

Detailed Course Outlines for BS Statistics

Course Code	Course Title	Credit Hours
Semester - I		
STA-301	Introduction to Statistics	3(3-0)
CSI-321	Introduction to Computing Applications	3(2-1)
MTH-321	Algebra and Trigonometry	3(3-0)
ENG-321	Functional English	3(3-0)
ISL-321	Islamic Studies	2(2-0)
ISL-322	Ethics (For Non-Muslim only)	2(2-0)
Total		14
Semester - II		
STA-302	Fundamentals of Probability and Random Variables	3(3-0)
MTH-322	Introduction to Calculus	3(3-0)
ECO-321	Introductory Economics	4(4-0)
STA-304	Introduction to Regression Analysis	3(3-0)
ENG-322	English Comprehension & Composition	3(3-0)
Total		16
Semester - III		
STA-401	Introduction to Probability Distributions	3(3-0)
CSI-301	Programming Fundamentals	3(2-1)
MTH-433	Mathematical Methods & Vector Analysis	3(3-0)
STA-403	Statistics and Society	3(3-0)
STA-405	Fundamentals of Parameter Estimation	3(3-0)
PST-321	Pakistan Studies	2(2-0)
Total		17
Semester - IV		
STA-402	Applied Statistics	3(3-0)
ECO-408	Issues in Pakistan Economy	3(3-0)
STA-404	Basics of Statistical Hypothesis Testing	3(3-0)
MTH-436	Linear Programming	3(3-0)
ENG-421	Communication Skills	3(3-0)
STA-406	Statistical Software	3(0-3)
Total		18
Semester - V		
STA-501	Probability and Probability Distributions-I	3(3-0)
STA-503	Sampling Techniques-I	3(3-0)
STA-509	Introduction to Data Science	3(3-0)
STA-505	Statistical Methods	4(4-0)
STA-507	Operational Research	3(3-0)
Total		16
Semester - VI		
STA-502	Probability and Probability Distribution-II	3(3-0)
STA-504	Sampling Techniques-II	3(3-0)
STA-506	Design and Analysis of Experiments-I	4(4-0)
STA-508	Population Studies	2(2-0)

STA-510	Statistical Quality Control	3(3-0)
STA-512	Survey Research Methods	3(3-0)
Total		18
Semester - VII		
STA-601	Econometrics-I	4(4-0)
STA-603	Design and Analysis of Experiments-II	4(4-0)
STA-605	Multivariate Analysis-I	3(3-0)
STA-607	Statistical Inference-I	3(3-0)
STA-611	Statistical Computing -I	3(0-3)
STA-629	Seminar	1(0-1)
Total		18
Semester - VIII		
STA-602	Econometrics-II	4(4-0)
STA-604	Statistical Computing -II	3(0-3)
STA-606	Multivariate Analysis-II	3(3-0)
STA-608	Statistical Inference-II	3(3-0)
Any One of The Following Courses		
STA-612	Analysis of Time Series and Forecasting	4(4-0)
STA-614	Categorical Data Analysis	4(4-0)
STA-616	Survival Data Analysis	4(4-0)
STA-618	Non Parametric Methods	4(4-0)
STA-622	Bayesian Statistics	4(4-0)
OR		
STA-620	Research Report	4(0-4)
Total		17
Total Credit Hours to be offered in BS Statistics		133

Changed/added courses for SEMESTER-I

STA-301	Introduction to Statistics	3(3-0)
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Meanings of Statistics, Main branches of Statistics, Types of variables, Measurements scales, Errors of measurement, Significant digits, Statistical data collection, Organizing of data, Classification of data, Graph and charts: Stem and Leaf diagram, Box and Whisker plots. Graph based on frequency distribution: Histogram, Frequency polygon, Ogive, Pie-chart.

Measure of central tendency: Arithmetic mean, Median, Mode, Geometric mean, Harmonic mean, Weighted arithmetic mean, Their properties, Merits and demerits, Quantiles, The box plots, Empirical relation between mean, median and mode.

Measure of Dispersion: Absolute and relative measure of dispersion, Their properties, Merits and demerits, Standardized variables, Moments, Sheppard's correction, Moments ratios, Coefficient of kurtosis and skewness, Trimmed and Winsorized mean.

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) "*Probability and Statistics*", 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). "Introductory Statistics", 5th ed. Jhon Wiley & Sons. New York.
3. Walpole, R.E (2020). "Introduction to Statistics", 3rd ed. Macmillan Publishing Company. New York.
4. Rauf, M (2001). "Polymer's Modern Statistics", Polymer Publication, Urdu Bazar, Lahore.
5. Chaudhary, SM and Kamal, S. (2011) "*Introduction to Statistical Theory*" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

Reference Books

1. Clark, G.M and Cooke, D. (2002), "*A Basic Course in Statistics*", 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), "*Probability and Statistics for Engineers and Scientists*", 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) "*Statistics for Business & Economics*", 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), "*Introductory Statistics*" 10th ed. Addison-Wesley Publication. Company. Boston.

CSI-321	Introduction to Computing Applications	3(2-1)
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As per outlines prepared by Department of Computer Science

MTH-321	Algebra and Trigonometry	3(3-0)
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As per outlines prepared by Department of Mathematics

ENG-321	Functional English	3(3-0)
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As per outlines prepared by Department of English

ISL-321	Islamic Studies	2(2-0)
ISL-322	Ethics (For No-Muslim only)	2(2-0)

As per outlines prepared by Department of Islamic Studies

SEMESTER-II

STA-302	Fundamentals of Probability and Random Variables	3(3-0)
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Sets theory, Counting rules: multiplication rule, combination, permutation, Random experiment, Types of events, Definitions of probability, Laws of probability: complement, addition, multiplication, independence, conditional probability, Total probability and Bayes' rule.

Random variable, Distribution function, Discrete random variables and its probability distribution, Continuous random variables and its probability density function, Joint distributions: bivariate distribution functions, bivariate probability functions, marginal probability functions, conditional probability functions, independence, continuous bivariate distributions. Mathematical expectations of a random variables, Median and mode of continuous random variables, Chebyshev's inequality, Moment generating functions, Cumulant generating functions, relation between cumulants and moments, Characteristic function.

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) "*Probability and Statistics*", 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). "Introductory Statistics", 5th ed. Jhon Wily & Sons. New York.
3. Walpole, R.E (2020). "Introduction to Statistics", 3rd ed. Macmillan Publishing Company. New York.
4. Rauf, M (2001). "Polymer's Modern Statistics", Polymer Publication, Urdu Bazar, Lahore.
5. Chaudhary, SM and Kamal, S. (2011) "*Introduction to Statistical Theory*" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

Reference Books

1. Clark, G.M and Cooke, D. (2002), "*A Basic Course in Statistics*", 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), "*Probability and Statistics for Engineers and Scientists*", 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) "*Statistics for Business & Economics*", 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), "*Introductory Statistics*" 10th ed. Addison-Wesley Publication. Company. Boston.

STA-304	Introduction to Regression Analysis	3(3-0)
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Concept of regression analysis, scatter diagram, Simple linear regression, its model and assumptions, Multiple linear regression, Fitting of non-linear regression, Standard error of estimate, Coefficient of determination and its interpretation, Correlation and causation.

Correlation coefficient, its properties and interpretation, Multiple and partial correlation coefficient and its interpretation.

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) “*Probability and Statistics*”, 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). “*Introductory Statistics*”, 5th ed. Jhon Wily & Sons. New York.
3. Walpole, R.E (2020). “*Introduction to Statistics*”, 3rd ed. Macmillan Publishing Company. New York.
4. Rauf, M (2001). “*Polymer’s Modern Statistics*”, Polymer Publication, Urdu Bazar, Lahore.
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1. Clark, G.M and Cooke, D. (2002), “*A Basic Course in Statistics*”, 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), “*Probability and Statistics for Engineers and Scientists*”, 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) “*Statistics for Business & Economics*”, 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), “*Introductory Statistics*” 10th ed. Addison-Wesley Publication. Company. Boston.

MTH-322	Introduction to Calculus	3(3-0)
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As per outlines prepared by Department of Mathematics

ECO-321	Introductory Economics	4(4-0)
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As per outlines prepared by Department of Economics

ENG-322	English Comprehension And Composition	3(3-0)
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As per outlines prepared by Department of English

SEMESTER-III

STA-401	Introduction to Probability Distributions	3(3-0)
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Basic properties (mean, variance, moment generating function) and applications of following univariate discrete probability distributions: Uniform Distribution, Bernoulli Distribution, Binomial Distribution, Poisson Distribution, Hypergeometric Distribution, Geometric distribution, Negative Binomial distribution.

Properties (total area under the normal curve, mean, median, mode, variance, mean deviation, quartile deviation, odd and even order moments, moment generating function, cumulant generating function, coefficient of skewness and coefficient of kurtosis) and application of the Normal distribution.

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) “*Probability and Statistics*”, 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). “*Introductory Statistics*”, 5th ed. Jhon Wily & Sons. New York.
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1. Clark, G.M and Cooke, D. (2002), “*A Basic Course in Statistics*”, 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), “*Probability and Statistics for Engineers and Scientists*”, 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) “*Statistics for Business & Economics*”, 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), “*Introductory Statistics*” 10th ed. Addison-Wesley Publication. Company. Boston.

STA-403	Statistics and Society	3(3-0)
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Statistical ideas and their relevance to public policy, business, humanities, and the social, health, and physical sciences; focus on critical approach to statistical evidence, quantitative or formal reasoning. How numbers are deployed in social settings, and how they are used in sociology to construct and challenge our understanding of the social world. Introduces students of quantification in modern societies, familiarization with the main instruments for the collection of quantitative data, and providing an overview of the methods used to treat such data in contemporary sociology. Descriptive and explanatory methods, and the vision of the social world implicitly associated with each of the methods we encounter. Basic descriptive skills of quantitative data analysis, notably how to download large data sets, how to manipulate variables and how to present statistical information in tabular and graphical form. Uses and misuses of Statistics in society.

References:

- **Wasserman, L.** (2004). *All of Statistics, A Concise Course in Statistical Inference*, Springer Texts in Statistics.
- **Chava, F. N. , Anna L. G.** (2018). *Social Statistics for a Diverse Society 8th Edition*, SAGE Publications Inc.
- **Dani, B. Z., Katie, M., Joan, G.** (2017) *International Handbook of Research in Statistics Education*, Springer

STA-405	Fundamentals of Parameter Estimation	3(3-0)
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Basic definition, Objective, advantages and disadvantages of sampling, Types of probability and non-probability sampling, Sampling distribution of mean under simple random sampling with and without replacements, Difference between two mean under simple random sampling with and without replacements, Variances, Proportion, Difference between two proportions, Central limit theorem.

Point estimation and its properties (unbiasedness, consistency, efficiency, sufficiency), Point estimate for population mean, Difference between two population means, proportion and difference between two population proportion, Population variance, Interval estimation, Confidence interval and its interpretation, Confidence interval for population mean, Difference between two population means, Proportion and difference between two population proportions, Population variance, One sided confidence interval, Determination of sample size for estimating population mean and proportion.

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) “*Probability and Statistics*”, 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). “*Introductory Statistics*”, 5th ed. Jhon Wily & Sons. New York.
3. Walpole, R.E (2020). “*Introduction to Statistics*”, 3rd ed. Macmillan Publishing Company. New York.
4. Rauf, M (2001). “*Polymer’s Modern Statistics*”, Polymer Publication, Urdu Bazar, Lahore.
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1. Clark, G.M and Cooke, D. (2002), “*A Basic Course in Statistics*”, 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), “*Probability and Statistics for Engineers and Scientists*”, 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) “*Statistics for Business & Economics*”, 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), “*Introductory Statistics*” 10th ed. Addison-Wesley Publication. Company. Boston.

CSI-301	Programming Fundamentals	3(2-1)
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As per outlines prepared by Department of Computer Science

MTH-433	Mathematical Methods & Vector Analysis	3(3-0)
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As per outlines prepared by Department of Mathematics

PST-321	Pakistan Studies	2(2-0)
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As per outlines prepared by Department of Pakistan Studies

SEMESTER-IV

STA-402	Applied Statistics	3(3-0)
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Index Number: Construction and application of index number. Simple and composite Index number. Fixed based and chain base method. Unweighted and weighted index number. Theoretical tests for index number.(Time Reversal Tests, Factor Reversal Test, Circular Test). Consumer price Index Number and Sensitive Price Index Number. Determination of Purchasing Power of Money, Real Wages, Inflation Rate on the basis of index number. Limitation of Index Number.

Time Series Analysis: Time Series Data, Components of Time Series, Measurements of Systematic components of time series (Measurement of Secular Trend, Seasonal Variation, Cyclical Fluctuation). Detrending, Deseasonalization of data, Forecasting and Prediction.

Vital Statistics: Meaning of Vital Statistics, registration of births and deaths in Pakistan. Uses of Vital statistics, Short comings of vital statistics, rates and ratio (Sex ratio, child ratio, birth and death ratio, population growth rate, classification of natal rates, death rates or mortality rates, crude death rate, infant mortality rate, specific death rate, case fatality rate, fertility rate, crude birth rate, specific birth rate, standardized death rate, reproduction rate, gross reproduction rate. Net reproduction rate, morbidity or sickness rate, marriage rate, divorce rate, etc. general fertility rate, total fertility rate.)

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) “*Probability and Statistics*”, 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). “*Introductory Statistics*”, 5th ed. Jhon Wily & Sons. New York.
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1. Clark, G.M and Cooke, D. (2002), “*A Basic Course in Statistics*”, 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), “*Probability and Statistics for Engineers and Scientists*”, 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) “*Statistics for Business & Economics*”, 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), “*Introductory Statistics*” 10th ed. Addison-Wesley Publication. Company. Boston.

STA-404	Basics of Statistical Hypothesis Testing	3(3-0)
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Basic definitions in hypothesis testing, types of error, power of test, construction and interpretation of OC curve. Hypothesis testing for single Normal population mean, proportion variance and regression parameters. Hypothesis testing for difference between two normal populations' means, proportions and ratio of two populations' variances.

Testing the hypothesis for equality of several normal population variances (test for homogeneity). Chi-Square independence test, Goodness of fit test.

Analysis of variance, One way analysis of variance, Two way analysis of variance, Partitioning of total SS and degree of freedom in one way and two way analysis of variance, Multiple comparisons tests.

Books Recommended:

1. Spiegel, M.R. Schiller, J.L. and Sirinivasan, R.L. (2001) "*Probability and Statistics*", 4th ed. Schaums Outlines Series. McGraw Hill. New York.
2. Wonnacott, T.H. and Wannacott, R.J (1999). "Introductory Statistics", 5th ed. Jhon Wiley & Sons. New York.
3. Walpole, R.E (2020). "Introduction to Statistics", 3rd ed. Macmillan Publishing Company. New York.
4. Rauf, M (2001). "Polymer's Modern Statistics", Polymer Publication, Urdu Bazar, Lahore.
5. Chaudhary, SM and Kamal, S. (2011) "*Introduction to Statistical Theory*" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

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1. Clark, G.M and Cooke, D. (2002), "*A Basic Course in Statistics*", 4th ed, Arnold, London.
2. Walpole, R.E., Myers, R.h and Myers, S.L. (2012), "*Probability and Statistics for Engineers and Scientists*", 9th Edition, Prentice Hall, New York.
3. Mclave, J.T., Benson, P.G. and Snitch, T. (2019) "*Statistics for Business & Economics*", 14th ed. Prentice Hall, New Jersey
4. Weiss, N.A. (2015), "*Introductory Statistics*" 10th ed. Addison-Wesley Publication. Company. Boston.

STA-406	Statistical Software	3(0-3)
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Statistical Data analysis using MS Excel, Minitab

MTH-436	Linear Programming	3(3-0)
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As per outlines prepared by Department of Mathematics

ECO-408	Issues in Pakistan Economy	3(3-0)
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As per outlines prepared by Department of Economics

ENG-421	Communication Skills	3(3-0)
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As per outlines prepared by Department of English

SEMESTER-V

STA-501	Probability and Probability Distributions-I	3(3-0)
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Probability set function. Kolomogrov's axioms. Conditional probability. Total probability and bayes theorem. Statistical Independence. Random variable. Probability functions. Probability density function and distribution function. Mathematical expectations. Moment generation function, cumulant generating function and characteristic function. Factorial moment. Joint density function. Conditional and marginal function and expectation. Uniqueness theorem. Inversion theorem. Chebyshev's inequality. Laws of large numbers. Central Limit Theorem.

Discrete uniform, Bernoulli, hyper geometric, Poisson, Negative Binomial, Multinomial. Distribution and their properties. Relationship among distribution

Continuous uniform, Normal, Negative exponential, gamma, beta, lognormal, weibull, Rayleigh, Pareto, double exponential and Cauchy Distribution. Applications of distributions and their properties. Relationship among distributions.

Books Recommended

1. Mood, A.M, Graybill, F.A and Boss, D.C.(1997). *Introduction to the Theory of Statistics*, MacGraw Hill, New York.
2. Hogg, R.M. and Craig, A.T. (1995), *Introduction to Mathematical Statistics*. Prentice Hall, Engle wood Cliffs, New Jersey.

Reference Books

1. Stirzaker, D. (1999). *Probability and Random Variables*. Cambridge University Press, Cambridge.
2. Stuart, A. and Ord; J.K. (1998), *Kendalls' Advanced Theory of Statistics*. Vol. I, Charles Griffin, London.
3. Freund, J. E. (1997)., *Mathematical Statistics*, Prentice Hall, New Jersey.

STA-503	Sampling Techniques-I	3(3-0)
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Basic Concepts, Requirement of a good Sample, Sampling and Non-Sampling Errors, Bias and its effects, Steps and Problems involved in planning and conduct of census and sample surveys. Probability and Non-Probability Sampling. Non-Probability Sampling Techniques, Quota Sampling, Judgment Sampling etc. Application and Limitations of Non-Probability Sampling Methods.

Probability sampling, Simple Random Sampling, Estimation of population mean, Total, Proportion, variance and standard error of estimates. Confidence limits. Sample Size Determination under different Conditions.

Supplementary Information: Stratification, Construction of Strata, Stratified random sampling. Different Method of allocation of Sample size. Sampling Variance (of stratified mean and stratified proportion) under various Allocation Methods, Gain in Precision in Stratified sampling as Compare to Simple Random Sampling. Essentials of Questionnaires Building.

Books Recommended

1. Cochran, W.G.(1996). *Sampling Techniques*, John Wiley and Sons, New York.
2. Kish, L. (1992). *Survey Sampling*, John VYiley, New York.

Reference Books

1. Ferguson, T.S. (1996), *A course in large sample theory*, Chapman & Hall, London.
2. Sukhatme, P.V, Sukhatme, B., Sukhatme, S., and Asok, A. (1985). *Sampling Theory of Survey with Application*. Iowa State University Press.
3. Des Raj, *Design of Sample Survey*. McGraw Hill, New York.

Singh, R. and Singh N, (1996), *Elements of Survey Sampling*, Kulwar, Dodrecht

STA-505	Statistical Methods	4(4-0)
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Applications of Binomial, Negative Binomial, Geometric, Hypergeometric, Poisson, Normal, Exponential, Chi-Square, t and F Distributions. Statistical Inference: Estimation of Parameters and Tests of Hypotheses, Simple and Composite Hypotheses. Type-I and Type-II Errors, Level of Significance and p-Values, Power of a test, Characteristic Function and O.C. Curve. Inference about Means, Proportions, Variances and Associated Power Curves, Determination of Sample Size.

Analysis of Linear Regression Models, Testing of Hypotheses about Simple and Multiple Regression Coefficients, Simple Correlation, Multiple and Partial Correlations Upto three Variables, Concept of Outliers.

Analysis of Categorized Data, Homogeneity of Variances, Bartlett Test. Partitioning of Chi-Square in a 2x2 Table, Fishers Exact Test, Log-Linear Models and their Applications. Non-Parametric Methods: The Sign Test. Wilcoxon Signed Rank Test, Mann-Whitney U Test, Runs test, Tests of Goodness of Fit, Tests of Randomness, Kruskal-Wallis Test, Friedman Test.

Books Recommended

1. Steel, R.G.D. Torrie, J.H. and Dickey, D.A. (1996). *Principles and Procedures of Statistics, Latest Editions*, McGraw Hill, New York.
2. Montgomery Douglas, C. and Peck Elizabeth A (1992), *Introduction to Linear Regression Analysis*, John Wiley and Sons, Inc. New York.
3. Dixon, W.J. and Massey, F.J. (1983). *Introduction to Statistical Analysis*, McGraw Hill, New York.

Reference Books

1. Zar J.H. “*Biostatistical Analysis*” 4th Edition, John Wiley and Sons, New York
2. Snedecor, G.W. & Cochran W.G. (1997). “*Statistical Methods*”, Iowa State University Press.
3. Ott, R.L. (1993). “*An Introduction to Statistical Methods and Data Analysis*”, Latest Edition, Duxbury Press, Belmont, California

4. Daniels. H., (1988). “*Applied Non-Parametric Statistics*”, John Wiley, New York
5. Larson, H.J. (1983.), “*Introduction to Probability Theory and Statistical Inference*”, John Wiley. New York.

STA-507	Introduction to Data Science	3(3-0)
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Big Data and data Science Hype, Datafication, Current Landscape of Perspectives, Skill Sets Needed. Statistical Inference: Population and Samples, Statistical Modeling, Probability Distributions, Fitting a model, Introduction to R. Exploratory Data Analysis and the Data Science Process: Basic Tools (Plots, Graphs, and Summary Statistics) of EDA, Philosophy of EDA, The Data Science Process. Three Basic Machine Learning Algorithms, Linear Regression, K-Nearest Neighbor (K-NN), K-Means. Machine Learning Algorithm, Application, and example of filtering Spam, Naive Bayes, Data Wrangling: APIs and other Tools for Scrapping the Web. Feature Generation and Feature Selection (Extracting meaning From Data), Customer Retention Example, Feature Generation (brainstorming, role of Domain expertise, and Place for Imagination), Feature Selection Algorithms, Filters, Wrappers, Decision Trees, Random Forests. Recommendation Systems: Building a User-Facing Data Product: Algorithmic Ingredients of a Recommendation Engine, Dimensionality Reduction, singular Value Decomposition, Principal Component Analysis. Mining Social-Network Graphs, Social Networks as Graphs, clustering of Graphs, Direct Discovery of Communities in Graphs, Partitioning of Graphs, and Neighborhood Properties of Graphs. Data Visualization: Basic Principles, Ideas and tools for Data Visualization, Examples of Inspiring Projects. Data Science and Ethical Issues, Discussions on Privacy, Security, Ethics, Next Generation Data Scientists.

Books Recommended:

- 1) O’Neil, C., and Schutt, R. (2014). “*Doing Data Science, Straight Talk from the Frontline*”. O’Reilly.
- 2) Leskovek, J., Rajaraman, A. and Ullman, J. (2014). “*Mining of Massive Datasets*”. v2.1, Cambridge University Press.
- 3) Murphy, K. P. (2013). “*Machine Learning: A Probabilistic Perspective*”.
- 4) Provost, F., and Fawcett, T. (2013). “*Data Science for Business: What You Need to Know about Data Mining and Data-analytic Thinking*”.

Reference Books:

- 1) Hastie, T., Tibshirani, R. and Friedman, J. (2009). “*Elements of Statistical Learning*”, 2nd ed. ISBN 0387952845.
- 2) Zaki, M. J., and Miera, W. (2014). “*Data Mining and Analysis: Fundamental Concepts and Algorithms*”. Cambridge University Press.
- 3) Han, J, Kamber, M., Pei, J. (2011). “*Data Mining: Concepts and Techniques*”, 3rd ed.

STA-507	Operational Research	3(3-0)
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Overview: history and definition of O.R. Introduction to linear programming. Formulation of LP model. Matrix Form, Canonical Form, Standard Form. Duality theory; Primal and dual form. Graphical solution of two variables. Row operations, Gaussian elimination. Simplex method. Network programming, Transportation, assignment and shortest path problems.

Integer programming: Gomoray's cutting plane method, Branch and Bound method, Introduction to CPM and PERT techniques. Inventory control models. ABC analysis and selective inventory management. Queuing Models.

Books Recommended

1. Taha, H.A. (1998). *Operations Research*. Mac Millan, London.
2. Brownson, R. (1983). *Operations Research - Schaums' Outline Series* - McGraw Hill.

Reference Books

1. Hillier, F.S. and Lieberman G. J. (1996): *Introduction to Operation' Research*, Holden Day.
2. Gupta, P.K. & Hira, D.S.(1994). *Operations Research*. S. Chand & Co., New Delhi.

SEMESTER-VI

STA-502	Probability and Probability Distributions-II	3(3-0)
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Transformation of variables of continuous and discrete types. Expectations of functions of random variables. Sum, Product and quotient of random variables. Cumulative distributions function and moment generation function techniques. Derivation of χ^2 , t and F-distributions and their properties. Cochran,s theorem. Distributions of sample mean and variance and their properties.

Bivariate distributions. Marginal and conditional distribution. Statistical independence. Conditional expectation and variance. Bivariate normal distribution and its properties. Variance of linear function of random variables.

Multivariate normal distribution. Its mean vector, covariance matrix and moment generating function j. Marginal and conditional distributions Distribution of quadratic forms in normally distributed random variable. Moments of quadratic forms.

Distribution of rth order statistics. Marginal density function of $Y(1)$, Marginal density function of $Y(n)$. Distribution of i-th and j-th order statistics. Joint density function of $Y(1)$ and $Y(n)$. Distribution of sample range, sample mid range. Moments of these order statistics and their properties. Sample Cumulative Distribution function.

STA-504	Sampling Techniques-II	3(3-0)
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Ratio Estimates in Simple and Stratified Random Sampling. Linear Regression Estimates and Their Variances in Simple and Stratified Sampling, Bias of Ratio and Regression Estimates The Variance and Estimated Variance for Ratio and Regression Estimates, Construction of Confidence Limits, Comparison of Simple Ratio and Regression Estimates, Combined Ratio and Separate Ratio Estimates.

Systematic Sampling, Sampling Variance of Estimate of Mean and Total, Comparison of Systematic Simple Random and Stratified Sampling for Linear Trend Population, Stratified Systematic Sampling in two Dimensions, One Stage Cluster Sampling, Sub-Sampling with Units of Equal and Unequal Sizes.

Critical Study of National Sample Surveys conducted in Pakistan: Census of Agriculture, Household Income and Expenditure Survey (HIES), Pakistan Demographic Survey (PDS) and National Population and Housing Census and Surveys (NPHCS)

Books Recommended

1. Cochran, W.G.(1996). *Sampling Techniques*, John Wiley and Sons, New York.
2. Kish, L. (1992). *Survey Sampling*, John VYiley, New York.

Reference Books

1. Ferguson, T.S. (1996), *A course in large sample theory*, Chapman & Hall, London.
2. Sukhatme, P.V, Sukhatme, B., Sukhatme, S., and Asok, A. (1985). *Sampling Theory of Survey with Application*. Iowa State University Press.
3. Des Raj, *Design of Sample Survey*. McGraw Hill, New York.

Singh, R. and Singh N, (1996), *Elements of Survey Sampling*, Kulwar, Dodrecht

STA-506	Design and Analysis of Experiments-I	4(4-0)
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Principals of Design of Experiments. Analysis of Variance and its Assumptions, Models: Fixed, Random and Mixed Effects Models. Analysis of Fixed Effects Models, Decomposition of Total Sum of Squares, Expected Values of Mean Squares. Model Adequacy Checking. Violation of the Assumptions and Transformations, Statement of Cochran's Theorem, Multiple Comparison Tests: Fisher's LSD Test, Duncan's Multiple Range Test (DMRT), Tukey's W-Honestly Significant Difference (HSD) Test, Scheffe's Test. Contrasts, Orthogonal Contrast, Testing of Hypotheses Involving Contrasts (Single Degree of Freedom Comparison), Scheffe's Method for comparing all Contrasts, Confidence Intervals

Basic Experimental Designs (Completely Randomized, Randomized Complete Block, Latin Square), Graeco-Latin Square. Cross-Over Designs. Layouts and Analysis. Missing Observations. Relative Efficiency of Designs. Analysis of Covariance with One Concomitant Variable For CR, RCB And LS Designs. Estimation of Missing Values by Analysis of Covariance.

Books Recommended

1. Montgomery D.C. (2000). *Design and Analysis of Experiments*, John Wiley, New York.
2. Steel, Rebert, G.D., Torrie James H., and Dickey David A. (1997). *Principles and Procedures of Statistics: A Biometrical Approach: Third Edition*. McGraw Hill, New York.

Reference Books

1. Kempthorne, O. and Mann, K.H. , Introduction to Experimental Design, , John Wiley & Sons.
2. Boniface, D.R. (1995). *Experiment Design & Statistical Methods*, Chapman & Hall.
3. Myres, R.H. and Montgomery, D.C. (1995). *Response Surface Methodology; Process & product Optimization using design*, John Wiley.
4. Clarke, G.M. (1994). *Statistics & Experimental Design.*, Edward Arnold.
5. Harold, R. L. (1992) *Analysis of Variance in Experimental Design*. Springer Verlag:
6. Maxwell, S.E. and Delaney, H.D.(1990). *Designing Experiments and Analysis of Data. A model comparison perspective*. Belmont and Wadson

STA-508	Population Studies	2(2-0)
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Sources of Demographic Data: The Population Census Registration of Vital Events. Housing & Demographic Surveys. Components of Population Growth, Composition of Population and

Vital Events. Testing the Accuracy of Demographic Data. Types and Sources of Errors. General Testing Procedures. Testing the Accuracy of Age and Sex Data. Basic Demographic Measures: Fertility And Mortality Measures. Mortality Rates. Total and General Fertility Rates. Life Tables: Construction of Complete and Abridged Life Tables. Different Types of Life Tables. Graphs of Lx, qx And dx. Description and Uses of Life Table Columns. Stationary Population Models. Population Estimates and Projections, Inter-Censal Estimates, Population Projections through Various Methods. Population Models: Theory of Demographic Transition. Consequences of World Population Growth & Population Explosion. State of Population In Pakistan. Development of Demographic Profile In Pakistan. Recent Demographic Parameters. Current and Future Demographic Activities in Pakistan.

Books Recommended

1. Hind, A., (1998). *Demographic Method*, Arriold.
2. Pollard, A.H., Yousaf, F & Pollard, G.M. (1982), *Demographic Techniques*, Pergamon Press, Sydney.

Reference Books

1. Govt. of Pakistan (1998), *National, Provincial and District census reports and other supplementary reports with respect to 1998 census*; PCO, Islamabad.
2. Palmore, J.A; Gardner , R.W. (1994), *Measuring Mortality Increase*; East West Centre, Honolulu.
3. Bogue, D.J; Arriagu, E.E. Anderton D.L. (1993), *Readings in Population Research Methodology, Vol. I-VIII*, United Nations Fund; Social Development Centre, Chicago.
4. Impagliazo J. (1993), *Deterministic Aspects of Mathematical Demography*, Springer Verlag, New York.
5. Rukanuddin AR. and Farooqi, M.N.I., (1988), *The State of Population in Pakistan - 1987*, NIPS, Islamabad.
6. Keyfitz N. (1983), *Applied Mathematical Demography*, Spnngler Venag N.Y.
7. United Nations (1996), *Added years of Life in Asia*. ESCAP; U.N., Thailand.
8. United Nations (1998), *World Population Assessment*, UNFPA: New York.

STA-510	Statistical Quality Control	3(3-0)
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Concept of quality control; total control; Total Quality Management (TQM). Statistical Methods in Quality Improvement. Statistical Process Control (SPC). Statistical Quality Control (SQC). Shewhart control charts: philosophy, construction, advantages. CUSUM and moving average control chart: Average Run Length (ARL); Fast Initial Response (FIR). ARL and FIR for X, R and S-charts. Process capability analysis: Designed experiments. Process improvements using design of experiments. Orthogonal fractional factorial designs. Acceptance sampling for attributes and variables. Acceptance sampling plans: Single, double, and multiple sampling plans with their O.C. curves, Military Standard 105 Sampling Plans. Introduction to ISO-9000 and ISO-14000 series.

Basic concepts of reliability: Structural reliability. Lifetime distributions (Failure models): Hazard rate; Gamma, Weibull, Gumbel, Log-Normal and Inverse Gaussian. Stochastic fatigue-rate models; point and interval estimation.

Books Recommended

1. Montgomery, D.C. (1998); *Introduction to Statistical Quality Control*. MacGraw Hill, New York.

Reference Books

1. Miltag H.J. and Rinne H. (1993), *Statistical Methods of Quality Assurance*, Chapman & Hall, London.
2. Nelson, W. (1990); *Accelerated Testing*. John Wiley, New York.
3. Gertsbakh, I.B. (1989); *Statistical Reliability Theory*. Marcel Dekker, New York.
4. Banks, J. (1989); *Principles of quality Control*. John Wiley, New York.
5. Ryan, T.P. (1989); *Statistical Methods for Quality Improvement*. John Wiley, New York.
6. Juran, J.M. and Grayana, F.K. (1988). ‘*Juran’s Quality Control Handbook*’. McGraw Hill New York.
7. Feigenbaum A.V. (1986). *Total Quality Control*. McGraw Hill, New York.
8. Lawless, J.F. (1982); *Statistical Models and Methods for Lifetime Data*. John Wiley, New York.

STA-512	Survey Research Methods	3(3-0)
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The Nature of Social Survey, Preliminary Study, The main Planning Problems, Pre-Test and pilot Survey, The Coverage of the Surveys, Methods of Collecting the Information; Documentary Soruces, Observation, Mail Questionnaires, Interviewing. Construction of Questionnaires; General principals of design, Question content, Question wording, open and pre-coded Questions, Question order. Scaling methods; Types of scales, rating scales, Thurstone scales, Likert Scales, Guttman Scales.Editing, Coding, Tabulation, Report Writing.

Sample Survey Project:

Conducting a small scale survey and preparing a comprehensive report.

Books Recommended

1. Abrams, M. A. (1951). *Social Surveys and Social Actions*, Heimemann, London.
2. Backstrom, C. H. and Hursh, G.D. (1963). *Survey research*,. North-western University Press, Evanston, III
3. C.A. Moser and G.Kalton. (1971), *Survey Methods in Social Investigation*, Ashgate, England.

SEMESTER-VII

STA-601	Econometrics-I	4(4-0)
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Introduction and Basic Concepts; Nature of Econometrics, Simple Linear Regression and Least Square Estimators, Properties of Linear Regression and Least Square Estimators, Inference in the Least Square Model, Equivalence of Three Test of Regression Coefficients i.e. Regression, ANOVA & Correlation. Tests of Equality of Regression Coefficients and Intercepts of the Simple Linear Regression, Prediction in the Least Square Model.

Linear Regression Models: General Linear Model, Assumptions of the Linear Model, Ordinary Least Squares Estimators, Properties of Least Squares Estimators, Partition of the total Sum of Square & Degrees of Freedom, Properties of the Residual, Prediction in General Linear Regression Model, Significance Tests and Confidence Intervals, Tests of Single and Set of Regression Coefficients. Least Square Estimators for Partition Matrix, Use of Extraneous Information in General Linear Regression Model, Tests of Significance of Subset of Coefficients, Exact Linear Restrictions, Extraneous Unbiased Restricted Estimator for Partition Matrix

Detection and Study of Outliers, Orthogonal Polynomials, Stepwise Regression, PC Regression. Specification of Models, Introduction to Models with Binary Response Variables, Generalized Linear Models, Generalized Additive Models.

Books Recommended

1. Gujrati. D. (1998). *Econometrics*, John Wiley, New York.
2. Johnston, J. and Di. Nardo, J., (1997). *Econometric Method*, Latest Edition, McGraw Hill, New York.

Reference Books

1. Baltagi, B. H. (1999). *Econometrics*, Latest Edition, Springer Varlog.
2. Draper, N.R. and Smith, H. (1998). *Applied regression analysis*, John Wiley, New York.
3. Wonnacot, T.H. and Wonnacot R.J. (1981). *Econometrics*, John Wiley, New York.
4. Guttman, I. (1980); *Linear Models: An Introduction*, John Wiley, New York.
4. Koutsoyiannis, A. (1980), *Theory of Econometrics*, MacMillan.

STA-603	Design and Analysis of Experiments-II	4(4-0)
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Factorial Experiments: 2^k , 3^k Series and Mixed Level Factorial Experiments and Their Analyses. Advantages and Disadvantages of Factorial Experiments $P \times Q$ Factorial In Randomized Complete Design.

Confounding in Factorial Experiments: Complete and Partial Confounding. Confounding in Fractional Replications, Split-Plot, Split Block and Nested Design. Missing Observations in Split-Plot Design.

Incomplete Block Designs: Balance Incomplete Block Design BIBD-Lattice Designs, Lattice Square and Youden Squares. Partially Balance Incomplete Block Design PBIBD with

Recovery of Intra-Block Information. Generalized Lattices, Introduction of Response Surface Methodology: First and 2nd Order Designs, Central Composite Designs, Fitting of Response Surface Models and Estimation of Optimum/Maximum Response.

Books Recommended

1. Montgomery D.C. (2000). *Design and Analysis of Experiments*, John Wiley, New York.
2. Steel, Rebert, G.D., Torrie James H., and Dickey David A. (1997). *Principles and Procedures of Statistics: A Biometrical Approach: Third Edition*. McGraw Hill, New York.

Reference Books

1. Mead, R. (1988). *The Design of Experiments*. Cambridge University Press, Cambridge.
2. Dad, M.N. and Giri, N.C, (1986). *Design and Analysis or Experiments*. John Wiley: New York.
3. Steel, Rebert, G.D., Torrie James H., and Dickey David A. (1997). *Principles and Procedures of Statistics: A Biometrical Approach: Third Edition*. McGraw Hill, New York.
4. Gomez, K.A., and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*, Latest Edition, John Wiley, New York.
5. Hicks, C.R. (1982) *Fundamental Concepts in Design and Analysis of Experiments*; Saunders.
6. Cochran, W.G. and Cox, G.M. (1957). *Experimental Design*, John Wiley, New York.

STA-605	Multivariate Analysis-I	3(3-0)
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Matrix Algebra. Introduction to Multivariate Analysis, Linear compound and linear combinations, Eigen values and eigen vectors.

Multivariate normal distribution, Its mean vector, covariance matrix , Moment generating function marginal distribution and conditional distribution, Estimation of mean vector and covariance matrix, Wishart distribution and their properties,

Hotelling's T^2 distribution and its application. Multivariate analysis of Variance (MANOVA).

Books Recommended

1. Johnson, R.A. and Wichern, D.W. (1992). *Applied Multivariate Statistical Analysis*. Prentice Hall, London.
2. Morrison, D. F. (1990) *Multivariate Statistical Methods*, McGraw Hill, NewYork.
3. Mardia, K.V., Kent, J.T. and Bibby, J.M. (1979) *Multivariate Analysis*, Academic Press, London.

Reference Books

1. Afifi, A. A. and Clark Virginia (1984). *Computer Aided Multivariate Analysis*, Lifetime learning publications. Belmont California.
2. Anderson, T.W. (1984). *An Introduction to Multivariate Statistical Analysis*, John Wiley, New York.
3. Chatfield, C. and Collins, A.J. (1980) *Introduction to Multivariate Analysis*, Chapman and Hall, London.
4. Everitt, B.J.(1974). *Cluster Analysis*, MacGraw Hill, New York.
5. Flury B. (1997) *A First Course in Multivariate Statistics*, Springer Valerg, New York.
6. Manly, B.F.J. (1994). *Multivariate Statistical Methods*, A Primer Latest Edition, Chapman and Hall, London.

STA-607	Statistical Inference-I	3(3-0)
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Properties of Estimators: Unbiasedness, Consistency, Sufficiency, Efficiency, Completeness. Cramer-Rao Inequality, Rao-Blackwell Theorem, and Lehman-Scheffe Theorem. Methods of Estimation of Parameters: Moments, Maximum likelihood, Least-squares, Minimum Chi-square, Bayesian method, Lyod's Method.

Recommended Books:

1. Mood, A.M., Graybill, F.A. and Boss D.C. (1997). *Introduction to the Theory of Statistics*. McGraw Hill, New York.
2. Hogg, R.V. and Craig, AT (1996). *Introduction to Mathematical Statistics*. Prentice Hall, New Jersey.

Reference Books

1. Levy, P.S. and Lemeshow, S. (1999). *Sampling of Populations: Methods and Applications*, Latest Edition, John Wiley, New York.
2. Lindgren, B.W. (1998). *Statistical Theory*. Chapman and Hall, New York.
3. Lehmann, E.L. (1997) *Testing Statistical Hypotheses*. Springer-Valag, New York.
4. Zacks, S. (1978), *Parametric Statistical Inference*, John Wiley, New York.
5. Lehmann, E.L. (1983) *Theory of Point Estimation*. John Wiley, New York.

6. Rao, C.R. (1973). *Linear Statistical Inference and its Applications*,. John Wiley, New York.
7. Stuart, A. and Ord. J.K. (1998). *Kendalls' Advanced Theory of Statistics* Vol. II. Charles Griffen, London.

STA-611	Statistical Computing-I	3(0-3)
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Statistical Data Analysis using any software; SPSS, or STATISTICA or SAS, Matlab

STA-629	Seminar	1(0-1)
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A special problem given by supervisor.

SEMESTER-VIII

STA-602	Econometrics-II	4(4-0)
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Errors In Variables, Problems of Autocorrelation; The Nature of the Problem, OLS Estimation in the Presence of Autocorrelation, The BLUE Estimator in the Presence of Autocorrelation, Consequences of Using OLS Estimation in Presence of Autocorrelation, Its Detection & Remedial Measures. Multicollinearity: It's Nature & the Estimation in the Presence of Multicollinearity, Consequences of Multicollinearity, Detection of Multicollinearity & its Remedial Measures.

Heteroscedasticity; its Nature & The OLS Estimation in the Presence Of Heteroscedasticity, Consequences of Using OLS in the Presence of Heteroscedasticity, Detection of Heteroscedasticity, Its Remedial Measures.

Ridge Regression, Lagged Variables, Dummy Variables, System of Simultaneous Linear Equations, Identification-Estimation Method: Least Variance Ratio, Two-Stage, Three-Stage and Restricted Least Squares. Test of Identifying Restrictions, Problems of Income and Wealth Distributions.

Books Recommended

1. Gujarati. D. (1998). *Econometrics*, John Wiley, New York.
2. Johnston, J. and Di. Nardo, J., (1997). *Econometric Method*, Latest Edition, McGraw Hill, New York.

Reference Books

1. Maddala, G.S. (1977). *Econometrics*, McGraw Hill. New York.
2. Searle, S.R.(1971) *Linear Models*, John Wiley, New York.
3. Montgomery, D.C., and Peck E.A. (1992). *Introduction to linear Regression Analysis*, Latest Edition. John Wiley and sons Inc. New York.
4. A Re-issue of Statistical Methods for Research Workers, The Design of Experiments and Statistical Methods and Scientific Inference, Edited by J. H Bennett, with a forward by F. Yates.

STA-604	Statistical Computing-II	3(0-3)
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Data Analysis and Statistical Programing using R Language

STA-606	Multivariate Analysis-II	3(3-0)
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Principal Component Analysis; Derivation of Principal Components, Principal Components From Covariance Matrix and Correlation matrix. Advantages and Disadvantages of Principal Component Analysis. Factor Analysis; Estimating the Factor Loading and Error Variance, Factor Rotation. Method of Estimation.

Discriminant Analysis; Discrimination Rules, Classification, Calculation of Misclassification Probabilities. Canonical Correlation; Derivation of Canonical

Correlations and Canonical Variables, Identifying the Canonical Variables. Cluster Analysis. Multidimensional Scalling

Books Recommended

1. Johnson, R.A. and Wichern, D.W. (1992). *Applied Multivariate Statistical Analysis*. Prentice Hall, London.
2. Morrison, D. F. (1990) *Multivariate Statistical Methods*, McGraw Hill, New York.
3. Mardia, K.V., Kent, J.T. and Bibby, J.M. (1979) *Multivariate Analysis*, Academic Press, London.

Reference Books

1. Afifi, A. A. and Clark Virginia (1984). *Computer Aided Multivariate Analysis*, Lifetime learning publications. Belmont California.
2. Anderson, T.W. (1984). *An Introduction to Multivariate Statistical Analysis*, John Wiley, New York.
3. Chatfield, C. and Collins, A.J. (1980) *Introduction to Multivariate Analysis*, Chapman and Hall, London.
4. Everitt, B.J.(1974). *Cluster Analysis*, MacGraw Hill, New York.
5. Flury B. (1997) *A First Course in Multivariate Statistics*, Springer Valerg, New York.
6. Manly, B.F.J. (1994). *Multivariate Statistical Methods*, A Primer Latest Edition, Chapman and Hall, London.

STA-608	Statistical Inference-II	3(3-0)
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Interval Estimation: Pivotal and other methods of finding confidence interval, confidence interval in large samples, shortest confidence interval, optimum confidence interval. Bayes Interval estimation.

Tests of Hypotheses: Simple and composite hypotheses, critical regions, Neyman-Pearson Lemma, power functions, uniformly most powerful tests. Deriving tests of hypothesis concerning parameters in normal, exponential, gamma and uniform distributions. Randomized Tests, Unbiased tests, Likelihood ratio tests and their asymptotic properties. Generalized likelihood-ratio tests.

Sequential Analysis: Introduction to sequential tests, Average sample number and Operating Characteristic functions.

Noncentral Distributions: The derivation of Chi-square, t and F and their applications.

Recommended Books:

1. Mood, A.M. Graybill, F.A. and Boss D.C. (1997). *Introduction to the Theory of Statistics*. McGraw Hill, New York.
2. Hogg. R.V. and Craig, AT (1996). *Introduction to Mathematical Statistics*. Prentice Hall, New Jersey.

Reference Books

1. Levy, P.S. and Lemeshow, S. (1999). *Sampling of Populations: Methods and Applications*, Latest Edition, John Wiley, New York.
2. Lindgren, B.W. (1998). *Statistical Theory*. Chapman and Hall, New York.
3. Lehmann, E.L. (1997) *Testing Statistical Hypotheses*. Springer-Verlag, New York.
4. Zacks, S. (1978), *Parametric Statistical Inference*, John Wiley, New York.
5. Lehmann, E.L.(1983) *Theory of Point Estimation*. John Wiley, New York.
6. Rao, C.R., (1973). *Linear Statistical Inference and its Applications*,. John Wiley, New York.
7. Stuart, A and Ord J.K. (1998). *Kendalls' Advanced Theory of Statistics Vol. II*. Charles Griffen, London.

➤ **ANY ONE FROM THE FOLLOWING OPTIONS**

STA-620	Research Report	4(0-4)
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OR

STA-612	Analysis Time Series and Forecasting	4(4-0)
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Stochastic Process, Stationary Time Series, Exponential Smoothing Techniques, Auto-Correlation and auto-covariance, estimates functions and standard error of the auto-correlation functions and PACF, Period gram, Correlogram, spectral density functions, comparison with ACF , Linear stationary models, autoregressive, moving average and mixed models, Non-stationary models, general ARIMA notations and models, minimum mean square forecasting, ARIMA Seasonal Models.

Books Recommended:

1. Chatfield, C. (1996). *“The Analysis of Time Series: An Introduction”*, Chapman and Hall, London.
2. Box, G.E.P. and Jenkins, G.M (1999). *“Time Series Analysis: Forecasting and Control”*, San Francisco.

Reference Books:

1. Cox, D. R., Hinckley D.V. and Nielsen O.E.B. (1996). “*Time Series Models- In Econometrics, finance and other fields*”, Chapman & Hall London.
2. Andy, P, West M. and Harrison, P. J. (1994) “*Applied Bayesian Forecasting and Time Series Analysis*“, Chapman & Hall New York.
3. Harvey, A.C. (1990). “*Forecasting Structural Time Series Models and the Calamander*”, Cambridge University Press, Cambridge.
4. Daggie, P.J. (1990), “*Time Series: A Biostatistics Introduction*”, Clarendon Press, Oxford.
5. Bovas, A. and Johannes, L. (1983), “*Statistical Methods for Forecasting*”, John Wiley. New York.
6. Priestley, M.B. (1981), “*Spectral Analysis and Time Series*”, Academic Press, London

OR

STA-614	Categorical Data Analysis	4(4-0)
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Introduction, describing two-way contingency tables, inference for two-way contingency tables, models for binary response variables, Log linear models, Fitting log linear and logit models, building and applying log linear models, log linear logit models for ordinal variables, multinomial response models for matched pairs, analyzing repeated categorical response data, logistic regression models and their analysis

Books Recommended:

1. Agresti, A. (1990), “*Categorical Data Analysis*”, John Wiley and Sons.
2. Cox, D.R. and Snell, E.j. (1989). “*The Analysis of Binary Data*”, Chapman and Hall, London.

Reference Books:

1. Bishop, Y.V.V., Fienberg, S.E. and Holland, P.W. (1975). “*Discrete Multivariate Analysis*”, MA: MIT Press Cambridge.
2. David, W.H., Leweshow, S.L. (1989). “*Applied Logistic Regression*”.
3. Mc Gullah, P. and Nelder, J.A. (1989). “*Generalized Linear Models*”, 2nd ed. Chapman and Hall, London.

OR

STA-618	Non Parametric Methods	4(4-0)
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The Binomial Test and Estimation of p, The Quantile Test and Estimation of the p-th quantile. Location estimates for single samples: The sign test, modified sign test, Wilcoxon signed rank test, confidence interval based on these tests, Runs test for randomness.

Distribution test and rank transformation. Kolmogrov’s test, Lilliefer’s test and Shapiro-Wilks test for normality, Tests and estimation for two independent samples; the median test, Wilcoxon Mann-whitney test, The Siegal-Turkey test, the squared rank test for Variance, Smirnov test, Tests for Paired samples, Kruskal-Wallis test, Friedman test, Multiple comparison with the Friedman test, Cochran’s test for binary responses. Spearman’s rank correlation coefficient, Kendall’s rank correlation coefficient. Theil’s regression method.

Recommended Books

- Conover, W.J. (1999), Practical Nonparametric Statistics, 3rd Edition. John Wiley and Sons, New York.
- Gibbons, L.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference. Marcel Decker, New York.
- Hollander, M. and Wolfe, A.D. (2013). Nonparametric Statistics Methods, 3rd Edition. John Wiley and Sons, New York.
- Maritz, J.S. (1995). Distribution-Free Statistical Methods. Chapman & Hall London.
- Sprent, P. and Smeeton, C.N. (2007). Applied Nonparametric Statistical Methods, 4th Edition. Chapman & Hall London.

OR

STA-616	Survival Data Analysis	4(4-0)
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Special features of Survival data: Patient time and study time, Survival function and hazard function, Time dependent and censored survival data. Nonparametric procedures: Estimation of Survival function, hazard function, median and percentiles of Survival times. Confidence interval and comparison of groups; stratified and log-rank tests for trend. Modeling of Survival data; hazard function modeling; its tests and confidence interval. The Weibul model for survival data. Exploratory data analysis and other models. Sample size requirement for survival study. Computer software for survival analysis; any available software like SPSS, S-plus, SAS, STATA.

Recommended Books:

1. Lee, E.T. (1997). “*Applied Survival Analysis*”, John Wiley and Sons, New York.
2. Parmer M.K.B. & Macklin D. (1995). “*Survival Analysis: A Practical Approach*”, John Wiley New York.
3. Lee, E.T. (1992). “*Statistical Methods for Survival Data Analysis*”, John Wiley. N.Y.

Reference Books:

1. Muller, R.G. and Xian Zhou (1996). “*Survival Analysis with long-term Survivors*”, John Wiley. New York
2. Brkett, M. (1995). “*Analyzing Survival Data from Clinical Trials and Observational Studies*”, John Wiley New York.
3. Collett, D. (1994). “*Modeling Survival Data in Medical Research*”, Chapman & Hall, London.
4. Eland Johnson, R.C and Johnson N.L. (1989). “*Survival Models & Data Analysis*”, John Wiley N.Y.
5. Turkey, J. (1987). “*Exploratory Data Analysis*”, John Wiley, New York.
6. Cox, DR. and Oakes, D. (1984). “*Analysis of Survival Data*”, Chapman & Hall London

OR

STA-616	Bayesian Analysis	3(3-0)
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Basic concepts of probability, Subjective probability, Probability density function and probability density kernel, Bayes theorem, Concept of Bayes theorem in Bayesian statistics, Application of Bayesian statistics, Differences between Bayesian statistics and classical statistics, Applications and concepts of Non-informative priors (uniform prior and

Jeffrey's prior), Informative priors, Conjugate priors and Posterior distributions, Selection and formulation of prior distribution for Bayesian analysis, Concept of hyperparameters, Different methods for elicitation of hyperparameter, Bayesian estimation of parameters, Bayes estimator, Posterior risk, Relationship between Bayesian method of estimation and classical methods of estimation, Use of softwares in Bayesian analysis.

Recommended Books

1. Reich, B. J., & Ghosh, S. K. (2019). Bayesian Statistical Methods. CRC Press, Taylor & Francis Group
2. Turkman, M. A. A., Paulino, C. D., & Müller, P. (2019). Computational Bayesian Statistics: An Introduction (Vol. 11). Cambridge University Press.
3. Bolstad, W.M. (2007). Introduction to Bayesian Statistics. 2nd Edition, John Wiley, New York.
4. DeGroot M. H. (2004) Optimal Statistical Decisions. John Wiley, New York.
5. Bernardo, J. M & Smith, A.F.M. (1994). Bayesian Theory, John Wiley, New York.
6. Lee, P. M. (1991). Bayesian Statistics, An Introduction, Oxford University Press, New York.
7. Berger, O.J. (1985), Statistical Decision Theory and Bayesian Analysis, 2nd Edition, Springer.
8. Ferguson, T.S. (1967) Mathematical Statistics: A Decision Theoretic Approach. Academic Press.
9. Miller, I., Miller, M., & Freund, J. E. (2014). John E. Freund's Mathematical Statistics with Applications. 8th Edition. Boston: Pearson.
10. Hogg, R. V., McKean, J. and Craig, A. T. (2012). Introduction to Mathematical Statistics. 7th Edition. Prentice Hall, Engle wood Cliffs, New Jersey.

