1. Introduction

Central Department of Statistics (CDS) shifted the M. Sc. / M. A. course of Statistics from annual system to semester system in 2012. The course was revised in 2015 mainly to maintain the uniformity among departments as regards to the allocation of total credits for the program and evaluation scheme, and also keeping in view of the international norms of the semester system. A considerable period of time has elapsed since the revision was made. At present, the need to revise and upgradation of the course was felt to address the current situation and international trends regarding the course contents of Statistics at Master level. Therefore, the course contents of the program have been re-designed, developed and revised thoroughly with the participation of concerned subject experts including external experts and faculty members of the Department. It consists of the core papers, optional papers, computer based statistical computing (practical) papers and dissertation. Some additional courses namely R programming language, Python programming, statistical simulation, etc. have been added to make it relatively more relevant in the present context. The designed course has incorporated and balanced between theoretical and applied aspects of Statistics as far as possible and practicable. The proposed revised course comprises of 67 credits (1675 marks) spread over two academic years equivalent to four semesters.

The re-structured syllabus for the M. Sc. / M. A. in Statistics in Semester System with major changes is forwarded to the Dean's Office, Institute of Science and Technology (IOST), Tribhuvan University (TU) for its approval.

1.1 Enrolment Quota

Considering the available laboratory space and its holding capacity, the Department has decided to fix quota for the number of students for enrolment in each batch. A maximum of eighty students will be admitted in M.Sc. / M. A. in each batch of semester system. The admission of the students will be made on the merit basis through entrance examination and as per the rules and regulations of TU.

1.2 Eligibility for Student Intake

Students for the semester system will be enrolled based upon the rules and regulations laid down by TU. Students having a Bachelor Degree in Statistics or equivalent degree recognized by TU are eligible to apply for admission in Semester System M. Sc. / M. A. in Statistics program. Each applicant must appear and pass entrance examination conducted by the Central Department of Statistics, IOST. Admission will be made in the merit basis of the entrance examination. Applicants with below cut-off point can be disqualified from enrollment.

1.3 Working Days and Class Duration

A. **Working Days**

Total number of working days for a semester will be 96 days equivalent to16 weeks.

B. **Class Duration**

- **Theory Paper**

  One credit will be equivalent to 16 teaching hours for theoretical papers in each semester. Consequently, theory papers of three credits will have three lecture hours per week totaling to 48 lecture hours.

- **Statistical Computing (Practical) Paper**

  1 practical class hour = 3 theory hours

  22 practical class hour = 4 credits

A computing paper of 4 credits will have 21-23 practical days in each semester. For Statistical Computing classes, groups of students will be formed having no more than 20 students in each group if the number of students exceeds 20. Three teachers (and/or instructors) will be allotted to instruct students simultaneously in each computing classes of each semester.

1.4 Dissertation and its Alternatives

Dissertation is not mandatory to all students. The department will provide rules and criteria for the selection of students for dissertation. It will be of 6 credits and is allocated in fourth semester. The department will provide its orientation within the first two weeks from the date of the commencement of the fourth semester. The duration of the dissertation work will be of 96 working days after the completion of orientation. A single student will be facilitated by one supervisor with 1 hour of assistance/ supervision per week. Provision of the co- supervisor is also applicable, if necessary. Regarding an alternative option to the dissertation work, students will have to take three theory papers of 2 credits each. The details of whichare given in the syllabus.

1.5 Completion of Dissertation

Dissertation should be completed within 3 months after the end of the fourth semester to beregarded as a regular student.

2. Course Structure

The program is divided into four semesters (six months per semester) with a total duration of 2 years. The program contains 13 core courses, 4 optional courses, 3 computing (practical) courses, dissertation and three additional courses as an alternative option for dissertation. The distribution of courses in different semesters is shown below.

Table 1: Distribution of Courses

Semester	Nature of the Course					Total Courses		Total Credit	Total Marks
	Core Theory	Optional Theory	Statistical Computing (Practical)	Dissertation or Alternative Papers		Option A	Option B		
				Dissertation (Option A)	Alternative Paper (Option B)				
1^{st}	6	0	1	0	0	7	7	21	525
2^{nd}	4	2	1	0	0	7	7	21	525
3^{rd}	3	2	1	0	0	6	6	19	475
4^{th}	0	0	0	1	3	1	3	6	150
Total Papers	13	4	3	1	3	21	23		
Total Credit	37	12	12	6				67	
Total Marks	925	300	300	150					1675

The details of the program as regards to the distribution of subjects, credit hours, and marks in different semesters are shown in the following table. In total there are 67credits (49 credits for theoretical papers,12 credits for computing papers, and 6 credits for dissertation or additional exam-based papers with 1675 marks in total allocated in the program.

Table 2: Course Structure

SN	Subject	Code	Credit	Marks
First Semester				
1.	Mathematics for Statistics	STA 511	3	75
2.	Probability	STA 512	3	75
3.	Statistical Inference	STA 513	3	75
4.	Mathematical Demography	STA 514	3	75
5.	Sampling Theory	STA 515	3	75
6.	R Programming Language	STA 516	2	50
7.	Statistical Computing-I	STA 517	4	100
	Total		**21**	**525**
Second Semester				
8.	Multivariate Analysis	STA 521	3	75
9.	Stochastic Processes	STA 522	3	75
10.	Statistical Simulation	STA 523	3	75
11.	Python Programming	STA 524	2	50
12.	Optional Paper (Any Two)		3×2 = 6	150
i.	Econometrics	STA 525		
ii.	Quality Control and Reliability	STA 526		
iii.	Operations Research	STA 527		
iv.	Nonparametric Statistics	STA 528		
13.	Statistical Computing-II	STA 529	4	100
	Total		**21**	**525**
Third Semester				
14.	Bayesian Inference	STA 631	3	75
15.	Research Methodology	STA 632	3	75
16.	Design of Experiments	STA 633	3	75
17.	Optional Paper (Any Two)		3×2 = 6	150
i.	Biostatistics	STA 634		
ii.	Environmetrics	STA 635		
iii.	Time Series Analysis	STA 636		
iv.	Actuarial Statistics	STA 637		
v.	Survival Analysis	STA 638		
18.	Statistical Computing-III	STA 639	4	100
	Total		**19**	**475**
Fourth Semester				
Any one between Dissertation and three Alternative papers				
19.	Dissertation	STA 641	6	150
20.	Alternative Papers (2 credit each, Any Three)			
i.	Meta-analysis	STA 642	2×3 = 6	150
ii.	Nonparametric Modeling	STA 643		
iii.	Population and Financial Statistics	STA 644		
iv.	Geographical Information System	STA 645		
v.	Machine Learning	STA 646		
	Total		**6**	**150**
	Grand Total		**67**	**1675**

3. Course Details

First Semester

Course Title: Mathematics for Statistics **Full Marks: 75**
Course Code: STA 511 **Pass Marks: 37.5**
Nature: Theory **Total Credits: 3**
Semester: First **Total Lecture Hours: 48**

Course Description

This course covers fundamental concepts and techniques in numerical analysis and real analysis which are useful for statistical analysis. It includes numerical techniques for solving equations to find roots, interpolation, and integration. It also provides the knowledge related to real analysis, including sequences, series, integration, and functions of multiple variables. Emphasis will be given on understanding the principles behind these methods, their geometrical interpretation and their applications in various mathematical contexts.

Learning Outcomes

After completion of this course, the students will be able to

- understand and apply various method of finding a root of an equation,
- be familiar with different methods finding a function for a set of data,
- find an approximate integral by using different methods,
- check the convergence of various series,
- understand the different theorems related integral and multiple integral,
- find the extreme values of the function of several variables.

UNIT 1: Numerical Analysis [18 LH]

Finding a Root: Algebraic and Transcendental Equations, Bisection method, Secant method, Fixed point Iteration method, Newton Raphson method, geometric interpretation of Bisection and Secant Method

Finding a Function: Interpolation and Extrapolation: Finite differences (forward, backward and central), Newton's formula for interpolation (forward, backward) and its application, Lagrange's interpolation formula

Finding an Integral: General formula for numerical differentiation and integration, Trapezoidal rule, Simpson's 1/3 and 3/8 rules, their application, Ordinary Differential Equations**:** Solution of Taylor's series, Picard's method, Euler's method, Runge- Kutta method

UNIT 2: Real Analysis [30 LH]

Sequences and Series: Sequences and series of functions, Point wise and uniform convergence, Cauchy general principle of convergence for sequence, Limit superior and limit inferior.

Power series: Radius of convergence, Convergence of power series, applications

Fourier series: Periodic function and its properties, Sum of Fourier series, Fourier series of even and odd functions, applications

Integration: Review of Riemann integral, Riemann-Stieltjes integral, Condition of integrability, Mean value theorem, Integration by parts, Improper Integral, Convergence of improper integrals, Convergence of Beta and Gamma function

Function of several variables: Definition of Limit &Continuity, Partial Derivative, Euler's Theorem, Jacobian, Maxima and Minima, Multiple integral, Dirichlet's theorem, Liouville's expansion to Dirichlet's theorem, Parametric integration

References

1. Apostol, T. M. (2002). *Mathematical analysis*. Narosa Publishing House.
2. Bartlett, R. G., & Sherbet, D.R. (1994). *Introduction to real analysis*. John Wiley and Sons.
3. Chatterjee, D. (2005). *Real analysis*. Prentice-Hall of India.
4. Malik, S. C., & Arora, S. (1992). *Mathematical analysis*. New Age International.
5. Sastri, S. S. (2003). *Introductory methods of numerical analysis*. Prentice-Hall of India.

Course Title: Probability **Full Marks: 75**
Course Code: STA 512 **Pass Marks: 37.5**
Nature: Theory **Total Credits: 3**
Semester: First **Total Lecture Hours: 48**

Course Description

This course explores into probability theory through a measure-theoretic approach, covering fundamental concepts like field, sigma field and Borel field. It covers key aspects like discrete and continuous random variables and its probability distributions and expectations. It also discusses on different probability space, distribution functions, cumulative distribution functions, quintile functions, and characteristic functions. Additionally, the course focuses on theoretical aspects and applications of different advanced level probability distributions such as multinomial distribution, generalized power series distributions, distribution of order statistics, some non-central distributions, extreme value distribution, compound probability distributions, prior and posterior distributions, mixed-type distributions, and some inverse distributions.

Learning Outcomes

After completion of this course, the students will be able to

- understand the concepts related to class of sets such as fields, sigma fields, Borel fields, measure theory of probability, and solve related problems,
- apply key concepts of probability, including discrete and continuous random variables, probability distributions, conditioning, independence, expectations, and variances,
- know the tools to describe a random variable, such as the probability density function, the cumulative distribution function, the quintile function and the characteristic function,
- be equipped with a solid theoretical understanding and practical skills related to multinomial distribution and the generalized power series distribution,
- demonstrate a comprehensive understanding of distribution of order statistics and non-central chi-square, t and f distribution,
- understand and apply concepts related to extreme value distributions, compound probability distributions, prior and posterior distributions, mixed-type distributions, and some inverse distributions in real-world scenarios.

UNIT 1: Sets, Fields, Measure and Random Variable [10 LH]

Limit and field: Event, algebra of sets, limit of sequence of sets, limit superior and limit inferior, field, Sigma field, minimal field, monotone field, Borel field

Function, measure and random variable: definition of function, set function, inverse function, measure, measure space and measurable function, probability measure, random variable

UNIT 2: Probability Space, Functions and Expectation [12 LH]

Probability Space: Axiomatic definition of probability, properties of probability measure including monotonicity and continuity, types of probability space -discrete, finite, countable and general probability spaces with examples

Conditional Probability Space: Conditional probability measure and independence of events, Distribution Function: Definition and its properties, continuous, discrete and mixed distribution functions, decomposition theorem, distribution function of random vectors

Quantile functions: Definition and their properties, quantile functions as random variables and their distribution functions

Expectation: Definition, existence and finiteness of expectations, expectation in univariate and multivariate distributions and independent random variables, conditional expectation, expectation of linear combinations, relation between expectation and cumulative distribution function

Characteristic function: definition and its properties, inversion formula and uniqueness theorem, examples of use of inversion formula

UNIT 3: Discrete Distribution [6 LH]

Multinomial Distribution: Probability mass function, moment generating and characteristic function, moments, covariance and correlation, distribution fitting and examples

Generalized Power Series Distribution: Unified PMF, its special cases (binomial, Poisson, negative binomial)

UNIT 4: Continuous Distribution [8 LH]

Extreme Value Distributions: Concept of extreme value distribution and generalized extreme value distribution, Gumbel Distribution, Fréchet Distribution and Weibull Distribution - Probability densities and distribution functions, moments, properties, examples and applications

Inverse Gamma Distribution and Inverse Gaussian Distribution: Concept, Density function, distribution function, moments, examples and applications

UNIT 5: Sampling Distribution [6 LH]

Distribution of Order Statistics: Distribution of kth order statistics, joint and marginal distributions of order statistics, distribution of sample median, sample range, maximum values and minimum values, problems and examples

Sampling Distributions of Statistics: Non-central chi-square, non-central t and F distribution, and their general features

UNIT 6: Some other Probability Distributions [6 LH]

Compound Probability Distribution: Concept, density function, distribution function, mean and variance, compound negative exponential distribution and its moments

Prior and Posterior Distributions: Concept, examples including cases binomial, poison and normal likelihood

Mixed Type Distribution: Mixed random variable, meaning and examples, computation of moments of mixed random variables

References

1. Bhat, B. R. (1999). *Modern probability theory - An introductory textbook* (3rd ed.). New Age International.
2. Biswas, S. (1991). *Topics in statistical methodology*. Wiley Eastern Limited.
3. Bolstad, W. M. (2007). *Introduction to Bayesian statistics.* John Wiley & Sons, Inc.
4. Hoel, P.G., Port, S. C., & Stone, C.J. (1971). *Introduction to probability theory.* Houghton Mifflin Company.
5. Hogg, R.V., & Tanis, E. A. (2001): *Probability and statistical inference.* Pearson Education.
6. Johnson N. L., Kotz S., & Balakrishnan N. (1994). *Continuous univariate distributions, volume I* (2nd ed.). John Wiley.
7. Johnson N.L, Kotz S., & Balakrishnan N. (1995). *Continuous univariate distributions, volume II* (2nd ed.). John Wiley.
8. Krishnamoorthy, K. (2016). *Handbook of statistical distributions with applications* (2nd ed.). CRC Press.
9. Meyer, P. L. (1970). *Introductory probability and statistical applications.* Addison-Wesley.
10. Rohatgi, V. K., & Saleh, A. K. M. E. (2015). *An introduction to probability and statistics*(3rd ed.). John Wiley & Sons, Inc.

Course Title: Statistical Inference | **Full Marks:75**
Course Code: STA 513 | **Pass Marks: 37.5**
Nature: Theory | **Total Credits: 3**
Semester: First | **Total Lecture Hours: 48**

Course Description

Statistical Inference course is designed to equip students with the theoretical and applied foundation of statistical methods as estimation, testing of hypothesis and interval estimation. This course explores both point estimation and interval estimation methods, equipping students with the theoretical knowledge and practical skills to make informed estimates and draw meaningful conclusions. Hypothesis testing is a fundamental aspect of statistical analysis, allowing students to make informed decisions based on sample data. This unit covers the theoretical foundations of hypothesis testing, various test statistics, and practical applications

Learning Outcomes

After completion of the course the students will be able to

- apply point estimation methods, including the method of moments and maximum likelihood estimation. Evaluate the properties of maximum likelihood estimators,
- construct confidence intervals and shortest length CI for population parameters, such as the mean, proportion, and variance,
- conduct hypothesis tests for one-sample situations, including tests for means and proportions,
- understand the principles of matched pairs and independent samples. Carry out likelihood ratio test for composite hypothesis.

UNIT 1: Estimation [12 LH]

Minimal sufficient statistics, completeness, exponential families and complete statistics, Fisher information for one and several parameters, necessary and sufficient conditions for Minimum Variance Unbiased Estimator (MVUE), Locally MVUE, Uniformly MVUE (with Proof), lower bound to variance of estimators, information inequality, Consistent Asymptotic Normal (CAN) estimator

Method of estimation, maximum likelihood estimation with application to standard statistical distributions (with alternative methods), asymptotic properties of maximum likelihood estimator (MLE is sufficient, consistent and efficient with proof), moment matching estimator

UNIT 2: Interval Estimation [13 LH]

Method of finding interval estimators by pivotal approach, confidence interval for difference between population mean by pivotal approach, confidence interval for population proportion and recovery of population proportion appears at the end point of inequality, confidence intervals for matched pair differences

Confidence interval for large samples based of central limit theorem, central and non-central confidence interval, construction of shortest expected length confidence interval, shortest length confidence interval for Normal, Gamma, Beta and Uniform distribution, Uniformly Most Accurate Unbiased confidence sets

UNIT 3: Testing of Hypothesis [11 LH]

Concept of composite hypothesis, one sided and two-sided composite alternative hypothesis, families of distribution with monotonic likelihood ratio, Uniformly Most Powerful (UMP) test, UMP test via Neymann Pearson's Lemma, UMP test via monotonic likelihood ratio, UMP test application to standard statistical distribution, unbiased test, UMP unbiased test

UNIT 4: Likelihood Ratio Test [12 LH]

Likelihood ratio test with derivation, derivation of likelihood ratio test for testing mean and variance in exponential families with one sample and two samples problem, Comparing the means: the partial difference t method, Likelihood ratio test for the correlation coefficient, Test for the variances, Behren's Fisher problem, Asymptotic properties of likelihood ratio test

References

1. Casella, G., & Berger R.L, (2002) *Statistical inference* (2nd ed.). Cengage Learning India Private Limited.
2. Hoel, Port, & Stone (1971) *Introduction to probability theory*. Houghton Mifflin Company.
3. Hogg R.V., & Criag A. T, (1978) *Introduction to mathematical statistics* (3rd ed.), Academic Press.
4. Rohatgi, V. K., & Saleh, A. K. Md. E. (2005) *An Introduction to probability and statistics* (2nd ed.) John Wiley.
5. Hogg, R.V., Tanis E. A., & Zimmerman D.L (2015) *Probability and statistical inference* (9th ed.). Pearson's Education.
6. Mukhopadhyay, N. (2006) *Probability and statistical inference*. CRC Press.
7. Kale, B. K. (1999). *A first course on parametric inference*. Narosa Publishing House.
8. Lehmann E. L. (1986). *Theory of point estimation*. John Wiley and Sons.
9. Lehmann E. L. (1986). *Testing statistical hypotheses*. John Wiley and Sons.

Course Title: Mathematical Demography | **Full Marks: 75**
Course Code: STA 514 | **Pass Marks: 37.5**
Nature: Theory | **Total Credits: 3**
Semester: First | **Total Lecture Hours: 48**

Course Description

This course broadly introduces the science of demography starting from the study of age distribution to indirect techniques of demographic estimation. The course is organized by comprising different facets of demography like migration, marital rate, nuptiality models, fertility models, and some indirect techniques for measuring fertility and mortality levels.

Learning Outcomes

After the completion of the course, students will be able to

- know the basic features of age distribution and execute the necessary adjustments in the reported age data,
- execute measures of migration using direct and indirect methods along with the fundamentals of migration,
- understand and derive the marital rate, nuptiality models, and fertility models with underlying theoretical concepts,
- recognize the importance of indirect techniques in demographic estimation and computation of some demographic indicators using such methods.

UNIT 1: Age Distribution [5 LH]

Sources of errors in age statement, population pyramid, ageing index, age adjustment: method of parabola, adjustment of error in age group 0-4 years, adjustment of error in age group 5-9 years, adjustment of error in the age group 75 and above

UNIT 2: Migration [9 LH]

Background, causes of migration, Neo-Marxist theory, migration in Nepal, measurement of migration: Direct methods (based on birthplace, based on place of residence, based on the duration of residence, based on residence on a fixed prior data), Indirect methods (residue method, survival ratio method, net migration of children, national growth rate method, net reproduction method), population redistribution with reference of Nepal

UNIT 3: Marital Rate [6 LH]

Risk for first marriage in demographic sense, measuring singulate mean age at marriage (SMAM): Hajnal method, cohort method, stable population method, Van de Walle method

UNIT 4: Nuptiality Models **[4 LH]**

Nuptiality and its trends in Nepal, models for the assessment of nuptiality; Coale's Gompertz curve, Coale and McNeil's extension of Gompertz curve, T. James Trussell's extension of Gompertz curve

UNIT 5: Fertility Models **[5 LH]**

Fertility levels and its status in Nepal, some fertility models; Parabolic model, Gompertz model, Coale and Trussell's model, Brass model

UNIT 6: Indirect Techniques in Measuring Fertility Levels [**12 LH]**

Requirement of indirect techniques, nature of data on children ever born (CEB), errors in fertility data, El-Badry correction for the data on CEB, estimation of ever-fertile women, estimation of number of women with known parity, Coale- Demeny's method of estimation of total fertility rate, adjustment of ASFR: Brass's P/F method and Coale- Trussell's method, comparing period fertility rates with a hypothetical cohort, Estimation of age-specific fertility from the increment of cohort parities between two surveys; cohort parity increment method, Estimation of birth rates and death rates from stable population model; ten years survival ratio method

UNIT 7: Indirect Techniques in Measuring Mortality Levels **[7 LH]**

Brass's method of estimation of infant and child mortality, ten-year survivorship method for estimation of death rates from stable population, indirect method of estimation of IMR, James M. Cann's method of estimation of life expectancy at birth, Vig's relation between life expectancy at birth and death rates

References

1. Siegel, J. S., & Swanson, D. A. (Eds.). (2004). *The methods and materials of demography* (2nd ed.). Elsevier Academic Press.
2. Cox, P. R. (1976). *Demography* (5th ed.). Cambridge University Press.
3. Preston, S. H., Heuveline, P., & Guillot, M. (2001). *Demography: Measuring and modeling population processes*. Blackwell Publishing.
4. Weinstein, J., & Pillai, V. K. (2015). *Demography: The science of population* (2nd ed.). Rowman & Littlefield.
5. United Nations (1983). *Indirect techniques for demographic estimation (Manual X).*
6. Bhende, A., & Kanitkar, T. (2006). *Principles of population studies*. Himalaya Publishing House.
7. Singh, M. L., & Sayami, S. B. (1997). *An introduction to mathematical demography*.

Course Title: Sampling Theory | **Full Marks: 75**
Course Code: STA 515 | **Pass Marks: 37.5**
Nature: Theory | **Credits: 3**
Semester: First | **Total Lecture Hours: 48**

Course Description

The course is designed to impart knowledge on random sampling methods used widely in sample surveys. Specifically, the course includes techniques adopted in multivariate ratio method of estimation, super population, cluster sampling, multistage sampling, double sampling, sampling methods in complex surveys and variance estimation.

Learning Outcome

After completion of the course the students will be able to

- apply sampling methods in order to execute sample surveys with theoretical understanding,
- use specific sampling methods namely cluster sampling, multistage and multiphase sampling in sampling-based studies,
- perform computational works related to estimation of parameters, sampling errors and related statistics,
- design and execute sampling design suitable for a specific sample survey.

UNIT1: Ratio Estimator [8 LH]

Concept of multivariate ratio estimator, multivariate ratio estimator for two auxiliary variables, comparison of multivariate ratio estimators with customary ratio estimator having single auxiliary variable and with simple random sampling without replacement, combined and separate ratio estimators, product estimator

UNIT 2: Cluster Sampling [12 LH]

Cluster sampling of equal cluster size, estimation of population mean, total, variance of mean and total, efficiency of cluster sampling with respect to SRS, comparison with stratified random sampling, intra-cluster correlation coefficient, estimation of optimum cluster size

Cluster sampling of unequal cluster size: Probability proportional to size (PPS) sampling, PPS sampling with and without replacement: Estimation of population mean, total and their variances, gain in efficiency, Hansen-Hurwitz estimator, Horvitz Thompson estimator and estimation of variance, Yates and Grundy estimator of variance, illustrative examples of estimating population mean, total and standard error

UNIT 3: Sub-Sampling [8 LH]

Concept of sub-sampling, two-stage sampling with equal first stage units: Estimation of the population mean, unbiased estimate of sampling variance; Three- stages sampling with equal first and second stages: estimation of mean and variance, illustrative examples of estimating population mean, total and standard error

UNIT 4: Multiphase Sampling **[6 LH]**

Concept of multiphase sampling, double sampling for stratification, optimum allocation, estimate of variances in double sampling for regression, illustrative examples

UNIT 5: Sample Design **[10 LH]**

Introduction, complex surveys, sample designs in complex surveys, self-weighting design, weighting in sample designs, estimation of sample size in complex surveys, design effect, post stratification, analytic domains, examples of sample designs in complex surveys with SRS, stratified sampling, cluster sampling, PPS sampling, systematic sampling, etc.; Sample designs in nationally representative survey of Nepal: Nepal Demographic and Health Survey (NDHS), Nepal Living Standards Survey (NLSS), Nepal Multiple Indicator Cluster Survey (NMICS), Household Budget Survey

UNIT 6: Variance Estimation **[4 LH]**

Concept, variance estimation in complex survey, methods of variance estimation: method of linearization, Jackknife and bootstrap methods, illustrative examples

References

1. Cochran, W. G. (1977). *Sampling techniques*. Wiley-Eastern.
2. Mukhopadhyay, P. (1998). *Theory and methods of survey sampling*. Prentice Hall of India.
3. Lohr, S. L. (1999). *Sampling: Design and analysis*. Duxbury Press.
4. Raj, D., & Chandhok, P. (1999). *Sample survey theory*. Narosa Publishing House.
5. Wolter, K. M. (1985). *Introduction to variance estimation*. Sringer-Verlag.
6. Chaudhuri, A. (2010). *Essentials of survey sampling*. PHI Learning Pvt.
7. Sampath, S. (2005). *Sampling theory and methods*. Narosa Publishing House.

Course Title: R Programming Language | **Full Marks: 50**
Course Code: STA 516 | **Pass Marks: 25**
Nature: Theory | **Total Credits: 2**
Semester: First | **Total Lecture Hours: 32**

Course Description

This is an introductory course on statistical concepts and applied techniques needed for data preparation, data modeling by using R. This course is intended as a guide to data analysis with the R system for statistical computing. This course covers an introduction to R, the R basics, logical operator, data structure, data management in R, matrix operation, data visualization and graphics in R, and basic statistical functions and inferences.

Learning Outcomes

After completion of this course, the students will be able to

- use real data sets and perform analysis using R,
- write programs using R for analyzing data,
- make graphs and charts by using R,
- use R for various statistical computations and inferences.

UNIT 1: An Introduction to R and Data Structure [6 LH]

Purpose of using R software, installing R and R Studio, The R environment and working with R, The R packages (Meaning and purpose of packages, installing, loading and learning Packages), Basic math, variables, data types, basic R function, List, Vectors, Matrices, Arrays, Data Frames, Factors

UNIT 2: Conditional and Control Flow [3 LH]

Relational Operators and vectors, Logical operators (AND, OR, NOT), Logical operators and vectors, Conditional statement

UNIT 3: Data Entering, Reading and Management [3 LH]

Data entering, Data reading from external files (CSVs, Excel, SPSS, Stata files), creating new variables, recoding variables, renaming variables, missing values, sorting data, merging data sets (Adding columns and rows to the data frame), selecting variables, dropping variables, selecting observations

UNIT 4: Matrix Operation [3 LH]

Matrix operations, creating matrix from vector, combine vectors or matrices, matrix addition, transpose matrix, Find the dimension of a matrix or dataset, matrix multiplication, finding the inverse of a matrix, component-wise multiplication, create a submatrix, create a diagonal matrix, a vector of diagonal elements, create a vector from a matrix, calculate the determinant, find eigenvalues and eigenvectors, find the singular value decomposition

UNIT 5: Graphics, Visualization and Summary Measures [5 LH]

Bar chart, Pie chart, Box plot, Histogram, Line graph, Density plots, Normal Q-Q plot, Scatter plot, Basics of ggplot, Measures of central tendency, Measures of variation, measures of skewness and Kurtosis

UNIT 6: Probability and Probability Distributions [4 LH]

Random Number, Random number generator, binomial distribution, Poisson distribution, exponential distribution, negative binomial distribution, normal distribution, plot for testing normality

UNIT 7: Statistical Inference [8 LH]

Inferences in the one sample case, Student's t distribution, comparing two variances (Fisher's F test), comparing two sample means with normal errors (Student's t-test), correlation coefficient, correlation matrix, testing for independence in contingency tables using chi-squared, linear regression, assumptions, standardized coefficient, hypothesis testing

References

1. Lander. J. P. (2014). *R for everyone: Advanced analytics and graphics.* Pearson Education.
2. Crawley, M. J. (2015). *Statistics: An introduction using R* (2nd ed.). John Wiley &Sons Ltd.
3. Fox, J. and Weisberg, S. (2019). *An R companion to applied regression* (3rd ed.). Sage Publication.
4. Dalgaard, P. (2008). *Introductory statistics with R* (2nd ed.). Springer.
5. Kabacoff, R. I. (2015). *R in action* (2nd ed.). Manning.

Course Title: Statistical Computing-I **Full Marks: 100**
Nature: Practical **Pass Marks: 50**
Course Code: STA517 **Total Credits: 4**
Semester: First **Total Duration: 64 hours**
Total Lectures: 21-23 Practical Days (3 Hours/Lecture)

Table 3: Subject-wise allocation of number of practical

SN	Subject Area	No. of Practicals (Minimum)
1	Mathematics for Statistics	4
2	Probability	4
3	Statistical Inference	4
4	Mathematical Demography	4
5	Sampling Theory	4
6	R Programming Language	10
	Total	30

Second Semester

Course Title: Multivariate Analysis
Course Code: STA 521
Nature: Theory
Semester: Second

Full Marks: 75
Pass Marks: 37.5
Total Credits: 3
Total Lecture Hours: 48

Course Description

This course is developed to provide fundamental knowledge of multivariate normal distribution and associated multivariate statistical methods with their applications. The course will impart theoretical as well as applied knowledge of advanced multivariate statistical methods namely principal components analysis (PCA), factor analysis, multivariate analysis of variance (MANOVA), discriminant analysis and canonical correlation analysis along with their applications using statistical computer software.

Learning Outcomes

After completion of this course, the students will be able to

- understand the characteristic features of multivariate normal distribution along with statistical inference and apply multivariate statistical methods to observed data,
- perform PCA and factor analysis with theoretical understanding,
- classify data using discriminant function with theoretical knowledge,
- understand and apply MANOVA and canonical correlations to observed data wherever applicable and suitable.

UNIT 1: Multivariate Normal Distribution (MVND) [8 LH]

Density function and characteristic function of MVND, distribution of linearly transformed multivariate normal random vector, marginal and conditional distribution of MVND, Necessary and sufficient condition for independence in MVND

UNIT 2: Estimation of Multivariate Normal Distribution Parameters [9 LH]

Concept about sampling from MVND, maximum likelihood estimators of mean vector and dispersion matrix, properties and distributions of maximum likelihood estimators, Wishart distribution and its properties, maximum likelihood estimators of simple, partial and multiple correlation coefficient and their distributions

UNIT 3: Hypothesis Testing in Multivariate Normal Distribution [7 LH]

Hotelling's T^2 statistic as a generalization of square of Student's t statistic, defining Hotelling's T^2 statistic from likelihood ratio test, distribution of Hotelling's T^2 statistic and its invariance property, applications of T^2 statistic in hypothesis testing (one sample and two sample problems), distance between two populations, Mahalanobis D^2 statistic

UNIT 4: Principal Components Analysis (PCA) [5 LH]

Model formulation, number of components and component structure, extraction of principal components, maximum likelihood estimators of principal components and their variances, applications

UNIT 5: Factor Analysis [6 LH]

Orthogonal factor model, estimation of factor loadings, communalities, factor extraction, factor rotation, factor scores and their applications, maximum likelihood estimators for random orthogonal factors, tests of hypothesis in factor models

UNIT 6: Discriminant Analysis [5 LH]

Separation and classification for two populations, applications of discriminant analysis, classification with two multivariate normal populations, Fisher's Discriminant function, classification with several populations,

UNIT 7: Multivariate Analysis of Variance (MANOVA) [4 LH]

Multivariate one-way analysis of variance model, Wilks test, Roy's Test and its application

UNIT 8: Canonical Correlation Analysis [4 LH]

Introduction, applications, population canonical correlations, sample canonical correlations, properties of canonical correlations, tests of hypotheses

References

1. Anderson, T. W. (2003). *An introduction to multivariate statistical analysis*. Wiley-Interscience.
2. C. Radhakrishna Rao. (2009). *Linear statistical inference and its applications*. John Wiley & Sons.
3. Johnson, R. A., & Wichern, D. W. (2019). *Applied multivariate statistical analysis*. Pearson.
4. Wolfgang Karl Härdle, & Simar, L. (2013). *Applied multivariate statistical analysis*. Springer Science & Business Media.
5. Tenko Raykov, & Marcoulides, G. A. (2008). *An introduction to applied multivariate analysis*. Routledge.

Course Title: Stochastic Processes **Full Marks: 75**
Course Code: STA 522 **Pass Marks: 37.5**
Nature: Theory **Total Credit: 3**
Semester: Second **Total Lecture Hours: 48**

Course Description

This course introduces the theory and applications of random processes required in various disciplines like finance, economics, physics, engineering, telecommunications, mathematical biology, medicine, environmental science, and many more. The overall course is designed across different topics including random walk, branching process, Markov chain, discrete and continuous Markov processes in continuous time, renewal theory, and queuing theory.

Learning Outcomes

After completion of the course, the students will be able to

- understand the fundamental concepts, classifications, and importance of stochastic processes,
- recognize and derive the theoretical relations of the random walk and branching process,
- know the theoretical background of the Markov chain and compute the different probabilities related to Markov chain problems,
- distinguish and understand the discrete and continuous Markov processes in continuous time,
- understand the basics of renewal theory and queuing theory along with their applications in different areas.

UNIT 1: Introduction to Stochastic Processes [13 LH]

Classification of stochastic processes according to state space and time domain, probability generating function (PGF) and its properties, martingales, types of martingales, some illustrations of martingale property

Random walk: Introduction, transition probabilities, return to originprobability, gambler's ruin problem, expected duration of the game

Branching Process: Galton-Watson branching process, PGF of generation size, mean and variance of generation size, probability of ultimate extinction, total progeny

UNIT 2: Markov Chain [9 LH]

Introduction, homogeneous Markov chain, transition probability, Lemmas on transition probabilities, absolute probability, two-state Markov chain, spectral analysis of two-state Markov chain, classification of states of Markov chain, theorems related to communicating, recurrent and transient properties of states of Markov chain, countable state Markov chain

UNIT 3: Discrete and Continuous Markov Processes in Continuous Time [14 LH]

Discrete Markov Processes in Continuous Time: Poisson process & its properties, probability mass function of Poisson process, homogenous birth and death processes (pure birth process, general birth process, simple linear death process, simple birth and death process, general birth and death process)

Continuous Markov Processes in Continuous Time: Introduction to continuous Markov process, diffusion process, Brownian motion process, Kolmogorov forward and backward diffusion equations, correlation coefficient for a Wiener process

UNIT 4: Renewal Theory [6 LH]

Introduction to renewal theory, general renewal theory, renewal function, integral equation of renewal theory, stopping time and Wald's equation, spent and residual time distribution, lattice random variable, elementary renewal theorem

UNIT 5: Theory of Queue [6 LH]

Basics of queue theory, structure of a basic queue system, M/M/1 queue system, steady state solution of M/M/1 queue, waiting time distributions in M/M/1 queue system, operating characteristic of M/M/1 queue system, M/M/s queue system, operating characteristics of M/M/s queue system

References

1. Pinsky, M. A. (2011). *An introduction to stochastic modeling* (4^{th} ed.). Academic Press.
2. Durrett, R. (2016). *Essentials of stochastic processes* (3^{rd} ed.). Springer.
3. Resnick, S. I. (1992). *Adventures in stochastic processes*. Birkhauser Boston.
4. Ross, S. M. (1983). *Stochastic processes* (2^{nd} ed.). Wiley.
5. Taylor, H. M., & Karlin, S. (1994). *An introduction to stochastic modeling*. Academic Press.
6. Tijms, H. C. (2003). *A first course in stochastic models*. Wiley.
7. Dobrow, R. P. (2016). *Introduction to stochastic processes with R*. Wiley.
8. Hoel, P. G., Port, S. C., & Stone, C. J. (1972). *Introduction to stochastic processes*.Houghton Mifflin Company.
9. Shrestha, H. B. (2009). *Stochastic processes, An introductory text*. Ekta Books.

Course Title: Statistical Simulation | **Full Marks: 75**
Course Code: STA 523 | **Pass Marks: 37.5**
Nature: Theory | **Total Credits: 3**
Semester: Second | **Total Lecture Hours: 48**

Course Description

This course is designed for master's level students aiming to provide students with a solid foundation in simulation methodology, enhance their computational skills, foster critical thinking abilities, and offer practical experience. This course covers various resampling methods, Monte Carlo, MCMC, and many other simulation methods and some special algorithms. This equips the students to effectively apply simulation techniques in statistical analysis and decision-making using R and Python and improves their critical thinking.

Learning Outcomes

After completion of the course, the students will be able to

- learn how to use statistical simulation effectively to solve various types of statistical problems and gain a strong grasp of its principles,
- gain proficiency in using software like R and Python for statistical simulations and improve their critical thinking abilities for complex data analysis,
- develop critical thinking abilities, through hands on projects, to handle complex statistical problems and apply simulation in real-world scenarios or research projects.

UNIT 1: Basic Simulations Techniques **[16 LH]**

Introduction to Statistical Simulation: Motivation and importance of statistical simulation, Overview of simulation Techniques and their applications, Advantages and limitations of simulation in statistical modeling and analysis

Random Number Generation: Basics of random number generation and random variates, Pseudo-random number generators, Sampling from probability distributions, Testing randomness and evaluating quality of random number generators

Resampling Methods: Bootstrapping: Basics, principles, types, applications, Jackknife resampling for bias estimation, Permutation tests and their use in hypothesis testing, Cross-validation and resampling techniques for model selection

Monte Carlo Simulation: Basics of Monte Carlo simulation and Monte Carlo integration, Sampling from probability distributions, Estimation and inference using MC method, Variance reduction techniques: importance sampling, rejection sampling

UNIT 2: MCMC and Advanced Simulation Methods **[16 LH]**

Markov Chain Monte Carlo (MCMC) Methods: Introduction to MCMC, its roles and properties, Metropolis-Hastings algorithm, Gibbs sampling and other MCMC algorithms, Sampling from complex posterior distribution, Convergence diagnostics (mixing, burn-in, and thinning)

Simulation-Based Inference: Simulation-based hypothesis testing and model comparison, Simulation for constructing confidence intervals, Assessing model fit using simulation-based techniques, Simulation-based computational Statistics and Bayesian computation
Advanced Simulation Techniques: Discrete event simulation, Sequential Monte Carlo methods, Rare event simulation, Parallel and distributed computing for simulation

UNIT 3: Other Algorithms and Applications of Simulation [16 LH]

Some Important Principles and Algorithms: Occam's Razor, Random Forest, Kalman Filter, EM Algorithms and Support Vector Machines
Applications, Case Studies and Project: Real-world examples /case studies demonstrating the use of simulation methods, (from epidemiology, environmental science, medicine, reliability etc.), Hands-on exercises/ projects applying simulation techniques to analyze datasets using R and /or Python

References

1. Ross, S. (2006). *Simulation* (4th ed.). Academic Press.
2. Rubinstein, R., & Kroese, D. (2016). *Simulation and the Monte Carlo method*. John Wiley.
3. Gelman, A., Jones, G., Brooks, S., & Meng, Xi. (2011). *Handbook of Markov Chain Monte Carlo* (Ed.). CRC Press.
4. Robert, C., & Casella, G. (1999). *Monte Carlo statistical methods*. Springer.
5. Robert, C. P., & Casella, G. (2010). *Introducing Monte Carlo methods with R*. Springer Science & Business Media.
6. Jones, O, Maillardet, R., & Robinson, A. (2014). *Introduction to scientific programming and simulation using R* (2nd ed.). CRC Press.

Course Title: Python Programming | **Full Marks: 50**
Course Code: STA 524 | **Pass Marks: 25**
Nature: Theory | **Total Credits: 2**
Semester: Second | **Total Lecture Hours: 32**

Course Description

This course covers different concepts of Python programming including basic language features, control statements, functions, object-oriented concepts, exception handling, file handling, modules and packages, and some common Python libraries.

Learning Outcomes

After completion of the course, the students will be able to

- provide knowledge to student with different concepts and object-oriented features of Python programming language,
- provide knowledge of some common Python libraries such as Numpy, Pandas, and Matplotlib.

UNIT 1: Introduction [3 LH]

Python Introduction; Why Python; Installing Python; Using Interactive Shell from Console; Running Python Scripts from Console; Using Interactive Shell from IDLE; Using IDEs; Installing Third Party Libraries; Virtual Environment; Writing Comments; Indentation; Variables; Operators

UNIT 2: Built-In Data Types [5 LH]

String; Integer; Float; Complex; List; Tuple; Range; Set; Dictionary; Boolean; Indexing and Slicing; Comprehensions

UNIT 3: Conditionals and Iterations [3 LH]

Introduction; The if Statement; The match-case Statement; The for Loop; The while Loop; The break and continue Statements

UNIT 4: Functions [3 LH]

Introduction; Why use Functions? Defining Functions; Passing Arguments; Return Values, Recursive Function

UNIT 5: Object-Oriented Programming [5 LH]

Object-oriented Programming Concepts; Creating Class and Object; Inheritance; Method Overriding Modules and Packages

UNIT 6: Exception and File Handling [3 LH]

Exceptions; Handling Exceptions; Reading and Writing Files

UNIT 7: Python Libraries **[10 LH]**

Numpy: Introduction; Creating Array; Dimensions; Array Attributes, Indexing and Slicing; Array Copy and View; Creating Array from Numerical Range; Array Broadcasting; Iterating Over Array; Sorting and Searching; Statistical Functions

Pandas: Series and Data Frames; Creating Data Frames; The head and tail Functions; Attributes; Working with Missing Data; Indexing, Slicing, and Subsetting; Merging and Joining Data Frames; Working with CSV Data

Matplotlib: Introduction; pyplot; The plot() function; Marker; Line; Color; Label; Grid Lines; Subplot; Scatter Plot; Bar Graph; Histogram, Pie Chart; Box Plot

Laboratory Work:

The laboratory work includes writing computer programs using Python programming language covering all the concepts studied in each unit of the course.

References

1. Summerfield, M. (2009). *Programming in Python 3: A complete introduction to the Python language.* Addison-Wesley Professional.
2. Lampart, K. A. (2018). *Fundamental of Python: First program*, (2nd Ed.), Cengage Learning Publishing.
3. Jackson, C. (2018*): Learn programming in Python with cody Jackson*. Packt Publishing.
4. Romano, F., & Kruger, H. (2021). *Learn Python programming – An in-depth introduction to the fundamentals of Python*, (3rd Ed.), Packt Publishing.

Course Title: Econometrics | **Full Marks: 75**
Course Code: STA 525 | **Pass Marks: 37.5**
Nature: Theory | **Total Credits: 3**
Semester: Second | **Total Lecture Hours: 48**

Course Description

Econometrics use statistical methods to answer economic questions. But also, it is equally important and applicable in every field of research. This course introduces the concept of econometrics and discusses on the necessary tools to conduct empirical research with a theoretical basis. A special focus will be given on explaining that available data is usually not experimental and what consequences this has on the empirical model. The main topic of this course will be linear regression models. Qualitative response variable regression modelling will also be discussed. Both theoretical and practical examples will be part of the course.

Learning Outcomes

After completion of the course, the students will be able to

- know statistical foundations of regression analysis with OLS,
- understand the causality concept in an empirical context,
- detect and treat violations of OLS assumptions, such as omitted variables, multicollinearity, heteroscedasticity, and serial correlation,
- learn of econometric modelling,
- understand qualitative response regression,
- find estimation and testing with OLS,
- know forecasting with regression modelling,
- read and critically discuss empirical papers,
- use statistical computer software for empirical analysis.

UNIT 1: Multiple Linear Regression (Matrix Approach) [13 LH]

Review of simple linear regression model with OLS and some matrices algebra The k variable regression model, model specification, assumptions in matrix notation, OLS estimation of the parameter vector, variance-covariance matrix of the estimated parameter vector, standard error of estimates, properties of vector estimate, unadjusted and adjusted multiple coefficients of determinations, correlation matrix, hypothesis testing of regression coefficients, testing of goodness of fit by analysis of variance, prediction. Problems and examples

UNIT 2: Violation of Assumptions [15 LH]

Multicollinearity: The nature of multicollinearity, estimation, detection, consequences and remedial measures., Heteroscedasticity: The nature of heteroscedasticity, OLS estimation in the presence of heteroscedasticity, detection of heteroscedasticity: Goldfeld-Quandt test, Breusch-Pagan-Godfrey test, White’s test, treatment of heteroscedasticity: method of weighted least squares, White’s Heteroscedasticity - consistent variance and standard errors, Autocorrelation and residual analysis: The nature of autocorrelation, detection and consequences of autocorrelation, Durbin Watson test, and remedial measures: Changing the functional form, Cochrane-Orcutt iterative procedure

UNIT 3: Econometric Modeling **[5 LH]**

Model specification criteria, Type of specification error, Consequence of model specification (overfitting and underfitting a model) Durbin Watson d Statistics for model misspecification. Distributed Lag Models: Model specification, estimation: Koyck approach and Almon lag

UNIT 4: Qualitative Response Regression **[15 LH]**

Binary Logistic Regression Model: Categorical dependent variable in regression, binary logistic regression: model specification, assumptions, estimation and interpretation of model parameters, odds ratio, Multinomial Logistic Regression Model: Model specification, assumptions, estimation of parameters (derivation not required) with interpretations, examples of fitted models with model adequacy tests, Ordinal Logistic Regression Model: Model specification, assumptions, estimation of parameters (derivation not required) with interpretations, examples of fitted models with model adequacy tests

References

1. Maddala, G. S. (2001). *Introduction to econometrics*. John Wiley and Sons.
2. Johnstone, J. (2007). *Econometric methods*. McGraw Hill Book Company.
3. Gujarati, D. N., Porter, D. C., & Gunasekar, S. (2011). *Basic econometrics*. McGraw Hill Education.
4. Bhumik, S. K. (2015). *Principles of econometrics*. Oxford University Press.
5. Wooldridge, J. M. (2019). *Introductory econometrics, A modern approach* (7th ed.). CengageLearning.

Course Title: Quality Control and Reliability | **Full Marks: 75**
Course Code: STA 526 | **Pass Marks: 37.5**
Nature: Theory | **Credits: 3**
Semester: Second | **Total Lecture hours: 48**

Course Description

This course explores advanced topics in quality systems and reliability analysis in three units. The first unit covers quality management foundations, customer-centric approaches, and recent developments. It also includes offline quality control strategies, a review of DOE in quality, and performance optimization using response surface methodology. The second unit focuses on statistical process control methods, including control chart evaluation, short run SPC techniques, and economic design of x-bar chart. It covers sampling inspection plans, OC functions, advanced plans like sequential, chain, and skip-lot sampling, corrective sampling plans, and methods for estimating sample sizes and constants. The third unit delves into reliability analysis, life testing models, system reliability, maintainability, and handling censored and truncated data in life testing experiments.

Learning Outcomes

After completion this course, students will be able to

- comprehend quality management principles, monitoring strategies, and recent developments,
- design effective quality experiments, incorporating Taguchi's strategies and response surface methodology,
- utilize proper SPC procedures for general and short runs, along with control chart design,
- implement various sampling inspection plans and interpret their performance, including corrective sampling plans,
- increase knowledge of reliability fundamentals and estimation techniques for different life testing models,
- interpret system reliability, maintainability, and handling censoring and truncated cases in life testing experiments.

UNIT 1: Quality Management and Designing Quality Experiments [16 LH]

Foundations of Quality Management; Philosophies behind quality and quality management, Quality Gurus and their key contributions, Quality management principles, Deming's circle and other continuous quality improvement strategies; Process capability improvement methods and recent developments; Customer-centric approaches: Kano Model, Quality Function Deployment
Designing Quality Experiments: Offline quality control and its significance, Taguchi's offline quality control strategies: Robust design strategy (system design, parameter design, tolerance design), variance reduction strategy, performance measure strategy, productivity enhance strategy, customer satisfaction strategy; Designing offline quality experiments using full factorial

and fractional factorial designs; Response surface methodology and optimization; Taguchi's orthogonal arrays

UNIT 2: Statistical Process Control and Sampling Inspection [20 LH]

SPC Strategy Analysis: Review of SPC and control chart procedures, OC functions, ARL and process capacity. Short run SPC techniques: Individual measurement and moving range chart, Moving average chart, EWMA chart, CUSUM (Tabular and V mask) charts, Multivariate control charts, Modified control chart, Acceptance control charts; Economic design of x-bar chart, Duncan's Model Application of quality control principles, methods, and control charts for non-manufacturing applications and research (healthcare, banking, education, customer service, hospitality, transportation, insurance etc.)

Sampling Inspection: Review of single and double acceptance sampling plans and their OC, AQL, LTPD, AOQ, AOQL, ASN, and ATI Multiple, sequential, chain, and skip-lot sampling plans; sampling plans for variables, Corrective sampling plan: Rectifying inspection program, Curtailed and semi-curtailed inspection plan, Method for estimating n and c using large sample for single, doble sampling plans

Unit 3: Reliability Analysis [12 LH]

Introduction to Reliability: Concepts, importance and applications of reliability analysis; Failure function, Reliability function, Hazard rate, Mean time to failure, Failure time distribution, General equation of failure rate distribution and related problems

Life testing models and reliability estimation: Exponential, Gamma, Weibull, Lognormal, Rayleigh and Bath-tub models, Reliability estimation techniques and interpretation for each model. System Reliability and Maintainability: Series, parallel and series-parallel systems and their reliability, Reliability of coherent system, Maintainability and Availability, System availability, Preventive maintenance. Censored and Truncated cases in life testing, and their reliability with some examples

References

1. Montgomery, D. C. (2004). *Introduction to Statistical Quality Control*. Willey.
2. Mitra, A. (1998). *Fundamentals of quality control and improvement* (2nd ed.). Prentice Hall.
3. Grant, E. L., & Leavenworth, R. S. (2004). *Statistical quality control*. Tata McGraw Hill.
4. Biswas, S. (1997). *Statistical quality control*. New Age India.
5. Sinha, S. K., & B. K. Kale (1980). *Life Testing and Reliability Estimation.* Willey Eastern.
6. Khatiwada, R. P. (2013). *An introduction to statistical quality control and reliability*. Quest Publication.

Course Title: Operations Research
Course Code: STA 527
Nature: Theory
Semester: Second

Full Marks: 75
Pass Marks: 37.5
Total Credits: 3
Total Lecture Hours: 48

Course Description

This course provides an introduction to fundamental principles, mathematical and analytical optimization techniques which are useful for solving simple as well as complex decision-making problems. It focuses on applications of operation research in various fields like business, management, economics, engineering, industry, finance and logistics.

Learning Outcomes

After completion of this course, the students will be able to

- be familiar with concepts of feasible, infeasible, basic solution, optimum solutions of linear programming problem,
- understand how to formulate and solve LP problems related different sectors, the concepts of duality of LP problem and importance of duality,
- measure the sensitivity of changing the price vector and requirement vector,
- find the integer solution of LP problem,
- know the importance of location planning, factors associated to it and different methods used for location planning,
- know the importance of capacity and aggregate planning, different methods of aggregate planning,
- be familiar with transformation process, importance of product design and concepts of product design,
- understand the concepts of crashing the project.

UNIT 1: Linear Programming [5 LH]

General Nature of programming problems, Scope and limitation, concepts of feasible, infeasible, optimum solutions, effective, ineffective, simultaneous linear equations, basic solutions, linear transformations, point sets, lines and hyper planes, convex cones

UNIT 2: Formulation and solution of Linear Programming Problems [10 LH]

Formulation of linear programming problems related to different sectors, Reviews of Simplex Method for LPP with maximization / minimization objective function. Dual linear programming problems, fundamental properties of dual problems, complementary slackness, unbounded solution in the primal, dual-simplex algorithm, importance of duality in LPP

UNIT 3: Post Optimal/ Sensitivity Analysis [5 LH]

Post-optimality problems, changing the price vector, changing the requirement vectors, adding and removing variables or constraints, upper and lower bounds

UNIT 4: Integer Programming [3 LH]

Introduction, Application of integer programming, methods of integer programming: Branch and bound algorithm, Gomery Fractional cut algorithm

UNIT 5: Location Planning [7 LH]

Introduction to facility location planning, problems due to improper location planning, strategies for multiple facility planning, factors affecting for location planning, methods used for location selection: Centre of gravity, factor rating, cost volume analysis, transportation technique

UNIT 6: Capacity and Aggregate Planning [8 LH]

Introduction to capacity, measure of capacity, types of capacity, utilization of capacity, aggregate planning, types of aggregate planning: level production plan, chase production plan, varying utility plan

UNIT 7: Designing a Product [3 LH]

Transformation process, defining a product, types of product: goods vs services, importance of designing a product, concepts of product design, life cycle of a product

UNIT 8: Network Analysis [7 LH]

Introduction of network diagram, critical path method, crashing of project

References

1. Hadle, G. (1978). *Linear programming*. Edision-Wesley Publishing Co.
2. Gupta, P. K., & Hira, D. S. (2007). *Operations research* (4th ed.). S. Chand & Company Ltd.
3. Vohra, N. D. (2006). *Quantitative techniques in management*. TATA McGraw Hill.
4. Bedi, K. (2013). *Production and operations management* (3rd ed.). Oxford University Press.
5. Heizer, J. & Render, B. (2015). *Operations management* (11th ed.). Pearson.

Course Title: Nonparametric Statistics — **Full Marks: 75**
Course Code: STA 528 — **Pass Marks: 37.5**
Nature: Theory — **Total Credits: 3**
Semester: Second — **Total Lecture Hours: 48**

Course Description

This course deals with statistical inference when parametric distributions are not assumed and presents the theory and procedures of decision making in absence of rigid distributional assumptions.

Learning Outcomes

After completion of this course, the students will be able to

- know about order statistics,
- know about distribution free statistics,
- know about different nonparametric statistics and their applications.

UNIT 1: Order Statistics [10 LH]

Probability integral transformation, Joint and marginal distribution of r^{th} order statistics, Moments of order statistics, Distribution of median and range, Asymptotic distribution of order statistics, Confidence interval estimates for population quintiles, Hypothesis testing for population quintiles

UNIT 2: Distribution-Free Statistics [10 LH]

Distribution-free statistics over a class, Counting statistics, Ranking statistics, U-statistics: one sample and two sample U-Statistics and their asymptotic properties, Asymptotically distribution-free statistics

UNIT 3: Non-Parametric Tests [28 LH]

One sample test: Binomial test, Tests based upon runs, Exact null distribution of R, Moments of the null distribution of R, Asymptotic null distribution of R, Sign test, Wilcoxon signed rank test, Tests of goodness of fit: Chi-square test, Kolmogorov-Smirnov test

Two sample tests: Wald-Wolfowitz runs test, Kolmogorov-Smirnov two sample test, Median test, Mann-Whitney U test Several sample tests: Kruskal-Wallis one way ANOVA test, Measures of association: Kendall's tau coefficient, Spearman's coefficient, Contingency coefficient, Coefficient of concordance, Friedman's two-way analysis of variance by ranks

References

1. Gibbons, J. D. (1985). *Nonparametric statistical inference*. Marcel Dekker.
2. Randles, R. H., & Wolfe, D. A. (1979). *Introduction to the theory of nonparametric statistics*. John Wiley and Sons.
3. Rohatgi, V. K., & Saleh, A. K. Md. E. (2005). *An introduction to probability and statistics*. John Wiley and Sons.
4. Conover, W. J. (1980). *Practical nonparametric statistics*. John Wiley and Sons.

Course Title: Statistical Computing-II **Full Marks: 100**
Nature: Practical **Pass Marks: 50**
Course Number: STA 529 **Total Credits: 4**
Semester: Second **Total Duration: 64 hours**
Total Lectures: 21-23 Practical Days (3 Hours / Lecture)

Table 4: Subject-wise allocation of number of practical

SN	Subject Area	No. of Practical (Minimum)
1	Multivariate Analysis	4
2	Stochastic Theory	4
3	Statistical Simulation	4
4	Python Programming	10
5	Two optional Papers of Semester-II	8
	Total	30