, Backward difference operator, Shift operator, Central difference operator, Relations between the operators, Newton's formulae for Interpolation, Lagrange's formula for unequal intervals. Numerical Differentiation.

Text 2: Chapter 22 Sections 22.1 - 22.8, 22.10.

Reference Books:

1. Kenneth Hoffman, Ray Kunze-linear Algebra (Second Edition) Prentice-hall India

2. Richard Bronson, Gabriel B. Costa - Linear Algebra An Introduction (Second Edition), Academic Press 2009, An Imprint Of Elsevier.

3. David C Lay: Linear Algebra, Pearson

4. . Erwin Kreyszig- Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

INTEGRATED M. Sc STATISTICS - COMPLEMENTARY (COMPUTER SCIENCE)
THIRD SEMESTER IST3CM05 – COMPUTER SCIENCE III
WEB TECHNOLOGY

Hours per Week : Theory – 3 **Credits : 3**

Course Objectives

1. To enable students to program for the World Wide Web using HTML and CSS.

2. To create web pages using HTML and CSS.

3.To know about internet technologies

Module -1:

Introduction to internet and web, An overview of internet programming –WWW design issues. Introduction to HTML-structure of HTML, tags, attributes, syntax of tags ,starting and ending tags, html doc elements-<html>,<title>,<body>,physical style tags ,listing, labeling, grouping, <img>-<a>

Module-2:

Table tags-<tr>,<td>,<th> attributes-height, width, rowspan, colspan, border, color.
Form- tagattributes-type-passwd, submit, radio, check, method, action. Frame-<frame>,<frameset>, <iframe>,<noframe> and other important tags and attributes.
Module -3:
Style sheets : Need for CSS, introduction to CSS, basic syntax and structure, using CSS, background images, colors and properties, manipulating texts, using fonts borders and boxes, margins, padding lists .

Module -4:

Internet as a network infrastructure : The Internet Today, The Future Infrastructure, The Intranet-Definition, Application of Intranet. The Extranet - Definition, Application of Intranet. Introduction to Email, Common Email Features, Google and its features(Google Drive, Google Docs, Google Forms, Google Sheets, Google Hangouts)

Text Books:

1.HTML-Definitive Guide O'reilley

References :

1. Steven Holzner,"HTML Black Book", Dremtech press.
2. Web Technologies, Black Book, Dreamtech Press
3. Web Applications : Concepts and Real World Design, Knuckles, Wiley-India
4. Internet and World Wide Web How to program, P.J. Deitel & H.M. Deitel Pearson.
5. Complete reference HTML-Tata McGraw Hill
6. Minoli and Minol, "Web Commerce Technology Handbook", TMH New Delhi.
7. Schneider Gary P, "Electronic Commerce- course Technology, Delhi.
8. Google Apps Express: The Fast Way to Start Working in the Cloud by James Beswick

9. Google In Your Classroom: A Guide to Google Apps and Chromebook for Teachers by Scott La Counte
10. Google Apps Made Easy: Learn to work in the cloud (Computers Made Easy) by James Bernstein

Software Lab III

Hours per week: Practical - 2

Web Technology Lab

1. Develop an HTML page using all basic tags

2. Develop an HTML page containing all types of lists

3. Write an HTML code to insert an image into the web page. Use the attributes height, width andborder. Also align some text with respect to the images

4. Create a web page giving the following train details in a tabular form with the heading Train Time Table.

- Train name, starting place, destination, arrival and departure time and fare

6. Create an HTML page with images. Clicking on the images should lead to external documents.

8. Create a web page for your college using frames, images and hyper links

9. Create an email registration form. Give necessary validations

10.Develop an HTML page that accepts any mathematical expression, evaluates that expression and display the result of the evaluation

11.Design a web page of your home town with an attractive background color, text

12.color, an Image, font etc. (use internal CSS).

13. Use Inline CSS to format your resume that you created.

14. Use External CSS to format your class timetable as you created.

15. Use External, Internal, and Inline CSS to format college web page that you

created.

16. Creating Email Account and Sending Email with file Attachment

17.Create Google Forms

18. Create Google Sheets

19.Create Google Docs

INTEGRATED M. Sc STATISTICS - COMPLEMENTARY (COMPUTER SCIENCE)
FOURTH SEMESTER IST4CM05 – COMPUTER SCIENCE IV
PYTHON PROGRAMMING

Hours per Week: Theory – 3 **Credits : 3**

Course Objectives

1. To know the basics of algorithmic problem solving
2. Demonstrate the use of built-in objects of Python
3. Demonstrate significant experience with python program development environment
4. Implement numerical programming, data handling and visualization through NumPy and Pandas

Unit I

Algorithmic Problem Solving : Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation(pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms

Unit-II

Introduction to Python: Structure of Python Program-Underlying mechanism of Module Execution-Branching and Looping-Problem Solving Using Branches and Loops-Functions - Lists and Mutability- Problem Solving Using Lists and Functions

Unit-III

Sequence Datatypes and Object-Oriented Programming :Sequences, Mapping and Sets-Dictionaries- -Classes: Classes and Instances-Inheritance- Exceptional Handling-Introduction to Regular Expressions using “re” module.

Unit-IV

Basics of NumPy-Computation on NumPy-Aggregations-Computation on Arrays- Comparisons, Masks and Boolean Arrays-Fancy Indexing-Sorting Arrays-Structured Data: NumPy’s Structured Array.
Data Manipulation with Pandas :Introduction to Pandas Objects-Data indexing and Selection-Operating on Data in Pandas- Handling Missing Data-Hierarchical Indexing - Combining Data Sets

Text Books :

[1] Jake VanderPlas ,Python Data Science Handbook - Essential Tools for Working with Data, O’Reily Media,Inc, 2016

[2]. Zhang.Y ,An Introduction to Python and Computer Programming, Springer Publications,2016

References

1. JoelGrus,DataSciencefromScratchFirstPrincipleswithPython,O’ReillyMedia,2016
2. T.R.Padmanabhan, Programming with Python,SpringerPublications,2016

3. Allen B. Downey, ``Think Python: How to Think Like a Computer Scientist'', 2nd edition,
4. Updated for Python 3, Shroff/O'Reilly Publishers, 2016 (http://greenteapress.com/wp/think- python/)
5. Guido van Rossum and Fred L. Drake Jr, "An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.

Software Lab IV **Hours :2**

1. Write the Python code to Print Hello World.
2. Write the Python code for Adding Two Numbers.
3. Write the Python code to find the Area of Triangle.
4. Write the Python code to check the leap year.
5. Write the Python code to find the ASCII key value of the characters.
6. Write the Python code to Convert Decimal to Binary.
7. Write the Python code to check whether the given number is Odd or Even.
8. Write the Python code to find the Area of Rectangle and Circle.
9. Write the Python code to find the Square root of a number.
10. Write the Python code to find the Fibonacci Serious.
11. Demonstrate usage of branching and looping statements
12. Demonstrate Recursive functions
13. Demonstrate Lists Lab Exercises
14. Demonstrate Tuples and Sets
15. Demonstrate Dictionaries
16. Demonstrate inheritance and exceptional handling
17. Demonstrate use of "re"
18. Demonstrate Aggregation
19. Demonstrate Indexing and Sorting
20. Demonstrate handling of missing data
21. Demonstrate hierarchical indexing

IST4CMP06 Computer Practical II : Credit : 2

INTEGRATED M. Sc STATISTICS – COMMON COURSE (ENGLISH) FOURTH SEMESTER IEN4CC01 – ENGLISH II- ENGLISH LANGUAGE SKILLS FOR ACADEMIC PURPOSES

Name of the Course	***English Language Skills for Academic Purposes***
Course Code	IEN4CCO1
Semester	4
Number of credits	4
Number of contact hours	90

Course Objectives:

This course seeks to develop the basic language skills of the students. The course attempts to give the students training in writing and speaking skills.

Course Description:

The course explores areas like writing and speaking skills. The course attempt to give the students training in the vocabulary and grammar. This course will equip the students to communicate effectively in English both in writing and speaking.

Module 1: Vocabulary and Grammar Section (36 HOURS)

Word Formation
Tenses
Concord
The passive Voice

Module 2: Writing Skills (36 HOURS)

Paragraph Writing
Email
Picture Description
Story Writing

Module 3: Speaking Skills (18 HOURS)

Day to Day Conversations
Oral Presentation Skills
Narrating a story

Core text

English Language Skills For Academic Purposes: A Text Book for College Students