COURSE OUTLINE BRIEFS

DEPARTMENT OF STATISTICS

SARGODHA UNIVERSITY
Pathway to Progress

FACULTY OF SCIENCES

OVERVIEW

Statistics is the grammar of science, eyes of administration and most powerful tool for proving the data of research. Statistics is used to design surveys and experimental research, collect and analyze data, interpret and evaluate numerical evidence and communicate results.

History of the Department of Statistics is as old as the institution itself. However, BS and MSc programs at the department were started in 2008. In 2014, the department launched MPhil program to meet the research requirements. During this period the Department of Statistics has evolved as prominent center in statistical data analysis for research.

The Department has highly qualified faculty including three PhDs and four MPhils. The department is focused to train researcher beyond the traditional boundaries of the discipline of statistics encompassing research in surveys, probability and statistics for decision making in areas like business, industry and society. The graduates of this department are serving in diverse fields all over the country.

Academic Programs Offered

1. BS Statistics
2. MSc Statistics
3. MPhil Statistics

BS Statistics

Eligibility: At least 45% marks in intermediate or equivalent.
Duration: 04 Year Program (08 Semesters)
Degree Requirements: 124 Credit Hours

Semester I

Course Code	Course Title	Credit Hours
URCE-5101	English-I	3(3+0)
URCI-5105	Islamic Studies/Ethics	2(2+0)
MATH-5125	Calculus-I	3(3+0)
*****	General Course	3(3+0)
*****	General Course	3(3+0)
STAT-5101	Introductory Statistics	3(3+0)

Semester II

Course Code	Course Title	Credit Hours
URCE-5102	English-II	3(3+0)
URCP-5106	Pakistan Studies	2(2+0)
MATH-5126	Calculus-II	3(3+0)
*****	General Course	3(3+0)
*****	General Course	3(3+0)
STAT-5102	Introduction to Probability Distributions	3(3+0)

Semester III

Course Code	Course Title	Credit Hours
URCE-5103	English-III	3(3+0)
STAT-5103	Introduction to Computer	3(3+0)
*****	General Course	3(3+0)
*****	General Course	3(3+0)
STAT-5104	Basic Statistical Inference	3(3+0)

Semester IV

Course Code	Course Title	Credit Hours

URCE-5104	English-IV	3(3+0)
*****	General Course	3(3+0)
MATH-5127	Linear Algebra	3(3+0)
STAT-5105	Introduction to Regression Analysis & Experimental Design	3(3+0)
STAT-5106	Applied Statistics	3(3+0)

Semester V

Course Code	Course Title	Credit Hours
STAT-6107	Statistical Packages	3(3+0)
STAT-6108	Regression Analysis	4(3+1)
STAT-6109	Probability & Probability Distributions-I	3(3+0)
STAT-6110	Sampling Techniques-I	4(3+1)
STAT-6111	Design & Analysis of Experiment-I	4(3+1)

Semester VI

Course Code	Course Title	Credit Hours
STAT-6112	Econometrics	4(3+1)
STAT-6113	Non Parametric Methods	3(3+0)
STAT-6114	Probability & Probability Distributions-II	3(3+0)
STAT-6115	Sampling Techniques-II	4(3+1)
STAT-6116	Design & Analysis of Experiment-II	4(3+1)

Semester VII

STAT-6117	Statistical Inference-I	3(3+0)
STAT-6118	Applied Multivariate Analysis	4(3+1)
STAT-6119	Research Methods/Internship	3(3+0)
STAT-61**	Elective Course	3(3+0)
STAT-61**	Elective Course	3(3+0)

Semester VIII

Course Code	Course Title	Credit Hours
STAT-6120	Population Studies	4(3+1)
STAT-6121	Statistical Inference-II	3(3+0)
STAT-61**	Elective Course	3(3+0)
STAT-61**	Elective Course	3(3+0)
STAT-6139	Project/Research Report	3(3+0)

MSc Statistics

Eligibility: At least 45% marks in BA/BSc with Statistics compulsory of 200 marks or Equivalent Duration: 02 Year Program (04 Semesters)
Degree Requirements: 66 Credit Hours

Semester-I

Course Code	Course Title	Credit Hours
STAT-6201	Statistical Methods	3(3+0)
STAT-6202	Mathematical Methods for Statistics	3(3+0)
STAT-6203	Probability and Probability Distributions-I	3(3+0)
STAT-6204	Design and Analysis of Experiments-I	4(3+1)
STAT-6205	Sampling Techniques	4(3+1)

Semester-II

STAT-6206	Probability and Probability distributions-II	3(3+0)
STAT-6207	Design and Analysis of Experiments-II	4(3+1)
STAT-6208	Sampling and Survey Methods	4(3+1)
STAT-6209	Regression Analysis and Econometrics-I	3(3+0)
STAT-6210	Statistical Packages	4(3+1)

Semester-III

STAT-6211	Regression Analysis and Econometrics-II	4(3+1)
STAT-6212	Statistical Inference-I	3(3+0)

OPTIONAL (S)/ Thesis (Three optional would be opted from the following List)

STAT-6213	i. Quality Control& Quality Management	3(3+0)
STAT-6214	ii. Management & Operations Research	3(3+0)
STAT-6215	iii. Official Statistics	3(3+0)
STAT-6216	iv. Actuarial Statistics-I	3(3+0)
STAT-6217	v. Robust Methods	3(3+0)

Semester-IV

STAT-6218	Statistical Inference-II	3(3+0)
STAT-6219	Non-Parametric Methods	3(3+0)
STAT-6220	Population Studies	4(3+1)

OPTIONAL(S)/ Thesis:

	(Two optional would be opted from the following List)		
STAT-6221	(i) Numerical Methods		
STAT-6222	(ii)	Time Series Analysis & Forecasting	3(3+0)
STAT-6223	(iii)	Multivariate Analysis	3(3+0)
STAT-6224	(iv)	Bio Statistics	3(3+0)
STAT-6225	(v)	Actuarial Statistics-II	3(3+0)
STAT-6226	(vi)	Decision Theory	3(3+0)
STAT-6227	(vii)	Bayesian Statistics	

MPhil Statistics

Eligibility: MSc/BS Statistics (16 years of education) degree from HEC recognized institution with at least second Division or CGPA 2.00 out of 4.00.
Duration: 02 Year Program (04 Semesters)
Degree Requirements: 30 Credit Hours

Core Courses in Semester I

Course Code	Course Title	Credit Hours
STAT-7101	Linear Models and Regression Analysis-I	3(3+0)
STAT-7102	Statistical Process Control	3(3+0)
Any two courses from the optional courses depending upon the availability of resources		

Core Courses in Semester II

Course Code	Course Title	Credit Hours
STAT-7103	Linear Models and Regression Analysis-II	3(3+0)
STAT-7104	Advanced Statistical Inference	3(3+0)
Any two courses from the optional courses depending upon the availability of resources		

Optional Courses

Course Code	Course Title	Credit Hour
STAT-7105	Advanced Probability Theory	3(3+0)
STAT-7106	Multivariate Methods	3(3+0)
STAT-7107	Multivariate Analysis	3(3+0)
STAT-7108	Time Series and Forecasting	3(3+0)
STAT-7109	Advanced Categorical Data Analysis	3(3+0)
STAT-7110	Logical Reasoning and Research Methods	3(3+0)
STAT-7111	Survey Sampling	3(3+0)
STAT-7112	Survival Data Analysis	3(3+0)
STAT-7113	Applied Stochastic Models	3(3+0)
STAT-7114	Spatial Data Analysis	3(3+0)
STAT-7115	Measure Theory	3(3+0)
STAT-7116	Inference in Stochastic Processes	3(3+0)
STAT-7117	Bayesian Analysis	3(3+0)
STAT-7118	Optimization Techniques	3(3+0)
STAT-7119	Statistical Ecology	3(3+0)
STAT-7120	Medical Statistics	3(3+0)
STAT-7121	Analysis of Clinical Trials	3(3+0)
STAT-7122	Stochastic Models in Finance	3(3+0)
STAT-7123	Genetic Data Analysis	3(3+0)

STAT-7124	Generalized Linear Models	3(3+0)
STAT-7125	Analysis of Repeated Measures	3(3+0)
STAT-7126	Design of Experiments-Factorial Experiments	3(3+0)
STAT-7127	Non-Linear Estimation	3(3+0)
STAT-7128	Applied Logistic Regression	3(3+0)
STAT-7129	Bayesian Decision Theory	3(3+0)
STAT-7130	Advanced Operations Research	3(3+0)
STAT-7131	Numerical Analysis and Stochastic Simulation	3(3+0)
STAT-7132	Mixture Distributions	3(3+0)
STAT-7133	Mathematical Demography	3(3+0)
STAT-7134	Multi-level Modeling	3(3+0)

Semester III-IV

	Dissertation	6(0+6)

BS
STATISTICS

STAT- 5101 **Introductory Statistics** **3(3+0)**

The purpose of this course is to elaborate the basic concepts and knowledge about statistics. The course is designed about the importance of statistics in daily life as well as the uses of statistics in different fields of life such as mathematics, agriculture, marketing, finance, geography, mass communication, computer science, engineering, social sciences, and various fields' medical science, etc. This course deals with the graphical representation to gives the general knowledge about how can justify the real life problem throw a graphical way. The course gives the guideline about the measure of the location like arithmetic mean, median, mode, harmonic mean, and geometric mean their uses, advantages and disadvantages with various aspects of real life data set. The application of the measure of dispersion is also an important part of this course. The shape of the distribution, method of identifying the shape of the distribution such as skewness and kurtosis are there in the scheme. The basic concepts of the probability theory, the classical probability with their application in various fields, and the different laws of probability are part of this course. This focuses on the conceptual and numerical formation of descriptive statistics.

Contents

1. The nature and scope of the statistics.
2. Measurement scales
3. Organizing of Data
4. Classification of Data
5. Graphs and Charts
6. Stem- leaf diagram,
7. Box and whisker plots and their Interpretation.
8. Measures of Central Tendency
9. Measure of Dispersion:
10. Properties of measure location
11. Uses of measure location
12. Application of the measure of dispersion
13. Calculations for the grouped and ungrouped Data.

Recommended Texts

1. Chaudhary, S. M. (2014). *Introduction to statistical theory* (8^{th} ed.). Lahore: Ilmi Kitab khana.
2. Clark, G. M. & Cooke, D. (1998). *A basic course of statistics* (4^{th} ed.). London: Arnold.

Suggested Readings

1. Weiss, N. A. (2015). *Introductory statistics* (10^{th} ed.). London: Pearson.
2. Spiegel, M. R., Schiller, J.L. & Sirinivasan, R. L. (2000). *Probability and statistics* (2^{nd} ed.). New York: McGraw Hill.
3. Walpole, R.E., Myers, R. H., & Myers, S.L. (1998). *Probability and statistics for engineers and scientist* (6^{th} ed.). New York: Prentice Hall.

STAT-5102 Introduction to Probability Distributions 3(3+0)

The main objective of introducing this course is to provide the basic concepts about the problems related to the probability theory. This course deals with the different rules of probability like additive and multiplicative law. The course also discusses the conditional probability of the events and their applications in multiple area. The empirical implication of discrete and continuous random variables in casual events is also considered. The course provides an understanding for discrete set of variables and their probability distributions and conversion of the probability distribution on special situations in different phenomena of the practical environments. This course concern with multiple types of discrete probability distributions like Bernoulli distribution, binomial distribution, negative binomial distribution, geometric distribution, Poisson distribution, multinomial distribution, and the hypergeometric distribution. The fitting of the parameter of these distribution and their applications are also the major part of this course. Some continuous type distribution such as Uniform distribution, Normal distribution, exponential distribution, gamma distribution, and beta distribution are also considered at the numerical platform. This course enables how to apply these distributions on real life situations for planning and suggestions.

Contents

1. Basic concepts of probability
2. Discrete random variable
3. Continuous random variable
4. Laws of Probability
5. Conditional Probability
6. Bernoulli trials.
7. Properties, applications.
8. Fitting of Binomial, Poisson.
9. Hypergeometric distribution,
10. Negative Binomial.
11. Geometric distributions.
12. Continuous Random Variable.

Recommended Texts

1. Spiegel, M. R., Schiller, J. L. & Sirinivasan, R. L. (2000). *Probability and statistics.* (2^{nd} ed.). New York: McGraw Hill.
2. Clark, G. M. & Cooke, D. (1998). *A basic course in statistics.* (4^{th} ed.). London: Arnold.

Suggested Readings

1. Walpole, R. E., Myers, R. H & Myers, S. L. (1998). *Probability and statistics for engineers and scientist*. (6^{th} ed.). New York: Prentice Hall.
2. Mclave, J. T., Benson, P. G. & Snitch, T. (2005). *Statistics for business & economics* (9th ed.). United States: Prentice Hall.

STAT-5103 Computer Applications in Statistics 3(3+0)

The objective of this course is to provide applicable knowledge about computer and the use of basic software's. It involves the transformation of data, Introduction to Microsoft Office Word, Excel and power point. It focuses on documents printing, scanning, internet application and private networks. Threats to computer security and measures to protect computer security are also the parts of the course. The course deals with the basic tools of statistics on Microsoft office. Several tools of measure of location are learning in excel. The applications of hypothesis testing are also doing in Microsoft excel. The numerical and theoretical application of testing are part of this course. Random number garneting with respect to various distribution like the normal distribution, gamma distribution, beta, binomial, chi-square, etc. the course also deals with the some measure of dispersion like range, mean deviation and variance on excel. Methods of drawing sample are also learned in this course. This course is very suitable for students with practical point of view.

Contents

1. What is Computer?
2. Computer for Individual users
3. Parts of computer Input and Output Devices
4. Transforming data into information
5. Data representation
6. Introduction to Ms Office(Ms Word, Ms Excel, Power Point, Document Imaging)
7. Documents scanning & printing,
8. Paint, Privacy and Security (Large databases)
9. Private networks
10. The internet Web, Major laws of privacy
11. Threats to Computer Security
12. Measures to protect Computer Security, Viruses)
13. Testing of hypothesis

Recommended Texts

1. Lebenon, G. & El-Geish, M. (2018). *Computing with data: An introduction to data industry.* USA: Springer.
2. Herkenhoff, L. and Fogli, J. (2013). *Applied statistics for business and management using microsoft excel.* USA: Springe

Suggested Readings

1. Foley, J. D., Van Dam, A., Feiner, S. K., Hughes, J. F., & Phillips, R. L. (1994). *Introduction to computer graphics.* Addison-Wesley: Laurie Ann Ulrich,
2. Faithe, W. (2016). Microsoft office 2016 at work for dummies. New York: John Wiley & Sons.

STAT- 5104 Basic Statistical Inference 3(3+0)

The aim of this course is to provide a strong conceptual foundation of basic statistical inference, with an emphasis on practical aspects of the interpretation. The course deals with the calculation of point estimation and interval estimation at numerical platform. The properties of a good estimator are also discussed in this course. It focuses on testing of hypothesis related to a single population mean, two means. The variety of tests for dependent and independent samples are also considered like z test, paired t test, pooled t test and welch t test. It also involves derivation of power functions of different tests for comparing and evaluation of the tests. Variation plays a vital role in data analysis. So, this also covers testing for population variances. The real-life application of statistical inference with respect to various field are also the part of this course.

Contents

1. Estimation
2. Interval Estimation
3. Interval estimation for one and two samples.
4. Nature of Hypothesis Testing and Types of errors.
5. Hypothesis Testing for Population Mean and variance.
6. Inferences for Two Population Means.
7. Large-sample inferences for Two Populations using Independent Samples.
8. Inferences for the Mean of Two Normal Populations using Independent Samples (variances are assumed Equal/Not Equal).
9. Inference for Two Populations Mean using Paired Samples.
10. Inferences for Population Proportions.
11. Hypothesis Testing for Population Proportion.
12. Inferences for Two Populations
13. Proportions using Independent Samples,
14. Estimation of sample size.
15. Chi-Square Procedure.

Recommended Texts

1. Walpole, R. E., Myers, R. H. & Myers, S. L. (2007). *Probability and statistics for engineers and scientists* (8th ed.). India: Pearson Prentice Hall.
2. Weiss, N. A. (2017). *Introductory statistics*. (10th ed.). United States: Pearson Education.

Suggested Readings

1. Spiegel, M. R., Schiller, J. L. & Sirinivasan, R.L. (2000). *Probability and statistics* (2nd ed.). New York: McGraw Hill.
2. Clark, G. M. & Cooke, D. (1998). *A basic course in statistics* (4th ed.). London: Arnold.
3. Mclave, J. T., Benson P.G. & Snitch, T. (2005). *Statistics for business and economics*. (9th ed.). Indian: Pearson Prentice Hall.

STAT-5105 Introduction to Regression Analysis & Experimental Design 3(3+0)

Regression is a statistical method used in finance, investing, and other disciplines that attempts to determine the strength and character of the relationship between one dependent variable and a series of other variables. The goal can be focused on explanation, prediction or both.). Regression analysis produces a regression equation where the coefficients represent the relationship between each independent variable and the dependent variable. Regression analysis is widely used for prediction and forecasting, however, in some situations it can be used to infer casual relationships between the independent and dependent variable. Another major use of regression analysis is determining the strength of predictors. The aim of this course is to develop a solid theoretical background in the regression analysis and helps in predicting and forecasting the results, also the applicable knowledge about statistics and experimental design, which can apply in different fields of study. It discusses the concepts of regression and correlation. This covers one-way and two-way analysis of variance, design of experiments, basic principles of design of experiments, also layout and analysis of different experimental designs and its applications in different fields. Multiple comparisons (LSD and Duncan's test) and non-parametric statistical methods are parts of the contents.

Contents

1. Concepts of Regression
2. Correlation.
3. Simple Linear regression,
4. Multiple Regression
5. Inference regarding regression parameters.
6. Linear correlation: simple,
7. partial and multiple correlation,
8. Inference regarding correlation coefficient.
9. Coefficient of determination.
10. One-Way ANOVA
11. Two-Way Analysis of Variance.
12. Design of Experiments,
13. Basic Principles of Design of Experiments.
14. Layout and Analysis of Completely Randomized Design,

Recommended Texts

1. Chaudhary, S. M. (2014). *Introduction to statistical theory.* (8th ed.). Lahore: Ilmi Kitab khana.
2. Clarke, G. M., & Kempson, R. E. (1994). *Introduction to the design and analysis of experiments*. New York: John Wiley & Sons.

Suggested Readings

1. Gujrati, D. (2004). *Basic econometrics*. New York: John Wiley & Sons.
2. Walpole, P. E., Myers, R. H., & Myers, S. L. (2007). *Probability and statistics for engineers and scientists* (8th ed.). India: Pearson Prentice Hall.

STAT- 5106 **Applied Statistics** **3(3+0)**

Applied statistics are the root of data analysis, and the practice of applied statistics involves analyzing data to help define and determine business needs. With today's increased access to big data, companies are looking for statisticians, data analysts, data for scientists, and other professionals with applied statistics knowledge who can visualize and analyze data, make sense of it all, and use it to solve real-world problems. Companies have so much data, and properly analyzing it can lead to increasing efficiency and profitability. Government agencies, nonprofits, and other organizations can use data to help prevent disease, collect important demographic information, steer political campaigns, and test potential life-saving pharmaceutical products. Data are a huge asset, and its growth has led to the overwhelming demand for statisticians and other professionals with advanced applied statistics skills. The aim of the course is to describe the mathematical or theoretical concepts, interpretation of statistically based conclusion and official use of statistics in different filled. The course is designed for making inference on the basis of a sample from a population, importance of sampling in the field area. This course deals with the component of time series index number and vital statistics. This course provides knowledge about the census and survey problems and factors of business and irregularity of data. This focuses on the conceptual and numerical formation and decision making.

Contents

1. Need of sampling
2. Sample versus population
3. Random and nonrandom sampling
4. Concepts of statistic and population parameter.
5. Sampling techniques:
6. Simple Random, Stratified
7. Systematic random sampling.
8. Census and survey problem, ramming of questionnaire.
9. Sampling and Non-Sampling Errors.
10. Index numbers: construction and uses of index numbers
11. Un-weighted index numbers (simple aggregative index, average of relative price index numbers).
12. Weighted index numbers (Laspayers, Paaches and Fishers ideal index numbers). Consumer price index (CPI) and Sensitive Price Indicators.
13. Time Series Analysis:

Recommended texts

1. Chaudhary, S. M. (2014). *Introduction to statistical theory* (8th ed.). Lahore: Ilmi Kitab khana.
2. Clark, G. M. & Cooke, D. (1998). *A basic course of statistics* (4th ed.). London: Arnold.

Suggested Readings

1. Cochran, W. G. (1977). *Sampling techniques*. (3rd ed.). New York: John Wiley & Sons.
2. Walpole, R. E., Myers, R. H. & Myers, S. L. (1998). *Probability and statistics for engineers and scientis*t (6th ed.). New York: Prentice Hall.

STAT-6107 **Statistical Packages** **3 (3+0)**

This course provides an understanding to tackle real life variables as well as the artificial environment of random variables by simulating on different software. After studying this course, student will be able to understand about inserting, coding, sorting, filtering and grouping variables on SPSS. It deals with implementing statistical tools like all measures of central tendency, dispersions, graphical procedures, measures of correlational structures Simple and Multiple Regression and various estimation and testing procedures. Computation of probability of different events and dealing with probability distributions are also of major concerns. It also discuss how to perform time series analysis on SPSS, MINITAB and Eviews. This course also signifies how to perform complex statistical analysis like principal component analysis, factor analysis, culture analysis and discernment analysis on different software. Methods to simulate any random variable or statistic and identifying distribution of random variables are also provided in this course.

Contents

1. Introduction to SPSS.
2. Introduction to Minitab.
3. Data manipulation in Minitab, graphical representation in Minitab, Qualitatively and Quantitative data presentation and analyzing data using Minitab.
4. Regression modeling with Minitab
5. Design of experiments using Minitab
6. Statistical quality control with Minitab
7. Time Series Analysis using Minitab
8. Programming and simulation in R.
9. Introduction of SPSS, data manipulation in SPSS.
10. Simple arithmetic in SPSS, SPSS function related to probability distributions, SPSS modules, simple graphing in SPSS.
11. Analysis using SPSS syntax programming.
12. Use of Eviews.

Recommended Texts

1. Ryan, B. F., Joiner, B. L. & Cryer, J. D. (2005). *Minitab handbook* (5th ed.). California: Duxbury Press.
2. Delwiche, L. D. & Slaughter, S. J. (1998). *The little SAS book: A primer* (2nd ed.). North Carolina: SAS institute.

Suggested Readings

1. Crawley, M. J. (2007). *The R book*. New York: John Wiley & Sons.
2. IBM SPSS. (2011). *IBM SPSS statistics 19.0 core system user's guide*. Prentice Hall.
3. Vogelvang, B. (2005). *Econometrics: Theory and applications with eviews*. Financal Times Management.

STAT-6108 **Regression Analysis** **4 (3+1)**

This course covers fitting and evaluating linear regression models (simple regression, multiple regression, and hierarchical regression), including assessing the overall quality of models and interpreting individual predictors for significance. R-Square is explored in depth, including how to interpret R-Square for significance. Together with coverage of simple, multiple and hierarchical regression, we'll also explore the correlation, an important statistical procedure that is closely related to regression. It aims to emphasize both the theoretical and practical aspects of statistical modeling typically focusing on the techniques for estimating regression models of different kinds. It also enlightens the applications of different prediction models utilized in the both long-term and short-term time period. This covers statistical methods related to modeling based strategies and cause and effect terminology. By the end of this course students will be skilled in running and interpreting their own linear regression analyses, as well as critically evaluating the work of others. Examples of running regression on some statistical software like SPSS, Minitab, Mathematica and R programs are provided.

Contents

1. Introduction to regression and its types
2. Introduction to correlation and its types
3. Simple and multiple linear regression models
4. Linear regression and its assumptions,
5. Least squares estimator,
6. Maximum Likelihood Estimator,
7. Tests of significance for regression model and regression parameters.
8. Confidence interval for regression parameters,
9. Interval estimation for predicted response
10. Regression models with single and multiple qualitative predictors
11. Stepwise regression and regression model selection criteria's
12. Test of linearity of regression, Use of extraneous information in linear regression model.
13. Residual analysis, Detection and study of outliers and influential observations,
14. Polynomial regression,
15. Orthogonal polynomial, orthogonal regression analysis and Specification of models

Recommended Texts

1. Draper, N. R. & Smith, H. (2004). *Applied regression analysis*. New York: John Wiley & Sons.
2. Montgomery, D. C., Peck, E. A. & Vining, G. G. (2012). *Introduction to linear regression analysis.* New York: John Wiley & Sons.

Suggested Readings

1. Rawlings, J. O., Pantula, S. G. & Dickey, D. A. (2001). *Applied regression analysis: A research tool*. USA: Springer.
2. Dielman, T. E. (2001). *Applied regression analysis for business and economics*. Pacific Grove.
3. Yan, X., & Zu, X. G. (2009). *Linear regression analysis: Theory and computing*. World Scientific Publications.

STAT-6109 Probability & Probability Distributions-I 3(3+0)

Probability theory is the branch of mathematics that deals with modeling uncertainty. Probability distribution indicates the likelihood of an event or outcome. It is important because of its direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. This course is designed to establish conceptual framework ofhandling and understanding uncertain events probability and probability distributional approach, basic probability axioms and rules and the moments of discrete and continuous random variables as well as be familiar with commonly named discrete and continuous random variables. This course enables the students to understand how to derive the probability density function of transformations of random variables and use these techniques to generate data from various distribution, how to calculate probabilities, and derive the marginal and conditional distribution of bivariate random variables. Methods on computations on Total probability theorem and Bayes theorem with implementation on the real life phenomenon are also provided. This course enables students how to derive distribution of functions of random variables by using the cumulative distribution function, transformation and m.g.f techniques.

Contents

1. Probability as a set function, Conditional Probability
2. Bayes' theorem, Chebychev's inequality.
3. Random Variables, Distribution function and Probability density function
4. Joint distributions
5. Probability density functions of two or more random variables
6. Marginal and conditional distributions
7. Stochastic independence
8. Mathematical expectations
9. Conditional expectations.
10. Variance and moments
11. Probability generating functions, Moment generating functions
12. Characteristics function and their existence properties.
13. Relation between moments and cumulants,

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2013). *Introduction to mathematical statistics* (7th ed.). New York: Prentice Hall.
2. Stuart, A. & Ord, J. K. (1998). *Kendal's advanced theory of mathematical statistics* (1st ed.). London: Charles Coriffi and Co.
3. Mood, A. M, Graybill, F. A. & Boes, D. C. (1997). *Introduction to the theory of Statistics*. New York: McGraw Hill.

Suggested Readings

1. John, R. 2006). *Mathematical statistics and data analysis*. Duxbury Press.
2. Khan, M. K. (1996). *Probability with applications*. Lahore: Maktiba Ilmi.
3. Scheaffer, R. L. (1990*). Introduction to probability and its applications.* Kent: PWS.

STAT-6110 Sampling Techniques-I 4(3+1)

A *sampling technique* is the name or other identification of the specific process by which the entities of the *sample* have been selected. Sampling techniques are an important source of statistical data. A great many published statistics on demographic, economic, and political and health related characteristics are based on survey data. Simple random sampling is a well-known method of sampling but, for reasons of efficiency and practical constraints, methods such as stratified sampling and cluster sampling are typically used by statistical authorities such as the Australian Bureau of Statistics and by market research organizations. A well designed sampling procedure ensures that we can summarize and analyze data with a minimum of assumptions and complications. This course deals with the basic concepts of sampling, requirements of a good sample, determination of sample size etc. The course provides the mathematical and conceptual formation of sampling techniques especially for simple random sampling and stratified random sampling which are the types of probability sampling. Ratio and regression estimates in simple random sampling are also the parts of the contents. This course is designed for the different types of sampling and selection and estimation procedures.

Contents

1. Basic concepts, advantages of sampling method, requirements of a good sample,
2. Bias, sampling and non-sampling errors.
3. Steps and problems involved in planning and conduct of census and sample surveys.
4. Selection and estimation procedures.
5. Description and properties of simple random sampling for properties and percentages.
6. Estimation of variances, standard errors
7. Confidence limits.
8. Sample size determination under different conditions.
9. Description and properties of stratified random sampling.
10. Formation of strata
11. Different methods of allocation sample size,
12. Systematic sampling.
13. Description and properties systematic sampling
14. Ratio and regression estimates in simple RS
15. Ratio and regression estimates in stratified random sampling.

Recommended Texts

1. Lohr, S. L. (2010). *Sampling design and analysis* (2nd ed.). Cole: Brooks.
2. Des, R. & Chandhok, P. (1998). *Sample survey theory*. New Delhi: Narosa Publishing House.

Suggested Readings

1. Scheaffer, R. L., Mendenhall, W., Ott R. L. & Gerow, K. G. (2012). *Elementary survey sampling*.(7th ed.). Cole: Brooks
2. Sukhatme, P.V., Sukhatme, B., Sukhatme, S. & Asok, A. (1985). *Sampling theory of survey with application.* Lowa State: University Press.

STAT-6111 Design and Analysis of Experiments-I 4(3+1)

The aim of this course is to deliver the applicable knowledge about Statistics and Experimental Design, which can apply in different fields of study and to develop a skills on the data collection from a designed experiment, description measures of data, interpretation of results, and decision making. It deals with a thorough introduction to statistical experimental design, and the statistical methods used to analyze the resulting data. The concepts of comparative experiments, ANOVA and mean separation procedures will be reviewed; blocking (complete and incomplete) will be discussed, the derivations of different Experimental Designs and its applications in different fields. It also discusses the estimation of missing observations in basic designs. Various designs are discussed and their respective differences, advantages, and disadvantages are noted. This covers Layout analysis and related efficiency of completely randomize, randomized complete block, Latin square, Greco Latin square and Cross-over designs. Multiple comparisons tests and Analysis of covariance are part of the contents. At the end of the semester, students will be trained in statistical modeling and in the choice of experimental designs for use in scientific investigations. More specifically, students will be able to design and conduct an experiment.

Contents

1. Principles of experimental design
2. One way and Two-way classification
3. Layout and analysis and related efficiency
4. Completely randomized complete block, its layout and analysis
5. Latin square Design, its layout and analysis
6. Greco Latin Square Design
7. Cross-over designs
8. Estimation of missing observations in basic designs.
9. Fixed effect models
10. Random effect models.
11. Mixed effect models
12. Multiple comparisons tests

Recommended Texts

1. Montgomery, D. C. Sons (2019). *Design and analysis of experiments* (10th ed.). New York: John Wiley & Sons.Clarke, G. M. & Kempthon, R. E. (1997). *Introduction to the design and analysis of experiments*. London: Edward Annold.
2. Boniface, D. R. (1995). *Experiment design and statistical methods*. London: Chapman and Hall.

Suggested Readings

1. Bland, M. (2015). *An Introduction to medical statistics* (4th ed.). Oxford: University Press.
2. Matthews, N. S. (2006). *Introduction to randomized controlled clinical trials* (2nd ed.). London: Chapman and Hall.

STAT-6112 **Econometrics** **4 (3+1)**

This course introduces the regression methods for analyzing data in economics. This is an introductory course in the theory and practice of classical Econometric Methods. The main components of the course deal with Single Equation Models, Dynamic Equation Models, Instrumental Variable Estimation and Multiple Equation Models. This course emphasizes both the theoretical and the practical aspects of statistical analysis, focusing on techniques for estimating econometric models of various kinds and for conducting tests of hypotheses of interest to economists. Some basic knowledge of matrix algebra and elementary statistical theory will be assumed, but a lot of it will be re-introduced during the lectures. The goal of this course is to help the students to develop a solid theoretical background in introductory level econometrics, the ability to implement the techniques and to critique empirical studies in economics. The computer is a fundamental tool in this course and students will be required to become familiar with some statistical software such as R, Eviews, STATA to analyze the econometric data and fitting of econometric models.

Contents

1. Introduction to econometrics.
2. Econometrics data types.
3. Autocorrelation: Definition, reasons, consequences, tests and solutions
4. Multicollinearity: Definition, reasons, consequences, tests and solutions
5. Heteroscedasticity: Definition, reasons, consequences, tests and solutions
6. Ridge regression.
7. Autoregressive and distributed lagged models
8. Dummy variables, Errors in Variables, Instrumental variables.
9. System of simultaneous equations.
10. Identification-Estimation method.
11. Indirect and two-stage least squares methods.
12. Three-stage least square estimation
13. Restricted least squares.
14. Test of identifying restrictions; Estimation with stochastic regressor,
15. Generalized least squares estimators.
16. Introduction to generalized linear models

Recommended Texts

1. Gujrati, D. (2004). *Basic econometrics.* (4th ed.). New York: John Wiley & Sons.
2. Draper, N. R. & Smith, H. (2004). *Applied regression analysis*. New York: John Wiley & Sons.

Suggested Readings

1. Baltagi, B. H. (2011). *Econometrics* (5th ed.). USA: Springer.
2. Johnston, J. & Nardo, J. (1997). *Econometric method (*4th ed.). New York: McGraw Hill.
3. Koutsoyiannis, A. (1980). *Theory of econometrics.* Macmillan.

STAT-6113 Non- Parametric Methods 3(3+0)

The main aim of this course is to introduce the principles and applications of commonly used nonparametric methods and to compare these methods to their parametric counterparts through simulation studies. The course gives an introduction to non-parametric statistics, starting with a repetition of the difference between the mean and the median and the influence of having data with a skewed distribution. Typical examples of such data within health economics are costs of stay or the length of stay. The course also covers simple non-parametric tests for comparing groups of observations. Prescribed course is concerned with the non-parametric approach instead of using the vast variety of parametric statistics test due to violating the assumption of normality in the data. Course also enlightens the significance of different supplementary tests those have no concern with the distribution of the data (should normally distributed) or central limit approach. This course based on the utilization of non-parametric tests specifically in such situation where fulfillment of assumptions relating to the sample (data) is quite difficult. Another direction of the course indicates the real life applications, problems and their solutions in an applied field of statistics.

Contents

1. Scales of measurements
2. Non-Parametric problems, when to use non-parametric procedures.
3. Parametric versus nonparametric tests
4. Trimmed and Winsorized means
5. One sample tests.
6. Binomial test, sigma test, wilcoxan signed ranks test,
7. Rank sum Test
8. Kolmogrov-smirnov test,
9. Run test
10. Tests for two related samples.
11. Sign test, run test
12. Chi-square test
13. Test for two independent samples: MANN-Whitney test
14. Median test
15. Chi-square test

Recommended Texts

1. Gibbons, J. D. & Chakraborti, S. (2011). *Nonparametric statistical inference*. Berlin: Springer.
2. Annette, J. D. (1991). *Introduction to generalized linear models*. London: Chapman and Hall.
3. Anderson, E. B. (1990). *The statistical analysis of categorical data*. New York: Springer-Verlag.

Suggested Readings

1. Conover, W. J. (1984). *Practical non-parametric statistics*. New Jersey: John Willey.
2. Sprent, P. (1984). *Applied non-parametric statistics*. New Jersey: John Willey
3. Fienberg, S. E. (2007). *The analysis of cross-classified categorical data*. Berlin: Springer.

STAT- 6114 Probability and probability distribution-II 3(3+0)

A probability distribution is a statistical function that describes all the possible values and likelihood that a random variable can take within a given range. These factors include the distribution's mean (average), standard deviation, skewness, and kurtosis. Probability distribution is a fundamental concept in statistics. They used both on a theoretical level and a practical level. Some practical uses of probability distributions are: To calculate confidence intervals for parameters and to calculate critical regions for hypothesis tests. In life there is no certainty about what will happen in the future but decisions still have to be taken. Therefore, decision processes must be able to deal with the problems of uncertainty. Uncertainty creates risk and this risk must be analyzed. The aim of the course is to provide the conceptual and mathematical formation of Continuous probability and other distribution with their derivation and properties. This course is designed for continuous probability functions and their applications. It deals with probability generating functions and moment generating function and their properties. Order statistics, Chi-square, t, F distributions and inequalities are also the part of content. The course focuses on mathematical formation of Continuous probability distribution and bivariate normal distribution.

Contents

1. Properties of Cauchy, Laplace, Weibull, Maxwell, Pareto, Raleigh and Log normal distributions.
2. Bivariate Normal distribution
3. Transformation of variables,
4. Cumulative distribution function and moment generating function techniques,
5. Central limit theorem.
6. Order Statistics,
7. Distribution of rth & sth order Statistics,
8. Distribution of median, range and quantiles
9. Methods of deriving exact sampling distribution for a population.
10. Independence of sample mean & variance.
11. Central t, F and chi-square distributions

Recommended Texts

1. Leon, G. (2008). *Probability, statistics, and random processes for electrical engineering* (3rd ed.). Wisconsin: Prentice-Hall.
2. Stuart, A. & Ord, J. K. (1998). *Advanced theory of mathematical statistics.* (1st ed.). London: Charles Coriffi and Co.
3. Bickel, P. J. & Docksum, K. A. (1997). *Mathematical statistics.* New York: Holden Day Inc

Suggested Readings

1. Sheldon, R**.** (2010). *Introduction to probability models***.** Academic Press.
2. Hogg, R. M. & Craig, A. T. (1995). *Introduction, to mathematical statistics*. New York: MacMillan Co.
3. Grimmett & Stirzaker. (2001). *Probability and random processes***.** (3rd ed.). Oxford: Press.

4. Peebles, P. (2001). *Probability, random variable and random signal processing.* (4th ed.). London: McGraw-Hill.

STAT-6115 Sampling Techniques-II 4(3+1)

Sample surveys are an important source of statistical data. A great many published statistics on demographic, economic, and political and health related characteristics are based on survey data. Simple random sampling is a well-known method of sampling but, for reasons of efficiency and practical constraints, methods such as stratified sampling and cluster sampling are typically used by statistical authorities such as the Australian Bureau of Statistics and by market research organizations. A well designed sampling procedure ensures that we can summarize and analyze data with a minimum of assumptions and complications. The aim of this course is to cover sampling design and analysis methods that would be useful for research and management in many fields and to develop your understanding of the principles and methods. This course is concerned with the design of sample surveys and the statistical analysis of data collected from such surveys. The course provides the mathematical and conceptual formation of sampling techniques especially for Cluster sampling, Double Sampling, Multistage or Multiphase sampling and different estimator's comparison. Non response or Randomized response and their sources are also the parts of the contents. This course is designed for the different types of sampling and selection and estimation procedures.

Contents

1. Cluster sampling
2. Cluster sampling and its analysis along with examples
3. Sub sampling
4. PPS-Sampling.
5. Double sampling
6. Multistage sampling
7. Multiphase sampling.
8. Thomson Hurwitz estimator
9. Thomson Hurwitz estimator and its applications
10. Comparison of different sample designs.
11. Critical study of National sample surveys conducted in Pakistan.
12. Census of Agriculture
13. Household Economic and Demographic Survey (HED), Household

Recommended Texts

1. Lohr, S. L. (2009). *Sampling: design and analysis.* London: Duxbury Press.
2. Des, R., & Chandhok, P. (1998). *Sample survey theory*. New Dehli: Narosa Publishing House.

Suggested Readings

1. Ferguson, T. S. (1996). *A course in large sample theory*. London: Chapman and Hall.
2. Sukhatme, P.V., Sukhatme, B., Sukhatme, S. & Asok, A. (1985). *Sampling theory of survey with application.* Lowa State: University Press.

STAT-6116 Design and Analysis of Experiments-II 4(3+1)

Data for statistical studies are obtained by conducting either experiments or surveys. Experimental design is the branch of statistics that deal with the design and analysis of experiments. The methods of experimental design are widely used in the fields of agriculture, medicine, biology, marketing research, and industrial production**.** One or more of these variables, referred to as the factors of the study are controlled so that data may be obtained about how the factors influence another variable referred to as the response variable, or simply the response. The aim of this course is to deliver the applicable knowledge about Statistics and Experimental Design, which can apply in different fields of study and to develop a skills on the data collection from a designed experiment, description measures of data, interpretation of results, and decision making. It deals with the model estimation of parameters of Factorial Experiments, 2^n, 3^n… P^n and mixed levels factorial experiments and its applications in different fields. This covers Confounding and its types, Fractional replication, Quasi-Latin squares, Split-plot, Split Split plot, split block and Incomplete Block Designs. Models and applications of 1^{st} and 2^{nd} order response surface designs are part of the content.

Contents

1. Factorial Experiments, 2^n, 3^n… P^n
2. Mixed levels factorial experiments:
3. Model estimation of parameters with applications.
4. Confounding and its types,
5. Fractional replication
6. Quasi-Latin squares,
7. Split-plot design
8. Split Split plot and split block designs,
9. Incomplete Block Designs
10. Balanced incomplete block designs
11. Partially balanced incomplete block designs
12. Balanced Lattices
13. Lattice squares; models and Analysis,
14. 1st and 2nd order response surface designs, their models and applications.
15. Youden Squares; models and Analysis,
16. 1st and 2nd order response surface designs, their models and applications.

Recommended Texts

1. Montgomery, D. C. (2019). *Design and analysis of experiments*. (10^{th} ed.). New York: John Wiley Sons.
2. Clarke, G. M. & Kempthon, R. E. (1997). *Introduction to the design and analysis of experiments.* England: Edward Annold.

Suggested Readings

1. Bland, M. (2015). *An Introduction to medical statistics* (4^{th} ed.). Oxford: University Press.

2. Matthews, N. S. (2006). *Introduction to randomized controlled clinical trials* (2nd ed.). New York: Chapman and Hall.

STAT-6117 Statistical Inference I 3(3+0)

Statistical inference is the process of drawing conclusions about populations or scientific truths from data. There are many modes of performing inference including statistical modeling, data oriented strategies and explicit use of designs and randomization in analyses. A key step in the Statistical Investigation Method is drawing conclusions beyond the observed data. Statisticians often call this "statistical inference. A practitioner can often be left in a debilitating maze of techniques, philosophies and nuance. This course presents the fundamentals of inference in a practical approach for getting things done. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Statistical estimation is concerned with the best estimating a value or range of values for a particular population parameter. It deals with the estimation of parameters, properties of good point estimator and its methods. It also discusses the parameter estimation of different probability distributions and their efficiency. Bayesian Statistics and its comparison with classical estimation approach are part of the content.

Contents

1. Methods of Estimation,
2. Method of least squares,
3. Method of moments.
4. Minimum chi-square.
5. Maximum likelihood
6. Bayes methods.
7. Estimates based on order statistic.
8. Observations, Simultaneous confidence intervals.
9. Properties of a good estimator
10. Unbiased
11. Consistency
12. Sufficiency
13. Efficiency.
14. Completeness

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2019). *Introduction to mathematical statistics.* (7th ed.). New York: MacMillan Co.
2. Mood, A. M., Graybill, F. A. & Boes, D. C. (1997). *Introduction to the theory of statistics*. London: McGraw Hill.

Suggested Readings

1. Lehmann, E. L. (1986). *Testing statistical hypotheses*. New York: John Wiley & Sons.
2. Hirai, A. S. (1973). *Estimation of statistical parameters*. Pakistan: IlmiKhana.

STAT-6118 Applied Multivariate Analysis 4(3+1)

Multivariate analysis is used to study more complex sets of data than what univariate analysis methods can handle. Essentially it is a tool to find patterns and relationships between several variables simultaneously. It lets us predict the effect a change in one variable will have on other variables. Multivariate analysis can reduce the likelihood of Type I errors. Sometimes, univariate analysis is preferred as multivariate techniques can result in difficulty interpreting the results of the test. This course is designed to enlighten the significance of multivariate analysis by entertaining the both mathematical and applied approaches of problems. This course deals with multiple variable analyses simultaneously. To impart skills on the data collection, description measures of data, interpretation of the results, model selection, decision making in the context of multivariate analysis. Nowadays, to accommodating, monitoring, sorting, and filtering, several variables in various fields like in manufacturing industries, social phenomenon, psychology, medical, information technology and biotechnology etc. simultaneously is a big challenge to the world. This is designed to enlighten the significance of multivariate analysis by entertaining the both mathematical and applied approaches of problems. Course also provides the simultaneous model structure, their assumptions and mathematical derivations of multivariate statistical designs.

Contents

1. Multivariate Normal Distribution.
2. Distribution of linear function of normal variates.
3. Distribution of Quadratic forms
4. MLE of Multivariate Normal Distribution
5. Wishart distribution.
6. Hotelling's T^2-distribution
7. Inferences about mean vector
8. Inferences about covariance matrices
9. Inferences about profiles
10. Canonical variates Analysis.
11. Discriminant Analysis

Recommended Texts

1. Johnson, R. A., & Wichern, D. W. (2002). *Applied multivariate statistical analysis* (5^{th} ed.). New Jersey: Prentice hall.
2. Gnanadesikan, R. (1997). *Methods for data analysis of multivariate observations* (2^{nd} ed.). New York: John Wiley and Sons.

Suggested Readings

1. Anderson, T.W. (1985). *An introduction to multivariate statistical analysis*. New York: John Wiley and Sons.
2. Chatfield, C. & Collin, A. J. (1980). *Introduction to multivariate analysis*. New York: Chapman and Hall.

3. Mardia, K.V., Kent, J. T. & Bibby J. M. (1979). *Multivariate analysis*. London: Academic press.

STAT-6119 Research Methods / Internship 3(3+0)

The purpose of introducing a course of research is to inform action. Goal of this course is to seek to contextualize the findings within the larger body of research. This course suggests to produce research that must be of high quality in order to produce knowledge that is applicable outside of the research setting. After learning this course student will be able to understand research terminology, research ethics, and research design and research language. This course aware ethical challenges and approval process. Types of research in broad sense like quantitative, qualitative and mixed method researches are discussed. Suggested course deals with identifying the components of a literature review process and .Critically evaluating previous studies .This course enables a student how to perform and pass the research process by providing them understanding about components of research like Introduction, Literature review, methodology, results and discussion on findings.

Contents

1. Definition of Research.
2. Types of Research
3. Selection of Problem
4. Search of References.
5. Formation of Hypothesis and Procedure for its Testing
6. Research Methodology.
7. Planning of Experiments to Test Hypothesis Objectivity
8. Principals of Experimental Design.
9. Steps in Experimentation,
10. Collection of Data
11. Data Analysis to Determine Functional Relationship Between Variables, Levels of Significance, Interpretation of Results,
12. Components of Scientific Reports.
13. Various Methods of Data Presentation,
14. Preparation of Scientific Reports,
15. Publication Procedures.
16. Survey of Literature on a Given Topic

Recommended texts

1. Hashmi, N. (1989). *Research, foundations and methodology*. Islamabad: Western Press. Style Manual of Technical Writings, USAID/NARC
2. Crowther, D. & Lancaster, G. (2012). *Research methods*. London: Routledge.

Suggested Readings

1. Bernard, H. R. & Bernard, H. R. (2013). *Social research methods: Qualitative and quantitative approaches*. England: Sage.

2. Gimbaled, J. & Acuter, W. S. (1988). *MLA handbook for writers of research papers*. America: McGraw the Modern Language Association of America.

STAT-6120 Population Studies 4(3+1)

Population studies are broadly defined as the scientific study of human populations. This course is an introduction to demography and population studies. Demography concerns itself with the formal (quantitative) analysis of population size, distribution, structure, and change, whereas population studies deals with the sociological determinants (broadly speaking) and consequences of demographic phenomena. Some topics include: Population History, Population Age-Sex Structure, Fertility, Mortality and Population Health, Migration, Explanations of Nuptiality Change and Canadian Nuptiality Trends, Urbanization, Population and Resources, and Population Change and Policy Concerns. The main aim of this course is to report significant advances in methods of population analysis, conceptual and mathematical theories of demographic dynamics and behavior, and the use of these theories and methods to extend scientific knowledge and to inform policy and practice. It also deals with the fertility rates, mortality rates, migration rates and life tables. It provides the necessary skill to evaluate the impact and consequence of population growth on society. It gives the knowledge of population policy and population measures and to impart basic and applied knowledge about Population Studies and its applications in different fields.

Contents

1. The population and housing census Registration of vital events,
2. Demographic surveys Components of population growth, composition of population and vital events.
3. Types and sources of errors General testing procedures
4. Testing the accuracy of age and sex data
5. Fertility and mortality measures
6. Total and general fertility rates.
7. Estimation from incomplete Data Construction of complete and abridged life tables Different types of life tables.
8. Graphs of Ix, qx and ex. Description and uses of life table columns
9. Stationary population models Population estimates and projections Intercensual estimates.
10. Population projections through various methods.
11. Theory of demographic transition Stable and stationary population models, their applications and uses.
12. Malthusian and post Malthusian theories of growth.
13. Consequences of world population growth & population explosion.

Recommended Texts

1. Weinstein, J. & Pillai, V. K. (2001). *Demography: The science of population*. England: Allyn and Bacon.
2. Hinde, A. (2014). *Demographic method* (2nd ed.). London: Routledge.

Suggested Readings

1. United, N. (1998). *World population assessment*. New York: UNFPA.
2. Govt. of Pakistan (1998). *National, provincial and district census reports and other supplementary reports with respect to 1998 census*. Islamabad: PCO.
3. United, N. (1996). *Added years of life in Asia.* Thailand: ESCAP U.N.

STAT- 6121 Statistical Inference –II 3(3+0)

Statistical inference is the process of using data analysis to deduce properties of an underlying distribution of probability. The goal is to use probability theory to make inferences about population parameters of interest. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. The fundamental principles of statistical inference procedures are confidence interval procedures and hypothesis testing; both are constructed on the sampling distribution. The course deals with testing of hypothesis, distribution free and randomization tests, interval estimation and scalar parameters. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Content includes: a review of the key concepts of estimation, and construction of Normal-theory confidence intervals; frequencies theory of estimation including hypothesis tests, methods of inference based on likelihood theory, including use of Fisher and observed information and likelihood ratio and sequential test.

Contents

1. Neyman Pearson Theorem.
2. Most powerful test
3. Uniformly most powerful tests.
4. Test for binomial distribution
5. MPT for poission
6. UMPT for discrete distribution
7. UMPT for continuous distribution
8. Exponential families of distibution
9. Likelihood ratio tests
10. Maximum likelihood
11. Generalized likelihood ration test
12. The sequential probability ratio test
13. Interval estimation and confidence tests.
14. Relation between testing and confidence intervals.

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2019). *Introduction to mathematical statistics* (7th ed.). New York: MacMillan Co.
2. Mood, A. M., Graybill, F. A. & Boes, D.C. (1997). *Introduction to the theory of statistics.* London: McGraw Hill

Suggested Readings

1. Hogg, A.V. (1995). *Probability and statistical inference*. London: McMillan Co.

2. Hirai, A. S. (1973). *Estimation of statistical parameters*. Lahore: IlmiKhana.
3. Staurt, A. & Ord, K. (1994). *Kendall's advanced theory of statistics* (2nd ed.).England: Charles Griffing and Co.

STAT-6122 Numerical Methods 3(3+0)

Numerical methods are the fast solution for mathematical problems. Numerical methods are algorithms used for computing numeric data. They are used to provide 'approximate' results for the problems being dealt with and their necessity is felt when it becomes impossible or extremely difficult to solve a given problem analytically. Methods such as finite difference method (FDM), finite volume method (FVM), finite element method (FEM), boundary element method (BEM) etc are commonly used for treating PDE numerically. All numerical methods used to solve PDEs should have *consistency*, *stability* and *convergence*. Statistics and data analysis are an essential part of a modern engineer's toolkit. So are numerical methods for solving a variety of mathematical problems. This course is designed to enhance the problem solving skills of students using an extremely powerful problem solving tool namely numerical methods. The tool is capable of handling large system of equations, nonlinearities and complicated geometries that are common in practice and that are often impossible to solve analytically. This also focuses on numerical Differentiation, Integration and numerical solutions of ordinary and partial differential equation.

Content

1. Approximation and Errors in computing: Introduction,
2. Significant digits, Inherent error, Rounding error,
3. Truncation error, Absolute and relative error, Error propagation.
4. Roots of Non Linear Equations and solution of system of Linear Equations: Bisection method,
5. False position Method, Newton-Raphson Method
6. Difference Operators & Interpolation: Forward and Backward difference operators and table, Interpolation with equidistant point,
7. Lagrange Interpolation Polynomial, Newton Interpolating Polynomial using divided Difference Table
8. Numerical Differentiation and Integration: Differentiating continuous functions, differentiating tabulated functions
9. Higher order derivatives
10. Richardson's Extrapolation, Newton – cotes integration formula

Recommended Texts

1. Grewal, B. S. (2014). *Numerical methods in engineering and science* (9th ed.). India: Khanna Publication.
2. Jain, M. K., Iyengar, S. R. K. & Jain, R.K. (2007). *Numerical methods for scientific and engineering computation* (5th ed.). Germany: New age International Publishers.

Suggested Readings

1. Curtis, F. G. & Patrick, O. W. (2007). *Applied numerical analysis* (7th ed.). London: Pearson Education.
2. Balagurusamy, E. (1999). *Numerical method* (1st ed.). England: Tata McGraw Hill Publication.

STAT- 6123 Time Series and Forecasting 3(3+0)

Time series analysis has many different objectives, depending on the field of application. These include forecasting future values of the series, extracting a signal hidden in noisy data, discovering the mechanism by which the data are generated, simulating independent realizations of the series to see how it might behave in the future (and hence, for example, to estimate the probability of extreme events like floods), and eliminating the seasonal component from data sets like the one in example 2 in order to reveal more clearly the underlying trend. So to fulfill the main objective of time series analysis the aim of this course is to impart the basic and applied knowledge about Time Series and its applications in different fields with an emphasis on practical aspects of the interpretation of statistically based conclusions in research. It deals with the method of data collection, description measures of data for interpretation of results, model selection, decision making and Forecasting. This course is designed for the modeling and forecasting of time series data. This focuses on the decomposition of time series, stationary data, models for stationary and non-stationary series, forecasting methods and properties of models like mean, variance, auto-covariance and auto-correlation function.

Contents

1. Stochastic Process
2. Stationary time-Series.
3. Auto-correlation and auto-covariance.
4. Estimate functions and standard error of the auto-correlation function (ACF).
5. Spectral Analysis:
6. Periodogram, spectral density functions,
7. Comparison with ACF.
8. Linear stationary models
9. Auto-regressive models
10. Moving average models
11. Mixed models.
12. Non-stationary models,
13. ARMA Models
14. ARIMA models
15. SARIMA models
16. Box-Jenkins Methodology
17. Minimum mean square forecasting.

Recommended Texts

1. Chatfield, C. (1996). *The analysis of time series, an introduction.* London: Chapman and Hall,
2. Cox, D. R., Hinklev, D .V. & Nielsen, O .E. B. (1996). *Time series models in econometrics finances and other fields.* London: Chapman Hall.

Suggested Readings

1. Andy, P., West, M. & Harrison, P .J. (1994*). Applied bayesian forecasting and time series analysis*. New York: Chapman Hall.
2. Harvey, A. C. (1990). *Forecasting structural time series models and the kalman filter*. Cambridge University: Press.

STAT- 6124 Official Statistics 3(3+0)

Statistics play a vital role in the economy of a country. Methods and techniques for producing register-based statistics are discussed in depth. Examples of problems addressed are linking, matching, derived variables, missing data and estimation. Models for quality assessment of official statistics are introduced and quality differences between sample-based and register-based statistics are discussed. Here the aspects on reliability and accuracy are of special interest. The aim of the course is to provide the knowledge of officially use of statistics in different fields and organization. This focuses on the methods of data collection, data processing, presentation and publication of statistics. The course is designed for the use of statistics in administration and planning and different organizations like NADRA, State bank of Pakistan, Ministry of finance and bureau of statistics etc. This deals with design and planning of statistical investigation, role of sampling in generation of statistics, role of official statistics and different surveys conducted in Pakistan. Concepts and evaluation of GDP, GNP, balance of trade and payment, measurement of income distribution are also the part of the contents.

Contents

1. Design and planning of a Statistical Investigation. Data collection approach and operation; Role of sampling in generation of statistics. Sampling plans and survey designs.
2. Sources of Errors, types of Errors, methods of their control. Data processing, presentation, and publication of statistics.
3. Different modes of data dissemination. Official statistics, statistics systems and standards, sources of official statistics, their role, working and publication. Role of official statistics, official publications.
4. Setup of official organizations in Pakistan their role, working & publication, statistics division,
5. Federal Bureau of statistics, Agricultural Census Organization, Population Census Organization, Ministry of Food , and Agriculture and Livestock;
6. National Data Bade and Registration Authority (NADRA). Provincial Bureaus of statistics.
7. Financial statistics: Ministry of Finance, state Bank of Pakistan-Department of statistics, their working publications and responsibilities.
8. Other organization's statistical output, National and International series, classification and standards.
9. Use of statistics in administration and planning.
10. Concepts and evaluation of GDP, GNP, NNP, balance of trade and payments.
11. Measurement of income Distribution,

Recommended Texts

3. Kish, L. (1982). *Survey sampling*. New York: John Wiley and Sons.
1. Statistics, D. (2005). *Activity report government of Pakistan*. Islamabad: Statistics division.

Suggested Readings

1. Statistical institute for Asia & Pacific SIAP. (1984). *Training of trainers in statistical operations and procedure*. Part-1, II. Tokyo, UNDP.
2. Murthy, M. N. (1979). *Quality of data, country course on sample survey*, Karachi: Statistics bureau.

STAT-6125 Categorical Data Analysis 3(3+0)

This course is designed to introduce basic concepts and common statistical models and analyses for categorical data; to provide enough theory, examples of applications in a variety of disciplines (especially in social and behavioral science); and practice using categorical techniques and computer software so that students can use these methods in their own research; to attain knowledge necessary to critically read research papers that use such methods. This course deals with the most fundamental regression models for binary, ordinal, nominal and count outcomes. While advances in software make it simple to estimate these models, post-estimation interpretation is difficult due to the nonlinearity of the models. Prescribed course is concerned with the applicable knowledge about statistics in the field of categorical nature of variables. Course is aimed at providing students with a formal treatment of categorical data specifically in the social sciences and decision making theories based on behavioral and attritional variables. This course also explores the basic concepts of advanced categorical methodologies with their mathematical derivations. Course communicates the high skills to play the major role in statistics by using the knowledge of categorical data. The course is heavily oriented with tools for analyzing categorical data with practical applications.

Contents

1. Introduction,
2. Describing two way contingency tables.
3. Chi-Square test
4. Models for binary response variables,
5. log linear models
6. Fitting log linear
7. logit models
8. Probit models
9. Building and applying log linear models,
10. Log linear logit models for ordinal variables.
11. Multinomial response models for matched pairs.
12. Analyzing repeated categorical response data.

Recommended texts

1. Agresti, A. (1999). *Categorical data analysis*. London: John Wiley and Sons.
2. Bishop, Y. V. V., Fienberg, S. E. & Holland, P. W. (1975). *Discrete multivariate analysis*. Cambridge: MIT Press.

Suggested Readings

1. Cox, D. R. & Snell, E. J. (1989). *The analysis of binary data*. London: Chapman and Hall.

2. Kleinbaum, D. G., Dietz, K., Gail, M., Klein, M. & Klein, M. (2002). *Logistic regression*. New York: Springer-Verlag.
3. Hosmer, D. W., Lemeshow, S. & Sturdivant, R. X. (2013). *Applied logistic regression*. New York: John Wiley and Sons.

STAT-6126 Stochastic Process 3(3+0)

Stochastic processes are the natural tool to model real-world phenomena involving randomness and uncertainty. They offer a power mathematical framework to analyze complex problems in a variety of applied areas, ranging from business and industry to economics, finance, social sciences, and biology and computer science. Moreover, the use of stochastic processes (and related probabilistic techniques) to build advanced statistical models is central to the ongoing data science revolution. The aim of the course is to provide students with a basic understanding of the probabilistic models and techniques underlying the most widely used classes of stochastic processes. The purpose of this course is to equip students with theoretical knowledge and practical skills, which are necessary for the analysis of stochastic dynamical systems in economics, engineering and other fields. More precisely, the objectives are, study of the basic concepts of the theory of stochastic processes; introduction of the most important types of stochastic processes; study of various properties and characteristics of processes; study of the methods for describing and analyzing complex stochastic models. The objective of the course is to provide the applicable knowledge about stochastic process, generating functions, difference equation, Laplace transforms, random walk and Markov chains. It covers the pure birth and death process, Markov process with discrete and continuous state space, expected duration of the game and classical gambler's ruin problem. The Wiener process is also the part of the course.

Contents

1. Introduction. Generating Functions.
2. Laplace Transforms. Difference equations.
3. Differential - difference equations.
4. Introduction to Stochastic Processes.
5. The Random Walk in one and two dimensions.
6. The Classical Gambler's Ruin Problem.
7. Expected Duration of the Game.
8. Markov Chains: Definition. Higher Transition Probabilities. Classification of States and Chains.
9. Markov Processes with Discrete State Space. Poisson Process and its Generalization.
10. Pure Birth and Death Processes.
11. Markov Process with Discrete State Space (Continuous Time Markov Chains).
12. Markov Processes with Continuous State Space.
13. Introduction to Brownian Motion.
14. The Wiener Process. Diffusion Equations for the Wiener Process.

Recommended Texts

1. Ross, S. (1996). *Stochastic process* (2nd ed.). New York: John Wiley and Sons.

2. Feller, W. (1992). *An introduction to probability theory and its applications.* New York: John Wiley and Sons.

Suggested Readings

1. Srinivasin, S. K. & Mehta, K. M. (1988). *Stochastic processes*. England: Tata McGraw Hill.
2. Karlin, S. A. & Taylor, H. M. (1984). *A first course in stochastic process*. London: Academic Press.

STAT-6127 Reliability Analysis 3(3+0)

Reliability refers to the extent to which a scale produces consistent results, if the measurements are repeated a number of times. It refers to the fact that a scale should consistently reflect the construct it is measuring. An aspect in which the researcher can use reliability analysis is when two observations under study that is equivalent to each other in terms of the construct being measured also have the equivalent outcome. Reliability in statistics is the overall consistency of a measure. A measure is said to have a high reliability if it produces similar results under consistence conditions. Score that is highly reliable is precise, reproducible, and consistence from one testing occasion to another. Reliability analysis allows to study the properties of measurement scales and the items that compose the scales. The aim of this course is to develop the basic concepts of reliability. It discusses the concepts of structural reliability. This covers lifetime distributions, gamma, Weibull, log normal, inverse Gaussian distribution and estimation. Testing reliability hypothesis, system reliability, failure models, inferences of these models and accelerated life testing are parts of the contents.

Contents

1. Basic concepts of reliability.
2. Structural reliability.
3. Lifetime distributions (Failure Models):
4. Hazard rate;
5. Gamma,
6. Weibill, Gumball,
7. Log-Normal
8. Inverse Gaussian Distribution.
9. Stochastic fatigue rate models.
10. Point and Interval estimation.
11. Fatigue life model.
12. Testing reliability hypothesis.
13. Monte-Carlo, Distribution free and
14. Baye's method in reliability
15. nSystem reliability
16. Series and parallel systems.
17. Failure Models

Recommended Texts

1. Haldar, A. & Mahadevan, S. (2000). *Reliability assessment using stochastic finite element analysis*. New York: John Wiley and Sons.
2. Crowder, M. J., Kimber, A., Sweeting, T. & Smith, R. (1994). *Statistical analysis of reliability data*. Germany: CRC Press.

Suggested Readings

1. Bryson, M. C. (1992). *Statistical analysis of reliability and life-testing models*. Germany: CRC Press
2. Gertsbakh, I. B. (1989). *Statistical reliability theory*. New York: Marcel Decker.

STAT-6128 Survival Analysis 3(3+0)

Statistics for analyzing the expected duration of time until one or more events happen. Survival analysis is used to estimate the lifespan of a particular population under study. The goal is to estimate the time for an individual or a group of individuals to experience an event of interest. This time estimate is the duration between birth and death events. A survival analysis can be used to determine not only the probability of failure of manufacturing equipment based on the hours of operations, but also to differentiate between different operating conditions. This course is designed for special features of survival data, survival functions and hazard function. It deals with time dependent data, non-parametric procedures, estimation of survival function, median and percentile of survival time, stratified and long rank test for trend. It provides knowledge about modelling of survival data, exploratory data analysis and the use of computer software for survival analysis. Main objectives of the course are, to identify characteristics of survival data and their implications for analysis, to Perform and interpret univariate analyses of survival data, to compare groups using common statistical procedures, to analyze survival data and interpret results.

Contents

1. Special features of survival data:
2. Patient time and study time,
3. Survival function
4. Hazard function,
5. Time dependent
6. Censored survival data.
7. Nonparametric procedures:
8. Estimation of survival function, hazard function,
9. Median and percentiles of survival times.
10. Confidence interval and comparison of group
11. Stratified and log-rank test for trend.
12. Modeling of survival data;
13. Hazard function modeling;
14. Tests and confidence interval.

Recommended texts

1. Lee, E. T. (1997). *Applied survival analysis*. New York: John Wiley and Sons.

2. Muller, R.G. & Zhou, X. (1996). *Survival analysis with long-term survivors.* New York: John Wiley and Sons.

Suggested Readings

1. Burkett, M. (1995). *Analyzing survival data from clinical trials and observational studies*. New York: John Wiley and Sons.
2. Cox, D. R. & Oakes, D. (1984). *Analysis of survival data*. London: Chapman & Hall.

STAT-6129 Actuarial Statistics-I 3(3+0)

This course covers survival models and their estimation as well as applications in insurance and finance. Specific topics include: the concept of survival models and actuarial notation; estimation of lifetime distributions; multiple state models; maximum likelihood estimation of transition intensities; the binomial model of mortality and its estimation; models with transition intensities depending on age and duration; the census approximation and formulae; statistical comparison of crude rates with a standard table; graduation of crude estimates and tests of fidelity and smoothness; analysis of mortality/morbidity and the main forms of selection; models for projection of mortality. This deals with Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality. It provides Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. To developing multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws suggested course is helpful. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Contents

1. Utility theory, insurance and utility theory
2. Models for individual claims and their sums,
3. Survival function, curate future lifetime, force of mortality.
4. Life table and its relation with survival function, examples,
5. Assumptions for fractional ages
6. Some analytical laws of mortality, select and ultimate tables.
7. Multiple life functions, joint life and last survivor status,
8. Insurance and annuity benefits through multiple lives function evaluation for special mortality laws.
9. Multiple decrement models,
10. Deterministic and random survivorship groups, associated single decrement tables, central tables of multiple decrement, net single premiums and their numerical evaluations.
11. Distribution aggregate claims,
12. Compound Poisson distribution and its applications.

Recommended Texts

1. Klein, J. P. & Moeschberger, M. L. (2003). *Survival analysis: techniques for censored and truncated data.* New York: Springer.
2. Bowers, N.L Gerber, H. U. Hickman, J.C. Jones, D.A. & Nesbitt, C.J. (1987). *Actuarial mathematic*. USA: Society of Actuarial, Ithaca.

Suggested Readings

1. Blackwell, D. & Graphic, M. A. (1966). *Theory of games and statistical decision*. New York: John Wiley and Sons.
2. Pitacco, E., Denuit, M., Haberman, S. & Olivieri, A. (2009). *Modelling longevity dynamics for pensions and annuity business*. Oxford University Press.

STAT-6130 Bayesian Statistics 3(3+0)

The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of Bayesian statistics, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Bayesian methods which allow for inclusion of relevant problem-specific knowledge in to the formation of one's statistical model. Bayesian statistical methods start with existing prior beliefs, and update these using data to give posterior beliefs, which may be used as the basis for inferential decisions. Bayesian procedures are concerned with the best estimating a value or range of values for a particular population parameter. It deals with the estimation of parameters in a different approach. Bayesian statistics are a system for describing epistemological uncertainty using the mathematical language of probability. Bayesian analysis, a method of statistical inference that allows one to combine prior information about a population parameter with evidence from information contained in a sample to guide the statistical inference process. It also discusses the parameter estimation of different probability distributions and their efficiency. Prior distribution, formulation of posterior distribution and predictive distribution estimation is part of the content. In Bayesian statistics, the key operations are to implement Bayes' theorem and then to derive relevant inferences or decisions from the posterior distribution.

Contents

1. Introduction to Bayesian Statistics
2. Prior information
3. Prior distributions
4. Likelihood Function
5. Methods of elicitation of prior distributions
6. Posterior distributions
7. The posterior means, median and mode
8. Loss Functions
9. Bayes estimators under loss functions
10. Variances of univariate posterior distributions
11. Variances of bivariate posterior distributions
12. Noninformative priors

Recommended Texts

1. Bolstad, W. M. & Curran, J. M. (2016). *Introduction to bayesian statistics.* New York: John Wiley and Sons.
2. Berger, J. O. (2013). *Statistical decision theory and bayesian analysis.* London: Springer Science and Business Media.

Suggested Readings

1. DeGroot, M. H. (2005). *Optimal statistical decisions.* New York: John Wiley and Sons.
2. Ferguson, T. S. (2014). *Mathematical statistics: A decision theoretic approach*. London: Academic press.
3. Carlin, B. P. & Louis, T. A. (2008). *Bayesian methods for data analysis*. England: CRC Press.

STAT-6131 Statistical Quality Control 3(3+0)

This course offers applications of the statistical process control techniques that are an integral part of the corporate-wide quality control efforts. The course will discuss the methods of statistical quality control within a broader framework of quality assurance and management. The course will define the various aspects of quality and address the issues of planning for quality as they relate to survey operations and processes. Statistical methods for quality control will be discussed. The uses and applications of various quality tools such as Pareto analysis, cause & effect diagrams, flow charting, etc., for generating quality improvements will also be addressed. This course is mathematical in nature and will contain some theoretical formulas and statistical concepts. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical quality control, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with the construction of control charts for monitoring location and dispersion parameters. This covers the process capability analysis, process improvements using design of experiments and Taguchi method. Acceptance sampling plans along with the different International Standards Organization series are part of the contents.

Contents

1. Statistical quality control
2. Measurement and control of quality.
3. Control charts for $\overline{X}$, R and Sigma,
4. Charts for P, C and U.
5. O.C. curves associated with control charts.
6. Leaf and Stem Plots
7. Box Plot
8. Producer's risk and consumer's risk
9. Process Capability Analysis
10. Acceptance sampling.
11. Single sampling plans
12. Double sampling plans
13. Introduction to multiple sampling plans

Recommended Texts

1. Montgomery, D. (2013). *Introduction to statistical quality control* (7th ed.). New York: John Wiley & Sons.
2. Juran, J. M. & DeFoe, J. A. (2010). *Juran's quality handbook* (6th ed.). London: McGraw-Hill Education.

Suggested Readings

1. Ryan.T. P. (1989). *Statistical methods for quality improvements*. New York: John Wiley and Sons.
2. Grant, E. l. & Leavenworth, R. S. (2000). *Statistical quality control*. New York: McGraw-Hill Education.

STAT-6132 Operations Research 3(3+0)

Operational research is the application of scientific methods to the study of complex organizational problems. It is concerned with applying advanced analytical methods to make effective decisions in strategic planning or operational planning, and builds more productive systems. This includes all key stages of solving real-world problems. Operational researchers and statisticians play a fundamental role in the modern world. The aim of this course is to fulfill the needs of society in the fields of Statistics and Operations and to understand different application areas of operations research like transportation problem, assignment model, sequencing models, dynamic programming, game theory, replacement models & inventory models. This is designed to impart basic and applied knowledge about Operation Research and its applications in different fields of marketing. This program is an ideal opportunity to provide your-self with the analytical and statistical skill set necessary for success in industry, business or in the public sector. Course also enlightens the significance of mathematical modeling based strategies based on both mathematical and applied nature of disciplines. The program for Operational Research and Statistics provides students with the ideal skill set in mathematical modeling, experimental design, statistical analysis, and numerical computation.

Contents

1. Historical study of operation research
2. Linear Programming.
3. Methods to solve LP models
4. Graphical Methods
5. Mathematical computations
6. The simplex methods.
7. Degeneracy and cycling
8. Artificial variables
9. Duality
10. The dual simplex method,
11. Sensitivity analysis.
12. Transportation
13. Methods of solving transportation
14. Assignment problems

Recommended Texts

1. Taha, H. A. (2017). *Operation research, an introduction* (10th ed.). London: Pearson.
2. Bhatti, S.A. & Bhatti, N. A. (1998). *Operation research, An Introduction*. Lahore: A-one publishers.

Suggested Readings

1. Gupta, P. K. & Hira, D. S. (1994). *Operation research*. New Delhi: S. Chand and Co.
2. Hillier, F. & Lieberman, G. (1992). *Introduction to operation research*. England: Holden Day.
3. Sposity, V. A. (1985). *Linear programming with statistical applications*. Lowa State: University Press.

STAT-6133 Robust Methods 3(3+0)

The aim of this course is to provide a strong mathematical and conceptual foundation of the methods of Robust Statistics with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Content includes: a review of the key concepts of basic statistics, estimation, and probability. Robust statistics are statistics with good performance for data drawn from a wide range of probability distributions, especially for distributions that are not normal. Robust statistical methods have been developed for many common problems, such as estimating location, scale, and regression parameters. It deals with the construction of objective functions of location and dispersion parameters along with M-estimators, E-estimator, R-estimator and W-estimator. It also discusses the performance measures, such as breakdown point, influence function and gross error sensitivity etc, of the estimators. This covers the M-estimator for scale, outliers and influential observations in regression analysis as well. In computer sessions, robust methods will be applied to real data sets and the results will be interpreted. Some properties of the estimators will be verified empirically, for instance by Monte Carlo simulation.

Contents

1. Introduction to Robustness.
2. Objective function.
3. M-estimator of location.
4. E-estimator and its functions
5. R-estimator and its functions
6. W-estimator. and its functions
7. Re descending M- estimators.
8. The Breakdown point of robust estimator Influence function.
9. M-estimator for scale.
10. Gross error sensitivity
11. Sensitivity Analysis
12. Contaminated normal distribution
13. Comparisons of usual and robust estimators
14. Monte Carlo simulation
15. Evaluation of breakdown point by simulation

16. Outliers and influential observations.
17. Outliers in Regression analysis.

Recommended Texts

1. Maronna, R., Martin, R. & Yohai, V. (2006). *Robust statistics: Theory and methods*. New York: John Wiley & Sons.
2. Rousseau, P. J. & Leroy, A. M. (1987). *Robust regression and outlier detection*. New York: John Wiley & Sons.

Suggested Readings

1. Huber, P. J. (1981). *Robust statistics*. New York: John Wiley & Sons.
2. Stuart, A. & Ord, J .K. (1998*). Kendall's advanced theory of statistics* (1st ed.). London: Charles Griffin.

STAT-6134 Bio Statistics 3(3+0)

Using the tools of statistics, biostatisticians help answer pressing research questions in medicine, biology and public health, such as whether a new drug works, what causes cancer and other diseases, and how long a person with a certain illness is likely to survive. Biostatisticians use their quantitative skills to team with experts in other fields, from biologists and cancer specialists to surgeons and geneticists. New statistical tools and software are often needed to interpret the massive amounts of data and to detect correlations and causations. The basic aim of this course is to highlight the advance applications of probabilistic approaches in the concern of statistical paradigm. Course explores the importance of risk factors and effective decision making strategies. This course also classified according to their metric requirements (i.e., metric level, commensurability across the dimensions, and lexicographic ordering) in the system, is given. A brief introduction to process tracing techniques is followed by a review of results reported in process tracing studies of decision making.

Contents

1. Definition of Biostatistics, vis-à-vis,
2. The type of variables and observations in biological.
3. Health and medical sciences
4. Uniqueness in terms of behavior of variables their domain, and units.
5. Categorical. Numerical data
6. Censored data.
7. Population, Target populations and samples.
8. Role of sampling in biostatistics
9. Size of samples of various types of studies.
10. Proportions
11. Rates and rations;
12. Incidence, prevalence and odds.
13. Distributional behavior of biological variables (Binomial, Poisson and Normal).
14. Role of transformation for analysis of biological variables.
15. Probit Models

Recommenced Texts

1. Zar, J. (2000). *Bio statistical analysis* (5th ed.). New York: John Wiley and Sons.
2. Shoukri, M. M. & Pause, C. C. (1998). *Statistical methods for health sciences* (2nd ed.). Florida: CRC press.

Suggested Readings

1. Daniel, W. W. (1996). *Biostatistics: A foundation for the health sciences* (6th ed.). New York: John Wiley & Sons.
2. Diggle, P., Diggle, P. J., Heagerty, P., Liang, K. Y., Heagerty, P. J. & Zeger, S. (2002). *Analysis of longitudinal data*. Oxford University: Press.
3. Dunn, G. & Everit, B. (1995). *Clinical biostatistics*. London: Edward Arnold.

STAT-6135 **Decision Theory** **3(3+0)**

Decision theory is an interdisciplinary approach to arrive at the decisions that are the most advantageous given an uncertain environment. Decision theory brings together psychology, statistics, philosophy, and mathematics to analyze the decision-making process. Decision theory is closely related to game theory and is studied within the context of understanding the activities and decisions underpinning activities such as auctions, evolution, and marketing. Descriptive, prescriptive, and normative are three main areas of decision theory and each studies a different type of decision making. Descriptive decision theory examines how irrational beings make decisions. Prescriptive decision theory tries to provide guidelines for agents to make the best possible decisions given an uncertain decision-making framework. Normative decision theory provides guidance for making decisions given a set of values. Decision theory framework generally identifies three types of decision classes: Decisions under certainty: an abundance of information leads to an obvious decision. Decisions under uncertainty: analysis of known and unknown variables lead to the best probabilistic decision. Decisions under conflict: a reactive approach that involves anticipating potential consequences to the decision, prior to making a decision. The basic aim of this course is to highlight the advance applications of probabilistic approaches in the concern of statistical paradigm. Course explores the importance of risk factors and effective decision-making strategies. This course also classified according to their metric requirements (i.e., metric level, commensurability across the dimensions, and lexicographic ordering) in the system, is given. A brief introduction to process tracing techniques is followed by a review of results reported in process tracing studies of decision making.

Contents

1. The nature and concept of loss functions, parameters,
2. Decisions and sample spaces.
3. Risk loss
4. Average loss, Admissibility and the class of admissible decisions.
5. Minimax principle and its application to simple decision problems.
6. Linear and quadratic losses and their uses in problems of estimation and testing hypotheses.
7. Asymptotically minimax procedure,

8. A prior distributions and conjugate priors.
9. Bayes' decision procedure,
10. Admissibility of Bayes; Maxmin procedures.

Recommended Texts

1. Anderson E. B. (1990). *The statistical analysis of categorical data.* London: Springer.
2. Berger, J. O. (1985). *Statistical decision theory and bayesian analysis.* London: Springer.

Suggested Readings

1. Blackwell, D., & Graphic, M. A. (1966). *Theory of games and statistical decision*. New York: John Wiley and Sons.
2. Bowers, N. L. Gerber, H. U. Hickman, J. C. Jones, D. A. & Nesbitt, C. J. (1997). *Actuarial mathematics*. USA: Society of Actuaries, Ithaca.

STAT-6136 Data Mining 3(3+0)

Data mining is defined as the practice of examining large pre-existing databases in order to generate new information. It is the process used to extract usable data from a larger set of raw data. It implies analyzing data patterns in large batches of data using one or more software. Data mining involves effective data collection and warehousing as well as computer processing. Data mining is a process used by companies to turn raw data into useful information. By using software to look for patterns in large batches of data, businesses can learn more about their customers to develop more effective marketing strategies, increase sales and decrease cost. Statistics are a component of data mining that provides the tools and analytical techniques for dealing with large amounts of data. It is the science of learning from data and includes everything from collecting and organizing to analyze and presenting data. This course focuses on the concepts of database including simple and relational database, data warehouses, classification and decision trees and clustering method from data mining viewpoints. It also involves dimension reduction and feature selection, artificial neural networks and regression tress. This course deals with the association rules and prediction.

Contents

1. Introduction to databases,
2. Simple database
3. Relational databases
4. Data warehouses.
5. Review of classification methods from multivariate analysis
6. Classification and decision trees.
7. Clustering methods from both statistical
8. Data mining viewpoints
9. Vector quantization.
10. Unsupervised learning from univariate and
11. Multivariate data
12. Dimension reduction and feature selection.
13. Supervised learning from moderate to high dimensional input spaces

14. Artificial neural networks

Recommended texts

1. Han, J. & Camber, M. (2000). *Data mining, concepts and techniques*. London: Morgan Gaufman.
2. Benson, & Smith, S. J. (1997). *Data warehousing, data mining, and OLAP*. New York: McGraw-Hill.

Suggested Readings

1. Mitchell, T. M. (1997). *Machine learning*. London: McGraw-Hill.
2. Ripley. (1996). *Pattern recognition and neural networks*. Cambridge University: Press.

STAT-6137 Actuarial statistics-II 3(3+0)

Statistics are all about processing data and extracting information. The information we seek is the parameters and distribution of the random variable that generated the data. Armed with this information we can answer questions about reality and optimize industrial processes. Statistics thus form the backbone of science and business and this course is designed to help you understand the components of this fundamental subject and how they all fit together. So Actuarial Statistics are a general term for the data used by actuaries in evaluating the risks of morbidity and mortality in partc ular groups, and projecting future financial liabilities of insurance policies and pensions. This course is designed for advance understanding of actuarial science in applied nature. How does it works with real life mechanism, this course is capable to answer. This course consists of Principles of compound interest: nominal and effective rates of interest and discount, continuous compounding. After studying this course student will be able to understand Life Insurance process, insurance payable at the moment of death and at the end of the year of death-level benefit insurance, recursions, commutation functions. Life annuities: a single payment, continuous life annuities, and complete annuities-immediate and apportion able annuities-due. Net premiums: continuous and discrete premiums.

Contents

1. Principles of compound interest: National and effective rated of interest and discount,
2. Force of interest and discount, compound interest accumulation factor, continuous compounding. Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance,
3. Deferred insurance and varying benefit insurance, recursions, commutation functions.
4. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.
5. Net premiums, Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions accumulation type benefits. Payment premiums, apportionable premiums, commutation functions.

6. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on a apportionable of discounted continuous basis,
7. Reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Recommended Texts

1. Bowers, N. L. Gerber, H. U. Hickman, J. C. Jones, D. A. & Nesbitt, C. J. (1997). *Actuarial mathematics (*2nd ed.). USA: Society of Actuaries.
2. Spurgeon, E. T. (1972). *Life contingencies*. Cambridge University Press.

Suggested Readings

1. Neill, A. (1977). *Life contingencies*. Heinemann: Routlegde.
2. Blackwell, D. & Graphic, M. A. (1966). *Theory of games and statistical decision*. New York: John Wiley & Sons.

STAT-6138 Mathematical Modeling and Simulation 3(3+0)

Mathematical modelling and simulation are important research and monitoring tools used to understand biological communities and their relationships to the environment. The field of advanced simulation contains powerful tools and techniques to study stochastic models and other objects which defy a direct mathematical analysis. Mathematical models are collection of variables, equation, and starting values that form a cohesive representation of a process or behavior. Simulation is the process of using a model to study the behavior and performance of an actual or theoretical system. This course introduces some statistical modeling simulation methods to evaluate the performance of statistical methods. This course emphasizes both the theoretical and practical aspects of statistical simulation and analysis. It deals with the different methods of generating random numbers and random variables. It focuses on acceptance and rejection techniques from various distributions. Variance reduction techniques and resampling techniques are also the part of the course.

Contents

1. Different methods of generating random numbers
2. Generation of random variables.
3. Acceptance techniques from various distributions
4. Rejection techniques from various distributions.
5. Comparison of algorithms to generate random variables,
6. generating random variables from failure rates
7. Generation from multinomial distribution
8. Monte Carlo integration
9. Monte Carlo simulation
10. Gibbs sampling and other resampling techniques
11. Variance reduction techniques:
12. importance sampling for integration
13. Control variates
14. Regression analysis

15. Testing of hypothesis
16. Control charts through simulation
17. Time Series Models in R
18. Antithetic variables.

Recommended Texts

1. Ross, S. M. (2002). *Simulation* (3rd ed.). London: Academic Press.
2. Crawley, M. J. (2012). *The R book* (3rd ed.). London: John Wiley & Sons.

Suggested Readings

1. Velten, K. (2009). *Mathematical modeling and simulation*. New York: John Wiley & Sons.
2. Vasishth, S. & Bore, M. (2010). *The foundations of statistics: A Simulation-based approach*. New York: Springer.

STAT-6139 Project / Research Report 3(3+0)

A research report is a publication that reports on the findings of a research project or alternatively scientific observations on or about a subject. Research reports are produced by many sectors including industry, education, and government and non-government organizations and may be disseminated internally, or made public i.e. published however they are not usually available from booksellers or through standard commercial publishing channels. Research reports are also issued by governmental and international organizations. This is purely designed for students to know how to work on a research project and how to write a report on any topic. As research is a key field in this world so this focuses on different topics assigned to the students. This course is used to establish or confirm facts, reaffirms the results of previous work, solve new or existing problems, support theorems, or develop new theories. This subject is very useful for students because after doing research report they are capable to use their theoretical knowledge in variety of different fields according situation.

Contents

1. Introduction to Research
2. Nature of research
3. Statement of problem
4. Method of data collection
5. Style of literature review
6. Concept of writing methodology
7. Evaluating of data analysis
8. Various method of reference
9. Research paper
10. Presentation of research report
11. Uses of software
12. Allocation of supervisor

13. Student's task related to research

Recommended Texts

1. Different journals
2. Websites

Suggested Readings
Website for data
1. World Bank
2. Index Mundi
3. FAO
4. WHO
5. UNICEF
6. Bureau of Statistics
7. NADRA
8. Agriculture marketing information service

URCE-5101 Grammar 3(3+0)

The course introduces the students to the underlying rules to acquire and use language in academic context. The course aims at developing grammatical competence of the learners to use grammatical structures in context in order to make the experience of learning English more meaningful enabling the students to meet their real life communication needs. The objectives of the course are to, reinforce the basics of grammar, understand the basic meaningful units of language, and introduce the functional aspects of grammatical categories and to comprehend language use by practically working on the grammatical aspects of language in academic settings. After studying the course, students would be able to use the language efficiently in academic and real life situations and integrate the basic language skills in speaking and writing. The students would be able to work in a competitive environment at higher education level to cater with the long term learners' needs.

Contents

1. Parts of speech
2. Noun and its types
3. Pronoun and its types
4. Adjective and its types
5. Verb and its types
6. Adverb and its types
7. Prepositions and its types
8. Conjunction and its types
9. Phrases and its different types
10. Clauses and its different types
11. Sentence, parts of sentence and types of sentence
12. Synthesis of sentence
13. Conditional sentences
14. Voices
15. Narration
16. Punctuation

17. Common grammatical errors and their corrections

Recommended Texts

1. Eastwood, J. (2011). *A basic English grammar*. Oxford: Oxford University Press.
2. Swan, M. (2018). *Practical English usage* (8th ed.). Oxford: Oxford University Press.

Suggested Readings

1. Thomson, A. J. & Martinet, A. V. (1986). *A practical English grammar*. Oxford: Oxford University Press.
2. Biber, D., Johansson, S., Leech, G., Conrad, S., Finegan, E., & Quirk, R. (1999*). Longman grammar of spoken and written English*. Harlow Essex: MIT Press.
3. Hunston, S., & Francis, G. (2000*). Pattern grammar: A corpus-driven approach to the lexical grammar of English*. Amsterdam: John Benjamins.

URCE-5102 Language Comprehension & Presentation Skills 3(3+0)

The course aims at developing linguistic competence by focusing on basic language skills in integration to make the use of language in context. It also aims at developing students' skills in reading and reading comprehension of written texts in various contexts. The course also provides assistance in developing students' vocabulary building skills as well as their critical thinking skills. The contents of the course are designed on the basis of these language skills: listening skills, pronunciation skills, comprehension skills and presentation skills. The course provides practice in accurate pronunciation, stress and intonation patterns and critical listening skills for different contexts. The students require a grasp of English language to comprehend texts as organic whole, to interact with reasonable ease in structured situations, and to comprehend and construct academic discourse. The course objectives are to enhance students' language skill management capacity, to comprehend text(s) in context, to respond to language in context, and write structured response(s).

Contents

1. Listening skills
2. Listening to isolated sentences and speech extracts
3. Managing listening and overcoming barriers to listening
4. Expressing opinions (debating current events) and oral synthesis of thoughts and ideas
5. Pronunciation skills
6. Recognizing phonemes, phonemic symbols and syllables,
7. Pronouncing words correctly
8. Understanding and practicing stress patterns and intonation patterns in simple sentences
9. Comprehension skills
10. Reading strategies, summarizing, sequencing, inferencing, comparing and contrasting
11. Drawing conclusions, self-questioning, problem-solving, relating background knowledge
12. Distinguishing between fact and opinion,
13. Finding the main idea, and supporting details
14. Text organizational patterns, investigating implied ideas, purpose and tone of the text
15. Critical reading, SQ3R method

16. Presentation skills, features of good presentations,
17. Different types of presentations

Recommended Texts

1. Mikulecky, B. S. & Jeffries, L. (2007). *Advanced reading power: Extensive reading, vocabulary building, comprehension skills, reading faster*. New York: Pearson.
2. Helgesen, M., & Brown, S. (2004). *Active listening: building skills for understanding*. Cambridge: Cambridge University Press.

Suggested Readings

1. Roach, C. A. & Wyatt, N. (1988). *Successful listening*. New York: Harper and Row.
2. Horowitz, R. & Samuels, S. J. (1987). *Comprehending oral and written language*. San Diego: Academic Press.

URCE-5103 Academic Writing 3(3+0)

Academic writing is a formal, structured and sophisticated writing to fulfill the requirements for a particular field of study. The course aims at providing understanding of writer's goal of writing (i.e. clear, organized and effective content) and to use that understanding and awareness for academic reading and writing. The objectives of the course are to make the students acquire and master the academic writing skills. The course would enable the students to develop argumentative writing techniques. The students would be able to the content logically to add specific details on the topics such as facts, examples and statistical or numerical values. The course will also provide insight to convey the knowledge and ideas in an objective and persuasive manner. Furthermore, the course will also enhance the students understanding of ethical considerations in writing academic assignments and topics including citation, plagiarism, formatting and referencing the sources as well as the technical aspects involved in referencing.

Contents

1. Academic vocabulary
2. Quoting, summarizing and paraphrasing texts
3. Process of academic writing
4. Developing argument
5. Rhetoric: persuasion and identification
6. Elements of rhetoric: Text, author, audience, purposes, setting
7. Sentence structure: Accuracy, variation, appropriateness, and conciseness
8. Appropriate use of active and passive voice
9. Paragraph and essay writing
10. Organization and structure of paragraph and essay
11. Logical reasoning
12. Transitional devices (word, phrase and expressions)
13. Development of ideas in writing
14. Styles of documentation (MLA and APA)
15. In-text citations

16. Plagiarism and strategies for avoiding it

Recommended Texts

1. Swales, J. M. & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills* (3rd ed.). Ann Arbor: The University of Michigan Press.
2. Bailey, S. (2011). *Academic writing: A handbook for international students* (3rd ed.). New York: Routledge.

Suggested Readings

1. Craswell, G. (2004). *Writing for academic success*. London: Sage.
2. Johnson-Sheehan, R. (2019). *Writing today*. Don Mills: Pearson.
3. Silvia, P. J. (2019). *How to write a lot: A practical guide to productive academic writing*. Washington: American Psychological Association.

URCE-5104 Introduction to English Literature 3(3+0)

The course is designed to provide the familiarity and comprehension of English literary pieces. The students may not be familiar or well-versed in the various genres of literature prior to taking this course. The course provides training and skills necessary to engage, understand, critically analyze, and enjoy the literary genres of literature: short story, poetry, novel and drama. The students will explore the basic concepts of literary technique, narrative, poetic, and dramatic structures and innovations to engage with the more advanced cognitive aspects of literature. In addition to these theoretical skills, students will also read below the surface of the texts for their historical, ethical, psychological, social, and philosophical value by developing insights in how literature gives us a window into both the experiences of others and wider appreciation for the human condition. The course explores literary production in English against local context in particular, by emphasizing shifts in thought as well as genre innovation, i.e. medieval to modern. It provides an introduction to key texts, authors and literary periods, exploring the relationship of texts to their contexts and considering multiple perspectives in the different literary genres.

Contents

1. Poems, Milton: *Book IX*, lines 897–959.
2. Shakespeare: All the World is a Stage.
3. Browning: My Last Duchess
4. Wordsworth: The Leech Gatherer
5. Keats: Ode to Autumn
6. Walter De La Mare: Tartary
7. Short Stories
8. *The Necklace*
9. The Woman Who had Imagination
10. Shadow in the Rose Garden
11. Essays
12. *My Tailor*

13. Whistling of the Birds
14. One Act Play
15. *Riders to the Sea*
16. Novel, *Animal Farm*

Recommended Readings

1. Kennedy, X.J. & Gioia, D. (2014). *Literature: An introduction to fiction, poetry, drama, and writing*. Boston: Pearson.
2. Mays, K. J. (2014). *The Norton introduction to literature*. New York: Norton.

Suggested Readings

1. Bausch, R & Cassill, R.V. (2006). *The Norton anthology of short fiction*. New York: Norton and Company.
2. Gardner, J. E., Lawn, B., Ridl, J. & Schakel, P. (2016). *Literature: A portable anthology*. Boston: Bedford St. Martins.

URCI-5105 1Islamic Studies 2(2+0)

Islamic Studies engages in the study of Islam as a textual tradition inscribed in the fundamental sources of Islam; Qur'an and Hadith, history and particular cultural contexts. The area seeks to provide an introduction to and a specialization in Islam through a large variety of expressions (literary, poetic, social, and political) and through a variety of methods (literary criticism, hermeneutics, history, sociology, and anthropology). It offers opportunities to get fully introductory foundational bases of Islam in fields that include Qur'anic studies, Hadith and Seerah of Prophet Muhammad (PBUH), Islamic philosophy, and Islamic law, culture and theology through the textual study of Qur'an and Sunnah. Islamic Studies is the academic study of Islam and Islamic culture. It majorly comprises of the importance of life and that after death. It is one of the best systems of education, which makes an ethical groomed person with the qualities which he/she should have as a human being. The basic sources of the Islamic Studies are the Holy Qur'an and Sunnah or Hadith of the Holy Prophet Muhammadﷺ. The learning of the Qur'an and Sunnah guides the Muslims to live peacefully.

Contents

1. Study of the Qur'an (Introduction to the Qur'an, Selected verses from *Surah Al-Baqarah, Al-Furqan, Al-Ahzab, Al-Mu'minoon, Al-An'am, Al-Hujurat, Al-Saff*)
2. Study of the Hadith
3. Introduction to Hadith literature, Selected Ahadith (Text and Translation)
4. Introduction to Qur'anic Studies
5. Basic Concepts of Qur'an
6. History of Quran
7. Basic Concepts of Hadith
8. History of Hadith
9. Kinds of Hadith
10. Uloom –ul-Hadith

11. Sunnah & Hadith
12. Seerat ul-Nabi (PBUH), necessity and importance of Seerat,
13. Role of Seerah in the development of personality, Pact of Madinah, Khutbah Hajjat al-Wada' and ethical teachings of Prophet (PBUH).
14. Legal Position of Sunnah

Recommend Texts

1. Hassan, A. (1990). *Principles of Islamic jurisprudence*. New Dehli: Adam Publishers.
2. Zia-ul-Haq, M. (2001). *Introduction to al-Sharia al-Islamia*. Lahore: Aziz Publication.

Suggested Readings

1. Hameedullah, M. (1957). *Introduction to Islam*. Lahore: Sh M Ashraf Publisher.
2. Hameedullah, M. (1980). *Emergence of Islam*. New Dehli: Adam Publishers.
3. Hameedullah, M. (1942). *Muslim conduct of state*. Lahore: Sh M Ashraf Publisher.

URCP-5106 Pakistan Studies 3(3+0)

The course is designed to acquaint the students of BS Programs with the rationale of the creation of Pakistan. The students would be apprised of the emergence, growth and development of Muslim nationalism in South Asia and the struggle for freedom, which eventually led to the establishment of Pakistan. While highlighting the main objectives of national life, the course explains further the socio-economic, political and cultural aspects of Pakistan's endeavors to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighboring and other countries are also included. This curriculum has been developed to help students analyze the socio-political problems of Pakistan while highlighting various phases of its history before and after the partition and to develop a vision in them to become knowledgeable citizens of their homeland.

Contents

1. Contextualizing Pakistan Studies
2. Geography of Pakistan
3. Geo-Strategic Importance of Pakistan
4. Freedom Movement (1857-1947)
5. Pakistan Movement (1940-47)
6. Muslim Nationalism in South Asia
7. Two Nations Theory
8. Ideology of Pakistan
9. Initial Problems of Pakistan
10. Political Developments in Pakistan
11. Constitutional Developments in Pakistan
12. Economy of Pakistan
13. Problems and Prospects
14. Society and Culture of Pakistan

15. Foreign Policy Objectives of Pakistan
16. Diplomatic Relations
17. Current and Contemporary Issues of Pakistan
18. Human Rights:
19. Issues of Human Rights in Pakistan

Recommended Texts

1. Kazimi, M. R. (2007). *Pakistan studies.* Karachi: Oxford University Press.
2. Ahmad, S. J. (2004). *Pakistan's political economic and diplomatic dynamics.* Lahore: Kitabistan Paper Products.

Suggested Readings

1. Sikandar, H. (2016). *Aspects of Pakistan movement*. Islamabad: National Institute of Historical and Cultural Research.
2. Kazimi, M. R (2009). *A concise history of Pakistan*. Karachi: Oxford University Press.
3. Ian, T. (1998). *Pakistan: A modern history*. London: Hurst and Company.

URCC-5110 Citizenship Education and Community Engagement 3(1+2)

The overall objectives of this course are to teach students the importance and role of active citizenship in promoting a productive, harmonious and developed society/world. Educate students about the importance of concepts, skills and philosophy of community linkages in developing a sustainable society. Inculcate the impotence of community involvement for ensuring an improved, tolerant and generative society/world. Provide an opportunity to the students to develop their relationship with the community. The primary outcome is inclusive development through active citizenship locally and globally. Moreover, the following are the detailed outcomes of the course based on the three domains of Bloom's Taxonomy i.e. affective, Psychomotor and Cognitive. The distinctive core of citizenship has been the possession of the formal status of membership of a political and legal entity and having particular sorts of rights and obligations within it. The students will be able to understand the overall organization of the society. Recognize and exercise their right, responsibilities and the significance of active citizenship in positive societal development. Identify and critically evaluate social issues and implement practicable community based solutions. Understand the concept of human rights and its significance.

Contents

1. Introduction to Citizenship Education and Community Engagement
2. Approaches and methodology for active citizenship
3. Identity, culture, and social Harmony
4. Components of Culture and Social Harmony
5. Cultural & Religious Diversity (Understanding and affirmation of similarities & differences)
6. Social structure and social hierarchy (Stake holders: decision makers: implements and others)
7. Inter-cultural dialogue (bridging the difference, promoting harmony)
8. Multi-cultural society
9. Role of civil society in promoting inter-cultural harmony
10. Importance of active citizenship at national and global level

11. Identification of resources (human, natural an others)
12. Strategic planning for development (community linkages and mobilization)
13. Human Rights, Constitutionalism and Citizens' Responsibilities
14. Constitutionalism and democratic process
15. Social Issues in Pakistan
16. Causes and solutions: critical thinking an evaluation: Social Action Project

Recommended Texts

1. Kennedy, K. J. & Brunold, A. (2015). *Regional contexts and citizenship education in Asia and Europe*. New York: Routledge.
2. Clarke, P. & Wales, J. (2005). *Learning citizenship: practical teaching strategies for secondary schools*. New York: Routledge.

Suggested Readings

1. Larsen, A. K., Sewpaul, V. & Hole, G. O. (2013). *Participation in community work: international perspectives*. New York: Routledge.
2. Jackson, R. (2003). *International perspectives on citizenship, education and religious diversity*. New York: Routledge.

MATH-5125 Calculus-I 3 (3+0)

Real number is a value of a continuous quantity that can represent a distance along a line. Real numbers can be thought of as points on an infinitely long line called the number line or real line, where the points corresponding to integers are equally spaced. Any real number can be determined by a possibly infinite decimal representation, such as that of 8.632, where each consecutive digit is measured in units one tenth the size of the previous one. The real line can be thought of as a part of the complex plane, and complex numbers include real numbers. The aim of the course is to learn about number systems. The course is designed for use of mathematical concepts in practical life problems by converting them in to simple mathematical equations. Sequence and series, binomial theorem and trigonometry are also a part of the contents. This course provided a foundation of important mathematical ideas for the future course work. This focuses in making connections among the various conceptual and numerical formation. This course helps the students to able in further more problem of statistics in advance level like in experimental design, sampling distribution and statistical inference.

Contents

1. Real number systems
2. Complex number systems
3. Introduction to sets,
4. Binary operations,
5. Functions and type of functions.
6. Types of matrices,
7. Inverses determinants,
8. System of linear equations Cramer's rule.
9. Quadratic equations,
10. Solutions and types,
11. Cube roots of unity,

12. relation between roots and coefficients of quadratic equations,
13. Solution of system of equations.
14. Sequences and series, arithmetic,

Recommended Texts

1. Howard, A. (2014). *Elementary linear algebra, applications version.* New York: John Wiley and Sons.
2. Hilfer, R. (2000). *Applications of fractional calculus in physics*. Singapore: World scientific.

Suggested Readings

1. Boyd, S. & Vandenberghe, L. (2018). *Introduction to applied linear algebra: vectors, matrices, and least squares*. Cambridge University: press.
2. Kolman, B. & Beck, R. E. (1995). *Elementary linear programming with applications*. California: Gulf Professional Publishing.

MATH-5126 Calculus-II 3(3+0)

Calculus is the mathematical study of continuous change, in the same way that geometry is the study of shape and algebra is the study of generalizations of arithmetic operations. It has two major branches, differential calculus and integral calculus; the former concerns instantaneous rates of change, and the slopes of curves, while integral calculus concerns accumulation of quantities, and areas under or between curves. These two branches are related to each other by the fundamental theorem of calculus, and they make use of the fundamental notions of convergence of infinite sequences and infinite series to a well-defined limit. The aim of the course is to analyze / interpret quantitative data verbally, graphically, symbolically and numerically. This course is designed for recognize the techniques of derivatives and integration and their applications in everyday life and particularly in statistics. The derivatives are helpful in analyzing the extremes values of the functions. The techniques of integrations are helpful in determining the areas and distances problems.

Contents

1. Functions
2. Graphs,
3. Solutions to absolute values,
4. Solutions to inequalities.
5. Limits,
6. Left hand and right hand limits.
7. Continuity
8. Continuous functions.
9. Derivatives and their applications,
10. differentiable functions,
11. differentiation of polynomials,
12. Rational and transcendental functions.
13. Integration and indefinite integrals,
14. Techniques of evaluation of indefinite integrals.
15. Integration by substitution,
16. Integration by parts: Change of variables in integrals: Multiple integrals.

Recommended Texts

1. Stewart, J. (2018). *Calculus* (6th ed.). McMaster University Press.
2. Anton, H. & Herr, A. (1988). *Calculus with analytic geometry*. New York: John Wiley and Sons.
3. Anton, H., Bevens, I. & Davis, S. (2005). *Calculus, a new horizon* (8th ed.). New York: John Wiley and Sons.

Suggested Readings

1. Swokowsli, E. W. (1983). *Calculus with analytic geometry*. Kent: PWS-Kent, company Boston.
2. Thomas G.B. & Finney A, (2005). *Calculus* (11th ed.). USA: Addison Wesley.
3. Weir, M. D. & Hass, J. (2010). *Thomas' calculus*. USA: Addison-Wesley.

MATH-5127 Linear Algebra 3(3+0)

Linear algebra is central to almost all areas of mathematics. For instance, linear algebra is fundamental in modern presentations of geometry, including for defining basic objects such as lines, planes and rotations. Also, functional analysis may be basically viewed as the application of linear algebra to spaces of functions. Linear algebra is also used in most sciences and engineering areas, because it allows modeling many natural phenomena, and efficiently computing with such models. For nonlinear systems, which cannot be modeled with linear algebra, linear algebra is often used for dealing with first-order approximations, using the fact that the differential of a multivariate function at a point is the linear map that best approximates the function near that point. The aim of the course is to arrange data in tabular forms. The course is designed for use of mathematical concepts in problem solving through matrices. This course is designed to learn special techniques of matrices. Analyze the structure of real world problems and to plan solutions strategies matrices determinants. This course will provide a foundation of important mathematical ideas in particular arrangements. This focuses in making connections among the various conceptual and numerical formation.

Contents

1. Matrices
2. Algebra of matrices
3. Inverses of matrices,
4. Elementary row operations in matrices,
5. Ranks and transformation in matrices.
6. System of linear equations,
7. Gaussian elimination method,
8. Gauss Gordan method.
9. Determinants of squares matrices,
10. Determinants
11. Order of matrices
12. Decomposition of matrices: Transpose of a matrices,
13. Algorithm to evaluate determinants and Inverses of matrices: Net work flow problems and their solutions.

Recommended Texts

1. Anton, H. (2014). *Elementary linear algebra, applications version*. New York: John Wiley and Sons.
2. Schneider, H. (2012). *Matrices and linear algebra*. George: Phillip Barker.

Suggested Readings

1. Boyd, S. & Vandenberghe, L. (2018). *Introduction to applied linear algebra: vectors, matrices, and least squares*. Cambridge University: press.
2. Kolman, B. & Beck, R. E. (1995). *Elementary linear programming with applications*. Germany: Gulf Professional Publishing.
3. Halmos, P. R. (1995). *Linear algebra problem book*. New York: John Wiley and Sons.
4. Penney, R. C. (2008). *Linear algebra: Ideas and applications*. London: Wiley-Interscience.

STAT-5107 Foundation of Education 3(3+0)

Foundations of Education refers to a broadly-conceived field of educational study that derives its character and methods from a number of academic disciplines, combinations of disciplines, and area studies, including: history, philosophy, sociology, anthropology, religion, political science, economics, psychology, cultural studies, gender studies, comparative and international education, educational studies, and educational policy studies. As distinct from Psychological Foundations of Education, which rely on the behavioral sciences, these Standards address the Social Foundations of Education, which rely heavily on the disciplines and methodologies of the humanities, particularly history and philosophy, and the social sciences, such as sociology and political science. The purpose of foundations study is to bring these disciplinary resources to bear in developing interpretive, normative, and critical perspectives on education. This course provides the basic concepts of education, types of education, Science or Art, aim of education, role of religion, culture and society. The main purpose of the course is to provide for the fullest possible development of each learner for living morally, creatively and productively in a society. It involves Islamic, philosophical and historical foundation.

Contents

1. Education: Meaning, concept and function.
2. Education: Science or Art. Types of education (formal, informal, non-formal).
3. Aims of education: Democratic and totalitarian. Role of Religion, Culture, Society and Ideology in education.
4. Foundation of education at a glance: Islamic Foundation,
5. Philosophical Foundation, sociological Foundation,
6. Economic Foundation, History Foundation.
7. Philosophy of education, the branches of philosophy,
8. Metaphysics/ontology, epistemology, axiology (Aesthetics, Ethics).
9. Sources of knowledge: Logic and Rational knowledge,
10. Empirical knowledge authority, Institution,
11. Inspiration from Allah (Revelation).
12. Link between philosophy and education, Islamic Foundations Education: Ontology of Islam: Concept of Ontology in Islam.

Recommended Texts

1. Rashid, M. (2000). *Allied material of foundation of education.* Islamabad: AIOU Press.
2. Hemlata, T. (2002). *Sociological foundation of education. New Delhi:* Kanishka. Publishers.

Suggested Readings

1. Shahid, S.M. (2005). *Foundation of education.* Islamabad: AIOU Press.
2. Singh, Y. K. (2008). *Philosophical foundation of education*. India: APH Publishing.
3. Singh, Y. K. (2007). *Sociological foundation of education*. India: APH Publishing.

STAT-5108 Psychology (Social Psychology) 3 (3+0)

Social psychology is the scientific study of how the thoughts, feelings, and behaviors of individuals are influenced by the actual, imagined, and implied presence of others.[1] In this definition, scientific refers to the empirical investigation using the scientific method, while the terms thoughts, feelings, and behaviors refer to the psychological variables that can be measured in humans. Moreover, the notion that the presence of others may be imagined or implied suggests that humans are malleable to social influences even when alone, such as when watching videos, quietly appreciating art, or even sitting on the toilet. In such situations, people can be influenced to follow internalized cultural norms. The aim of the course is to provide the students with human psychology, its nature and scope of social psychology. This also focuses on interpersonal communication along with attitudes and social influences. Cognitive prospective related to human behavior and mental perceptions are key features of the course. This course helps the students in term of social and psychological problem in different fields of life.

Contents

1. Nature Social Psychology
2. Scope of Social Psychology.
3. Social perceptions,
4. Social cognition
5. Understanding the social world
6. Interpersonal Communication,
7. Social situations: Social skills
8. Attitudes
9. Evaluating the social world
10. Social Influence
11. Changing others behavior: Groups and individuals: The consequences of belonging
12. Cognitive prospective
13. Cognitive prospective related to human behavior
14. Cognitive prospective related to mental perceptions.

Recommended Texts

1. Baron, R. A., Byrene, D. & Johnson, B.T. (1998). *Exploring social psychology* (4th ed.). London: Ayllon and Bacon.
2. Callan, V.J., Gallois, C. & Kashima, Y. (1991). *Social psychology* (2nd ed.). Australia: Harcourt Limited.
3. Deutsch, M. & Krauss, R. M. (1965). *Social Psychology*. New York: Prentice Hall.

Suggested Readings

1. Myers, G.R. (2003). *Social psychology* (6th ed.). New York: Prentice Hall.
2. Vallacher, R. R. & Nowak, A. E. (1994). *Dynamical systems in social psychology*. London: Academic Press.
3. Hogg, M. A. (1992). *The social psychology of group cohesiveness: From attraction to social identity*. London: Harvester Wheatsheaf.

STAT-5109 Economics (Principles of Economics) 3 (3+0)

Economics is the social science that studies the production, distribution, and consumption of goods and services. Economics focuses on the behavior and interactions of economic agents and how economies work. Microeconomics analyzes basic elements in the economy, including individual agents and markets, their interactions, and the outcomes of interactions. Individual agents may include, for example, households, firms, buyers, and sellers. Macroeconomics analyzes the economy as a system where production, consumption, saving, and investment interact, and factors affecting it: employment of the resources of labour, capital, and land, currency inflation, economic growth, and public policies that have impact on these elements. This course deals with economic system, basic functions of an economic system tools of economics analysis and demand. Economics is a field of study that is best place to trap, study, project and predict human behavior and as such is one of the most important and relevant skills for the world today. This course also provides the knowledge of basic functions of Supply and demands. This course helps students how society use scarce resources to produce valuable commodities and distribute them among different people.

Contents

1. Economic system
2. Basic functions of an economic system tools of economic analysis
3. Demand
4. Shift of demand.
5. Basic function of Supply
6. Shift of Supply
7. Price determination
8. Govt. and Market.
9. Tax and Subsidy
10. Demand Elasticity
11. Supply Elasticity
12. Theory of the Consumer: Theory of the Firm
13. Theory of Cost and Theory of Market Structure
14. Perfect Competition
15. Imperfect Markets. What is Macroeconomics?

Recommended texts

1. Varian, H.R. (1999). *Intermediate l micro-economics* (5th ed.). New York: W.W. Norton Company.
2. Nicholson, W. (1994). *Intermediate l micro-economics*. New York: The Drydon Press. Harcourt Brace College, Publishers.

Suggested Readings

1. Young, D. R. & Steinberg, R. (1995). *Economics for nonprofit managers*. New York: Foundation Center.
2. Myers, G.R. (2003). *Social psychology* (6th ed.). New York: Prentice Hall.

STAT-5110 International Relations 3 (3+0)

The study and practice of international relations is interdisciplinary in nature, blending the fields of economics, history, and political science to examine the topics such as human rights, global poverty, the environment, economics, globalization, security, global ethics, and the political environment. Historically, the establishment of treaties between nations served as the earliest form of international relations. International relations allows nations to cooperate with one another, pool resources, and share information as a way to face global issues that go beyond any particular country or region.This course provides a comprehensive introduction to international relations, focusing in particular on its origins and historical evolution, its key concepts, major theoretical frameworks, main actors and institutions, the global architecture of power, and its dynamic nature in the process of globalization. More specifically, this course introduces concepts of power, statecraft, diplomacy, foreign policy, political economy and international security, and examines the evolution of international relations as a subject.

Contents

1. IR as an Academic Field
2. Realism, Liberalism, Marxism, Social Constructivism
3. Relevance to Current Issues
4. US, Russia and Rise of China
5. Development of the International System
6. History of state development (City State to Empires)
7. Westphalia and Emergence of State system
8. Industrial Revolution and French Revolution
9. World War I & World War II
10. Cold War and Post-Cold War
11. States and Other Actors
12. Sovereignty and Nationalism
13. States, IGOs, TNAs
14. Globalization
15. Foreign Policy: Diplomacy

Recommended texts

1. Devetak, R., George, J. & Percy, S. (2017). *An introduction to international relations*. Cambridge: Cambridge University Press.
2. Baylis, J., Smith, S. and Owens, P. (2004). *The globalization of world politics*. London: Oxford University Press.

Suggested Readings

1. Jackson, R. & Sørensen, G. (2016). *Introduction to international relations* (6th ed.). London: Oxford University Press.
2. Carlsnaes, W., Carlsnaes, W., Risse-Kappen, T. & Simmons, B. (2013). *Handbook of international relations*. London: Sage Publications.

STAT-5111 Introduction to Mass Communication 3(3+0)

This course is an examination of the effect and impact of mass media on contemporary life and society. The course covers both the historical evolution of media as well as contemporary developments and issues. Areas of coverage include newspapers, magazine and book publishing, radio and television broadcasting, Internet and social media, cable and satellite communication, advertising and public relation. This course will further aimed at understand of the communication process and distinguish among various mass media like traditional and new media. This course will make students able to evaluate their own media consumption habits and critically ascertain the impact of mass media on their own lives. Major objective of this course is to know about basic factors affecting mass communication in the digital age. Another aim is to build an understanding of society's impact on the media and the media's impact on individuals and society. This will develop an increased understanding and awareness of students about media influences on multiculturalism, politics and diverse areas of life.

Contents

1. Fundamentals of Communications
2. Understanding the Concept of Communication and Mass Communication
3. Nature and Characteristics of Communication
4. Elements of the Communication Process, Functions of Mass Communication
5. Models of Communication
6. Forms of Communication (Verbal Communication, Non-Verbal Communication, Intra and Interpersonal Communication, Group and Public Communication)
7. Cross Culture/International Communication
8. Media of Communication, types (Print Media: Books, Newspaper, Magazine, Book Publishing
9. Broadcast Media: Television and Radio, Narrowcast media: Film and Cinema, Cable Television)
10. Online Media: Online Newspapers and Magazines, Internet Radio etc
11. Adjunct/Impact of the Mass Media
12. Concept, Development and Functions of Public Relations
13. Concept, Development and Functions of Advertising
14. Effects of the Mass Media on the Society and Criticism on media and globalization

Recommended Texts

1. Stanley B. J. (2016). *Introduction to Mass communication: Media literacy and culture* (10th ed.). New York: McGraw Hill.
2. John, P. & Shawn, M. (2017). *Converging media; A new introduction to mass communication*. New York: Oxford University Press.

Suggested Readings

1. Cambell, R., Martin, C. & Fabos, B. (2014). *Media and communication: mass communication in digital age*. New York: Bedford/St.Martin's.
2. Dominick, J. (2014*). Dynamics of mass communication* (12th ed.). New York. McGraw-Hill.

3. Sambe, J.A. (2005). *Introduction to mass communication practice in Nigeria*. Ibadan: Spectrum Books.
4. Vivian, J. (2015). *Media of mass communication.* New York: Pearson Inc.

STAT-5112 Business Administration (Entrepreneurship) 3 (3+0)

Business administration is the administration of a business. It includes all aspects of overseeing and supervising business operations. From the point of view of management and leadership, it also covers fields that include accounting, finance, project management and marketing. The administration of a business includes the performance or management of business operations and decision-making, as well as the efficient organization of people and other resources to direct activities towards common goals and objectives. In general, "administration" refers to the broader management function, including the associated finance, personnel and MIS services. This course provides the basic concept of management yesterday and today, organizational environment and social responsibilities. It includes the performance or management of business operation and decision making as well as the efficient organization of people and other sources. This course also deals with human resource management and motivating employees. The course helps the students to able to learning the some basic term and concepts of the business which are related to statistics and their daily life work.

Contents

1. Introduction
2. Management Yesterday & Today
3. Organizational Environment.
4. Social responsibilities
5. Decision making
6. The essence of Manager's job,
7. Foundation of Planning.
8. STRATEGIC Management,
9. Planning tools and Techniques.
10. Organizational structure
11. Organizational design,
12. Managerial communication.

Recommended texts

1. Gijselaers, W. (1995). *Educational innovation in economics and business administration: The case of problem-based learning* (1st ed.). London: Springer Science and Business Media.
2. Beardwell, J. & Claydon, T. (2010). *Human resource management: A contemporary approach.* New York, NY: Pearson Financial Times/Prentice Hall.

Suggested Readings

1. Baker, M. (2012). *The marketing book*. London: Routledge.
2. Briscoe, D. R. & Schuler, R. S. (2004). *International human resource management: policy and practice for the global enterprise*. Dale: Psychology Press.
3. Schewe, C. D. & Hiam, A. (1998). *The portable MBA in marketing*. New York: John Wiley and Sons.

STAT-5113 Human Resource Management 3(3+0)

Human resource management is the strategic approach to the effective management of people in a company or organization such that they help their business gain a competitive advantage. It is designed to maximize employee performance in service of an employer's strategic objectives. The overall purpose of human resources (HR) is to ensure that the organization is able to achieve success through people.[5] HR professionals manage the human capital of an organization and focus on implementing policies and processes. They can specialize in finding, recruiting, training, and developing employees, as well as maintaining employee relations or benefits. Training and development professionals ensure that employees are trained and have continuous development. This is done through training programs, performance evaluations, and reward programs. Employee relations deal with the concerns of employees when policies are broken, such as cases involving harassment or discrimination. Managing employee benefits includes developing compensation structures, parental leave programs, discounts, and other benefits for employees. This course is designed for providing the conceptual knowledge about human resource management, its planning, job design and analysis. The course focuses on recruitment, selection, motivation, reward system and performance appraisal. It also deals with career planning and development, compensation management and employee relations.

Contents

1. Introduction to HRM.
2. Human Resource Planning,
3. Job Design and Analysis.
4. Recruitment: Selection.
5. Motivation & Reward System: Career Planning
6. Performance appraisal: Development.
7. Training & Development.
8. Performance Appraisal.
9. Compensation Management
10. Employee Relation: Employee Health and Safety.

Recommended texts

1. Briscoe, D. R. & Schuler, R. S. (2004). *International human resource management: policy and practice for the global enterprise*. Dale: Psychology Press.
2. Beardwell, J. & Claydon, T. (2010). *Human resource management: A contemporary approach*. New York: Pearson Financial Times/Prentice Hall.

Suggested Readings

1. Grobler, P. A. (2005). *Human resource management in South Africa*. India: Cengage Learning EMEA.

2. Storey, J. (Ed.). (2007). *Human resource management: A critical text*. India: Cengage Learning EMEA.
3. Pinnington, A. & Edwards, T. (2000). *Introduction to human resource management*. Germany: OUP Catalogue.
4. Sparrow, P., Brewster, C. & Chung, C. (2016). *Globalizing human resource management*. London: Routledge.

STAT-6114 Environmental Sciences 3(3+0)

Environmental science is an interdisciplinary academic field that integrates physical, biological and information sciences including ecology, biology, physics, chemistry, bio technology, earth science, plant science, zoology, mineralogy, oceanography, limnology, soil science, geology and physical geography, and atmospheric science to the study of the environment, and the solution of environmental problems. Environmental science emerged from the fields of natural history and medicine during the Enlightenment.[1] Today it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems. Environmental studies incorporate more of the social sciences for understanding human relationships, perceptions and policies towards the environment. Environmental engineering focuses on design and technology for improving environmental quality in every aspect. This course provides the concepts of ecosystem, basic global ecosystem, biological, nitrogen, phosphorus, sulpher and water cycle. It includes the study about the interaction of the physical, chemical and biological components of the environment and also the relationship and effect of these components with the organisms in the environment.

Contents

1. An overview of concepts of ecosystem with emphasis on interaction and homeostasis,
2. Basic global ecosystems,
3. Biological cycle, nitrogen, phosphorus, Sulpher, water, carbon nutrients,
4. Limiting factors, basic concepts, temperature, Soil, Water & Humidity, Light, Fire, Energy.
5. Laws of thermodynamics,
6. Primary and Secondary productions, tropic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs,
7. Population ecology, basic population characters.
8. Growth and growth curves, population dynamics and regulations, Community ecology, basic concepts and types,
9. An overview of major biomes of the world
10. Applied Ecology, Resources and their ecological management mineral,
11. Agriculture and forest, Range management.
12. Desalination and weather modification, landscape and land use,

Recommended Texts

1. Odum. E. P (1994). *Fundamentals of ecology*. London: Saunders Press.
2. Dondson, S. I., Allen, T.F.N, Carpenter, S; R., Ives, A., Jeanne, R.L. Kitchell, J.F. Langston, N.E. & Turner, M.G. (1998). *Ecology.* Oxford University Press.

Suggested Readings

1. Singby, D. & Cork, D. (1986). *Practical ecology.* London: McMillan Education Ltd.

2. Cunningham, W. P., Cunningham, M. A. & Saigo, B. W. (2001*). Environmental science: A global concern.* Boston: McGraw-Hill.

STAT-5115 Principles of Management and Marketing 3(3+0)

This course is divided in two parts. First part is about the management of organizations. It provides guidelines to students on principles of management that have general applicability to all types of enterprises. It highlights basic management philosophy and decision making techniques, and recent concepts in management. It elaborates principals involved in planning, organizing, leading, and controlling the organizational activities. The principles learned in this course will allow the students to effectively work with and through others people in an organization. The course will also encourage the students to explore and inquire the applicability of western management principles and theories in local settings. Second part is about principles of marketing. The basic objective of this part is to introduce the marketing concepts and how we identify, understand and satisfy the needs of customers and markets. It highlights how organizations create value for consumers in their products. To analyze companies and competitors and to introduce marketing strategy to increase awareness of the strategic and tactical decisions behind today's top performing brands.

Contents

1. Introduction to managers and management.
2. History of management.
3. The decision making process: The essence of manager‘s job.
4. Planning: The foundations of planning, the process of Planning, purposes of Planning.
5. Organization structure and design: The dimension of organization structure.
6. Global management.
7. Define marketing and outline the steps in the marketing process.
8. Understanding the Marketplace and Customer Needs.
9. Designing a Customer-Driven Marketing Strategy.
10. Companywide strategic Planning. Defining marketing's Role. Designing the business portfolio.
11. Planning marketing process.
12. Marketing environment.
13. Marketing Research, marketing information.
14. Model of Consumer Behavior. Characteristics Affecting Consumer Behavior.
15. Pricing and pricing strategies.

Recommended Texts

1 Laudon, K. C. & Laudon, J. P. (1999). *Management information systems*. New York: Prentice Hall PTR.

2 Philp, K. & Gary A. (2017). *Principle of marketing* (17th ed.). London: Pearson McGraw Hill Co.

Suggested Readings

1 Robbins, S.P. & David, A. (2010). *Fundamentals of management* (7th ed.). New York: Prentice Hall
2 Pinnington, A. & Edwards, T. (2000). *Introduction to human resource management*. Germany: OUP Catalogue.
3 Sparrow, P., Brewster, C. & Chung, C. (2016). *Globalizing human resource management*. London: Routledge.

STAT-5116 Financial Management 3(3+0)

Financial Management means planning, organizing, directing and controlling the financial activities such as procurement and utilization of funds of the enterprise. It means applying general management principles to financial resources of the enterprise. This course is related to basic concepts of management, goal of a firm, organization of financial management function and income statement/balance sheet ratio. To ensure regular and adequate supply of funds is the concern. The course ensures adequate returns to the shareholders which will depend upon the earning capacity, market price of the share, expectations of the shareholders. It's also relate the safety on investment, i.e, funds should be invested in safe ventures so that adequate rate of return can be achieved. It includes the planning, organizing, directing and controlling the financial activities.it also deals with interest rates, preferred stock valuation, rate of return and probability distribution to measure risk.

Contents

1. Defining Financial, Management, goal of the Firm, Organization of the Financial Management Functions, The Business Environment, Financial statements, Balance sheet ratios, Income statement and income statement/Balance sheet ratio, Trend analysis, Common-size and index analysis.

2. The interest rate, Simple and compound interest, Compounding more than one, Amortizing a loan, Distinction among valuation Concept, Bond Valuation, Preferred stock valuation, Common stock valuation, Rate of Return (or Yields), Defining risk and return, Using probability distribution to measure risk, Attitudes toward risk.

3. Risk and return in a portfolio context, Diversification, The capital asset pricing, Credit and collection policies, Analyzing the credit application, Inventory management and control. Spontaneous financing, Negotiation financing, Factoring accounts receivable, Composition of short-term financing, Motives for holding cash pay-outs, Electronic Commerce, Investment in marketable securities.

Recommended Texts

1. Ehrhardt, M. C. & Brigham, E. F. (2011). *Financial management: theory and practice.* India*:* South-Western Cengage Learning.
2. Shapiro, A. C. & Hanouna, P. (2019). *Multinational financial management*. New York: John Wiley and Sons.

Suggested Readings

1. Saunders, A. & Lange, H. P. (1997). *Financial institutions of management: A modern perspective*. New York: Irwin.

2. Pinnington, A. & Edwards, T. (2000). *Introduction to human resource management*. Germany: OUP Catalogue.

.STAT-5117 Principals of Accounting 3 (3+0)

Principles of accounting are the title of the introductory course in accounting. It was also common for the textbook used in the course to be entitled *Principles of Accounting*. Principles of accounting can also refer to the basic or fundamental principles of accounting: cost principle, matching principle, the full disclosure principle, the revenue recognition principle, going concern assumption, economic entity assumption, and so on. In this context, principles of accounting refer to the broad underlying concepts which guide accountants when preparing financial statements. The purpose of the course is to provide the knowledge about basic terminologies of accounting, accumulate and report on financial information about the performance, financial position and cash flaws of business and then use this information to reach decision about how to manage the business or invest in it or lend money to it. This course also gives information about capital and revenue provision and reverse.

Contents

1. Introduction to Accounting,
2. Basic Accounting terminologies,
3. Generally accepted.
4. Accounting Principles,
5. Accounting System,
6. Accounting Equation (Balance Sheet Concept).
7. Accepting Cycle. Recording the Business transactions. Vouchers, Journal,
8. Ledger and Trial Balance.
9. Subsidiary Ledgers for sales,
10. Purchases, cash,
11. Banking transactions,
12. Bank Reconciliation.
13. The periodical adjustment and closing process of accruals,
14. Deferrals, inventory, depreciation,
15. Uncollectable and correction of errors.
16. Capital and Revenue Provision and Reserve.
17. The Work sheet, cash Flow statement (Direct Method) statements of Owner's equity.

Recommended Texts

1. Collier, P. M. (2015). *Accounting for managers: interpreting accounting information for decision making.* New York: John Wiley and Sons.
2. Ghani M. A. (2013). *Principles of accounting*, Lahore: Salman Publishers.

Suggested Readings

1. Mutter, D. W. & Parker, P. J. (2004). *School money matters: A handbook for principals. Association for supervision and curriculum development (ASCD*). Alexandria: North Beauregard.
2. Wolk, H. I., Dodd, J. L. & Rozycki, J. J. (2008). *Accounting theory: Conceptual issues in a political and economic environment*. New York: Sage.

GEOG – 5101 Fundamentals of Geography 3(3+0)

This course is graduate-level course to expose students with the founding principles of Geography and geographical knowledge. A systematic descriptive introduction to the diverse elements of landscape including geomorphic, climatic, and biotic elements, human settlement and land-use patterns; cartographic approaches to the analysis of selected processes of landscape change is included. This course provides an opportunity for understanding part of the complex physical and biological environment in which human beings live. The nature and processes of geo-system and its constituent parts: atmosphere, lithosphere, hydrosphere and biosphere; structure and composition of the atmosphere: atmospheric circulation, weather and climate, energy transmission, spatial variation of energy inputs and energy budget; structure and composition of the earth: tectonics and related processes; hydrological cycle and its components: precipitation, evapotranspiration, groundwater, surface water and the oceans; vegetation zones of the world: world soils, ecosystems, biomes, energy and matter flows.

Contents

1. Introduction, Definitions, scope and branches of Geography
2. Roots of the discipline and basic geographic concepts
3. Themes and traditions of Geography
4. Tools of Geography, The Universe, Galaxies and solar system
5. The Earth as a planet, Celestial positions, its shape and size
6. Rotation, revolution and related phenomena
7. Spheres of the earth, Lithosphere, Atmosphere, Hydrosphere
8. Biosphere
9. Man-environment interaction

Lab. Work

1. Comprehension of atlases
2. Map reading skills, location of places
3. Features and relevant work related to topics of the theoretical section.

Recommended Texts

1. Arbogast, A. F. (2007). *Discovering physical geography*. London: John Wiley and Sons.

2. Christopherson, R. W. (2009). *Geo systems: An introduction to physical geography*. New Jersey: Pearson Prentice Hall.

Suggested Readings

1. De Blij, H. J & Muller, P. O. (1996). *Physical geography of the global environment*. New Jersey: John Wiley and sons Inc.

2. Strahler, A. (2013). *Introduction to physical geography*. New Jersey: John Wiley & Sons.

STAT-6201 **Statistical Methods** **3(3+0)**

Statistical methods used in practice are based on a foundation of statistical theory. One branch of this theory uses the tools of probability to establish important distributional results that are used throughout statistics. The application of statistical methods extracts information from research data and provides different ways to assess the robustness of research outputs. Another major branch of statistical theory is statistical inference. The course covers a wide range of statistical methods. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical method, probability distribution and statistical inference with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. This course enables students to understand about set theory, role of set theory in probability discipline, events, probability of an events, random variables, types of random variables and their distribution. Some topics include hypothesis testing, and multiple regression analysis. This is a calculus-based course. It also involves derivation of power functions of different tests for comparing and evaluation of the tests. The application of statistical methods extracts information from research data and provides different ways to assess the robustness of research outputs.

Contents

1. Applications of standard discrete and continuous distributions: Binomial, Hyper-geometric, Multinomial, Negative Binomial, Geometric, Poisson,
2. Exponential and Normal probability distributions.
3. Basic ideas about sampling distributions with particular reference to normal, chi-square, t and F distributions.
4. Basic ideas of statistical inference, Point and interval estimation, Confidence intervals, testing of hypotheses. Simple and composite hypotheses.
5. Calculation of type I and type II errors, Power of a test, Operating characteristic (OC) function.
6. Inferences about means, proportions and variances.
7. Determination of Sample Size. P-Value.
8. Inference about regression coefficient for simple and multiple linear regressions up to three variables.
9. Standard error of estimate. Coefficient of determination.
10. Linear correlation.
11. Multiple and Partial correlation.
12. Confidence intervals for regression and correlation coefficients.
13. Sequential test. Test for proportion. Operating Characteristic (OC) function. Average sample number (ASN) function. Test for standard deviation.

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2013). *Introduction to mathematical statistics* (7th ed.). Prentice Hall.
2. Steel, R.G.D. & Torrie, J.H. (1980). *Introduction to statistical analysis* (2nd ed.). New York: McGraw-Hil.

Suggested Readings

1. Wilcox, R. (2001). *Fundamentals of modern Statistical methods*. New York: Springer.
2. Larson, H.J. (1982). *Introduction to Probability Theory and Statistical Inference* (3rd ed.). New York: John Wiley and Sons.

STAT-6202 Mathematical Methods for Statistics 3(3+0)

Mathematical methods are organized into different units. Topics broaden students' mathematical experience and provide different scenarios for incorporating mathematical arguments and problem solving. This course builds on Mathematical Methods for Differential Equations in that it is concerned with ways of solving the (usually partial) differential equations that arise mainly in physical, biological and engineering applications. Analytical methods have considerable intrinsic interest, but their importance for applications is the driving motive behind this course. The main analytical tools developed in this course can be thought of as generalizations of the Fourier and power series representations of functions studied in this course. This leads to new types of functions and to practical methods for solving differential equations. Students taking this course will develop an appreciation of various techniques, transforms and mathematical methods related to the solution of differential equations. The aim of this course is to enlighten the significance of the mathematical method by entertaining the both mathematical and applied approaches of problems. This course deals with multiple variable analyses simultaneously. Course also provides the simultaneous model structure, their assumptions and mathematical derivations of multivariate statistical designs.

Contents

1. Counting techniques
2. Combinations and Permutations
3. Review of Matrices and Vectors
4. Matrix Differentiation, Eigenvalues, Eigenvectors and their Properties
5. Positive definite matrix
6. Semi positive definite matrix,
7. Introduction to quadratic forms
8. Maximization of Quadratic Forms Variance-Covariance matrix
9. Partitioned Matrices, Rank of Matrix.
10. Gamma and Beta functions with their applications, Line integrals, transformation of coordinates (Cartesian & Polar)
11. Change of variables in multiple integrals
12. Extreme of functions of two variables

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2013). *Introduction to mathematical statistics* (7th ed.). Prentice Hall.
2. Mood, A. M. Grabill, F.A., & Boes, D.C. (1997). *Introduction to the theory of statistics.* New York: McGraw-Hill.

Suggested Readings

1. Wilcox, R. (2001). *Fundamentals of modern statistical methods*. New York: Springer.
2. Kaplan, W.C. (1984). *Advance calculus*. Addison and Wiley.
3. Stuart, A. and Ord, J. K. Kedalls, (1998). *Advanced theory of mathematical statistics.* London: Charles Coriffi & Co.

STAT-6203 Probability & Probability Distributions-I 3(3+0)

Probability theory is the branch of mathematics that deals with modeling uncertainty. Probability distribution indicates the likelihood of an event or outcome. It is important because of its direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. This course is designed to establish conceptual framework of handling and understanding uncertain events probability and probability distributional approach, basic probability axioms and rules and the moments of discrete and continuous random variables as well as be familiar with commonly named discrete and continuous random variables. This course enables the students to understand how to derive the probability density function of transformations of random variables and use these techniques to generate data from various distribution, how to calculate probabilities, and derive the marginal and conditional distribution of bivariate random variables. Methods on computations on Total probability theorem and Bayes theorem with implementation on the real life phenomenon are also provided. This course enables students how to derive distribution of functions of random variables by using the cumulative distribution function, transformation and m.g.f techniques.

Contents

1. Probability as a set function, Conditional Probability
2. Bayes' theorem, Chebychev's inequality.
3. Random Variables, Distribution function and Probability density function
4. Joint distributions
5. Probability density functions of two or more random variables
6. Marginal and conditional distributions
7. Stochastic independence, Mathematical expectations, Conditional expectations.
8. Variance and moments
9. Probability generating functions, Moment generating functions
10. Characteristics function and their existence properties.
11. Relation between moments and cumulants,
12. Standard Probability distributions, Binomial, Poisson,

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2013). *Introduction to MATHEMATICAL Statistics*,(7th ed.), Prentice Hall
2. Stuart, A. & Ord, J. K. Kedalls. (1998). *Advanced theory of mathematical statistics*. London: Charles Coriffi & Co.

3. Mood, A.M, Graybill, F A. & Boes, D.C. (1997). *Introduction to the theory of statistics.* McGraw Hill, New York.

Suggested Readings

1. John, R. (2006). *Mathematical statistics and data analysis*. Duxbury Press.
2. Khan, M. K. (1996). *Probability with applications.* Pakistan: Maktiba Ilmi.
3. Scheaffer, R.L. (1990*). Introduction to probability and its applications,* PWS Kent.

STAT-6204 Design and Analysis of Experiments-l 4(3+1)

The aim of this course is to deliver the applicable knowledge about Statistics and Experimental Design, which can apply in different fields of study and to develop a skills on the data collection from a designed experiment, description measures of data, interpretation of results, and decision making. It deals with a thorough introduction to statistical experimental design, and the statistical methods used to analyze the resulting data. The concepts of comparative experiments, ANOVA and mean separation procedures will be reviewed; blocking (complete and incomplete) will be discussed, the derivations of different Experimental Designs and its applications in different fields. It also discusses the estimation of missing observations in basic designs. Various designs are discussed and their respective differences, advantages, and disadvantages are noted. This covers Layout analysis and related efficiency of completely randomize, randomized complete block, Latin square, Greco Latin square and Cross-over designs. Multiple comparisons tests and Analysis of covariance are part of the contents. At the end of the semester, students will be trained in statistical modeling and in the choice of experimental designs to use in scientific investigations. More specifically, students will be able to design and conduct an experiment.

Contents

13. Principles of experimental design
14. One way and Two way classification
15. Layout and analysis and related efficiency
16. Completely randomized complete block, its layout and analysis
17. Latin square Design, its layout and analysis
18. Greco Latin Square Design
19. Cross-over designs
20. Estimation of missing observations in basic designs.
21. Fixed effect models
22. Random effect models.
23. Mixed effect models

Recommended Texts

1. Montgomery, D. C. (2019). *Design and analysis of experiments* (10th ed.). New York: John Wiley & Sons.
2. Clarke, G. M. & Kempthon, R. E. (1997). *Introduction to the design & analysis of experiments*. Edward Annold.

Suggested Readings

1. Bland, M. (2015). *An introduction to medical statistics (*4th ed.). Oxford University Press.
2. Matthews, N.S. (2006). *Introduction to randomized controlled clinical trials* (2nd ed.). Chapman and Hall.
3. Boniface, D. R. (1995). *Experiment design & statistical methods*. Chapman & Hall.
4. Clarke, G.M. (1994). *Statistics & experimental design*. Edward Annold.

STAT-6205 Sampling Techniques 4(3+1)

A *sampling technique* is the name or other identification of the specific process by which the entities of the *sample* have been selected. Sampling techniques are an important source of statistical data. A great many published statistics on demographic, economic, political and health related characteristics are based on survey data. Simple random sampling is a well-known method of sampling but, for reasons of efficiency and practical constraints, methods such as stratified sampling and cluster sampling are typically used by statistical authorities such as the Australian Bureau of Statistics and by market research organizations. A well designed sampling procedure ensures that we can summarize and analyze data with a minimum of assumptions and complications. This course deals with the basic concepts of sampling, requirements of a good sample, determination of sample size etc. The course provides the mathematical and conceptual formation of sampling techniques especially for simple random sampling and stratified random sampling which are the types of probability sampling. Ratio and regression estimates for simple random sampling are also the parts of the contents. This course is designed for the different types of sampling and selection and estimation procedures.

Contents

1. Basic concepts, advantages of sampling method, requirements of a good sample,
2. Bias, sampling and non-sampling errors.
3. Steps and problems involved in planning and conduct of census and sample surveys.
4. Selection and estimation procedures.
5. Description and properties of simple random sampling for properties and percentages.
6. Estimation of variances, standard errors
7. Confidence limits.
8. Sample size determination under different conditions.
9. Description and properties of stratified random sampling.
10. Formation of strata
11. Different methods of allocation sample size,

Recommended Texts

1. Lohr, S.L. (2010). *Sampling design and analysis* (2nd ed.). Brooks/Cole
2. Raj, D. & Chandhok, P. (1998). *Sample survey theory*. New Dehli: Narosa Publishing House.
3. Cochran, W.G. (1996). *Sampling techniques*. New York: John Wiley & Sons.

Suggested Readings

1. Scheaffer, R,L., Mendenhall, W., Ott, R.L. & Gerow, K.G. (2012). *Elementary survey sampling* (7th ed.). Brooks/Cole.
2. Sukhatme, P.V., Sukhatme, B., Sukhatme, S. & Asok, A. (1985). *Sampling theory of survey with application.* Lowa State University Press.
3. Barnett, V. (2002). *Sample survey principles and methods* (3rd ed.). New York: John Wiley & Sons.

STAT-6206 Probability & Probability Distributions-ll 3(3+0)

A probability distribution is a statistical function that describes all the possible values and likelihood that a random variable can take within a given range. These factors include the distribution's mean (average), standard deviation, skewness, and kurtosis. Probability distributions are a fundamental concept in statistics. They use both on a theoretical level and a practical level. Some practical uses of probability distribution are: To calculate confidence intervals for parameters and to calculate critical regions for hypothesis tests. In life there is no certainty about what will happen in the future but decisions still have to be taken. Therefore, decision processes must be able to deal with the problems of uncertainty. Uncertainty creates risk and this risk must be analyzed. The aim of the course is to provide the conceptual and mathematical formation of Continuous probability and other distributions with their derivation and properties. This course is designed for continuous probability functions and their applications. It deals with probability generating functions and moment generating function and their properties. Order statistics, Chi-square, t, F distribution and inequalities are also the part of content. The course focuses on mathematical formation of Continuous probability distributions and bivariate normal distribution.

Contents

12. Properties of Cauchy, Laplace, Weibull, Maxwell, Pareto, Raleigh and Log normal distributions.
13. Bivariate Normal distribution
14. Transformation of variables,
15. Cumulative distribution function and moment generating function techniques,
16. Central limit theorem.
17. Order Statistics,
18. Distribution of rth & sth order Statistics,
19. Distribution of median, range and quantiles
20. Methods of deriving exact sampling distribution for a population.
21. Independence of sample mean & variance.

Recommended Texts

1. Leon, G. (2008). *Probability, statistics, and random processes for electrical engineering* (3rd ed.). India: Pearson Prentice-Hall.
2. Stuart, A. & Kedalls, J.K. (1998). *Advanced theory of mathematical statistics*. London: Charles Coriffi & Co.

Suggested Readings

1. Sheldon, R. (2010). *Introduction to probability models* (10th ed**.).** USA: Academic Press.
2. Hogg, R. M. & Craig, A. T. (1995). *Introduction, to mathematical statistics*. New York: MacMillan.

STAT-6207 Design and Analysis of Experiments-ll 4(3+1)

Data for statistical studies are obtained by conducting either experiments or surveys. Experimental design is the branch of statistics that deal with the design and analysis of experiments. The methods of experimental design are widely used in the fields of agriculture, medicine, biology, marketing research, and industrial production. One or more of these variables, referred to as the factors of the study are controlled so that data may be obtained about how the factors influence another variable referred to as the response variable, or simply the response. The aim of this course is to deliver the applicable knowledge about Statistics and Experimental Design, which can apply in different fields of study and to develop a skills on the data collection from a designed experiment, description measures of data, interpretation of results, and decision making. It deals with the model estimation of parameters of Factorial Experiments, 2^n, 3^n… P^n and mixed levels factorial experiments and its applications in different fields. This covers Confounding and its types, Fractional replication, Quasi-Latin squares, Split-plot, Split Split plot, split block and Incomplete Block Designs. Models and applications of 1st and 2nd order response surface designs are part of the contents.

Contents

1. Factorial Experiments, 2^n, 3^n… P^n and mixed levels factorial experiments:
2. Model estimation of parameters with applications.
3. Confounding and its types,
4. Fractional replication
5. Quasi-Latin squares,
6. Split-plot design
7. Split Split plot and split block designs,
8. Incomplete Block Designs
9. Balanced incomplete block designs
10. Partially balanced incomplete block designs
11. Balanced Lattices
12. Lattice squares; models and Analysis,

Recommended Texts

1. Montgomery, D. C. (2019). *Design and analysis of experiments* (10th ed.). New York: John Wiley & Sons.
2. Clarke, G. M. & Kempthon, R. E. (1997). *Introduction to the design & analysis of experiments.* New York: John Wiley & Sons.

Suggested Readings

1. Bland, M. (2015). *An introduction to medical statistics* (4th ed.). USA: Oxford University Press.
2. Matthews, N.S. (2006). *Introduction to randomized controlled clinical trials* (2nd ed.). New York: Chapman & Hall.

STAT-6208 Sampling and Survey Methods 4(3+1)

Sample surveys are an important source of statistical data. A great many published statistics on demographic, economic, political and health related characteristics are based on survey data. Simple random sampling is a well-known method of sampling but, for reasons of efficiency and practical constraints, methods such as stratified sampling and cluster sampling are typically used by statistical authorities such as the Australian Bureau of Statistics and by market research organizations. A well designed sampling procedure ensures that we can summarize and analyze data with a minimum of assumptions and complications. The aim of this course is to cover sampling design and analysis methods that would be useful for research and management in many fields and to develop your understanding of the principles and methods. This course is concerned with the design of sample surveys and the statistical analysis of data collected from such surveys. The course provides the mathematical and conceptual formation of sampling techniques especially for Cluster sampling, Double Sampling, Multistage or Multiphase sampling and different estimator's comparison. Non response or Randomized response and their sources are also the parts of the contents. This course is designed for the different types of sampling and selection and estimation procedures.

Contents

1. Cluster sampling
2. Cluster sampling and its analysis along with examples
3. Sub sampling
4. PPS-Sampling.
5. Double sampling
6. Multistage sampling
7. Multiphase sampling.
8. Thomson Hurwitz estimator
9. Thomson Hurwitz estimator and its applications
10. Comparison of different sample designs.
11. Critical study of National sample surveys conducted in Pakistan.
12. Census of Agriculture
13. Household Economic and Demographic Survey (HED), Household
14. Income and Expenditure Survey (HIES)
15. Pakistan Demographic Survey (PDS)
16. Nation population and housing census surveys (NPHCS).

Recommended Texts

1. Lohr, S.L. (2009). *Sampling: Design and analysis*. Duxbury Press.
2. Des R. & Chandhok, P. (1998). *Sample survey theory*. New Dehli: Narosa Publishing House.
3. Cochran, W.G. (1996). *Sampling techniques*. New York: John Wiley & Sons.

Suggested Readings

1. Ferguson, T.S. (1996). *A course in large sample theory*. London: Chapman & Hall.
2. Sukhatme; P.V., Sukhatme, B., Sukhatme, S. & Asok, A. (1985). *Sampling theory of survey with application*. Lowa State University Press.
3. Des, R. (1998). *Design of sample survey*. New York: McGraw Hill, New.

STAT-6209 Regression Analysis & Econometrics –l 3 (3+0)

This course introduces the regression methods which are the basics for econometrics course for analyzing economic data of a particular problem. This is an introductory course in the theory and practice of classical Econometric Methods. The main components of the course deal with Single Equation Models, Dynamic Equation Models, Instrumental Variable Estimation and Multiple Equation Models. This course emphasizes both the theoretical and the practical aspects of statistical analysis, focusing on techniques for estimating econometric models of various kinds and for conducting tests of hypotheses of interest to economists. Some basic knowledge of matrix algebra and elementary statistical theory will be assumed, but a lot of it will be re-introduced during the lectures. The goal of this course is to help the students to develop a solid theoretical background in introductory level econometrics, the ability to implement the techniques and to critique empirical studies in economics. The computer is a fundamental tool in this course and students will be required to become familiar with the some statistical softwares such as R, Eviews, STATA to analyze the econometric data and fitting of econometric models.

Contents

1. Introduction to regression and correlation analysis
2. Regression estimation methods and Assumptions.
3. General linear model.
4. Test of hypotheses and confidence intervals about parameters.
5. Stepwise regression.
6. Polynomial regression: orthogonal polynomials
7. Interval estimation for predicted response
8. Regression analysis with qualitative predictors
9. Residual Analysis. Outlier and Influence Analysis
10. Introduction to Generalized Linear models
11. Logistic and Poisson regression
12. Linear regression modeling using Minitab, R and Mathematica
13. Fitting Generalized linear models with Minitab, R and Mathematica

Recommended Texts

1. Gujrati, D. (2004). *Basic econometrics* (4th ed.). New York: Johan Wiley.
2. Montgomery, D. C., Peck, E. A. & Vining, G. G. (2012). *Introduction to linear regression analysis*. New York: Johan Wiley.

Suggested Readings

1. Draper, N.R., & Smith, H. (2004). *Applied regression analysis*. New York: Johan Wiley.
2. Theil, H. (1987). *Introduction to Econometric*. Prentice Hall.
3. Johnston, J. (1997). *Econometric methods* (4th ed.). McGraw Hill.

STAT- 6210 Statistical Packages 4(3+1)

This course provides an understanding to tackle real life variables as well as the artificial environment of random variables by simulating on different software. After studying this course, student will be able to understand about inserting, coding, sorting, filtering and grouping variables on different statistical software i.e. SPSS, Minitab, R, Mathematica etc. It deals with implementing statistical tools like all measures of central tendency, dispersions, graphical procedures, measures of correlational structures Simple and Multiple Regression and various estimation and testing procedures. Computation of probability of different events and dealing with probability distributions are also of major concerns. It also discusses how to perform time series analysis on different Statistical Software's i.e. SPSS, MINITAB and Eviews. This course also signifies how to perform complex statistical analysis like principal component analysis, factor analysis, cluster analysis and discernment analysis on different software. Methods to simulate any random variable or statistic and identifying distribution of random variables are also provided in this course.

Contents

1. Introduction to Statistical Packages
2. Data analysis using MS Excel
3. Introduction to Minitab
4. Introduction to SPSS
5. Introduction to R
6. Introduction to Mathematica
7. Introduction to Eviews
8. Descriptive and graphical analysis with Minitab, SPSS, and R
9. Matrix Analysis using Minitab, R and Mathematica
10. Probability distributions fitting and analysis with Minitab, Mathematica, and R
11. Testing of hypothesis with Minitab, R and SPSS
12. Regression and correlation analysis with Minitab, R, SPSS, and Mathematica
13. Design of Experiments with Minitab, SPSS, and R
14. Analysis of categorical data with Minitab and SPSS
15. Time series analysis and forecasting with Minitab, R, Eviews, SPSS and Mathematica
16. Statistical Quality Control using Minitab, SPSS and R
17. Multivariate analysis with Minitab, SPSS and R

Recommended Texts

1. Gupta, B. C., Guttman, I. & Jayalath, K. P. (2020). *Statistics and probability with applications for engineers and scientists using MINITAB, R and JMP* (2nd ed.). New York: John Wiley & Sons.
2. Rayan, B. F., Joiner, B. L. & Cryer, J. D. (2005). *MINITAB handbook* (5th ed.). Duxbury Press.

Suggested Readings

1. Crawley, M. J. (2007). *The R book*. New York: John Wiley & Sons.
2. IBM SPSS. (2011). *IBM SPSS statistics 19.0 core system user's guide*. Prentice Hall.
3. Vogelvang, B. (2005). *Econometrics: Theory and applications with eviews*. Financal Times Management.

STAT-6211 Regression Analysis & Econometrics –ll 4 (3+1)

This course introduces the regression methods for analyzing data in economics. This is an introductory course in the theory and practice of classical econometric methods. The main components of the course deal with Single Equation Models, Dynamic Equation Models, Instrumental Variable Estimation and Multiple Equation Models. This course emphasizes both the theoretical and the practical aspects of statistical analysis, focusing on techniques for estimating econometric models of various kinds and for conducting tests of hypotheses of interest to economists. Some basic knowledge of matrix algebra and elementary statistical theory will be assumed, but a lot of it will be re-introduced during the lectures. The goal of this course is to help the students to develop a solid theoretical background in introductory level econometrics, the ability to implement the techniques and to critique empirical studies in economics. The computer is a fundamental tool in this course and students will be required to become familiar with some statistical software such as R, Eviews, STATA to analyze the econometric data and fitting of econometric models.

Contents

1. Introduction to econometrics and its types.
2. Econometrics data types
3. Review of the linear regression model assumptions
4. Testing and dealing with multicollinearity.
5. Ridge regression and use of extraneous information,
6. Heteroscedasticity: Definition, reasons, consequences, tests and remedial measures
7. Weighted least square estimation method
8. Autocorrelation: Definition, reasons, consequences, tests and remedial measures
9. Error in variables problems
10. Simultaneous equations systems
11. Identification
12. Autoregressive and distributed lagged models.
13. Seemingly unrelated Regression. Simultaneous equations models
14. Two-stage and three-stage Least Squares.
15. Econometrics modeling with eviews and R

Recommended Texts

1. Green, W. H. (2000). *Econometrics analysis* (4th ed.). Prentice Hall International.
2. Gujrati, D. (2004). *Basic econometrics* (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Draper, N.R., & Smith, H. (2004). *Applied regression analysis*. New York: John Wiley & Sons.
2. Theil, H. (1987). *Introduction to Econometric*. Prentice Hall.
3. Wonnacot, T. H. & Wonnacot, R. J. (1979). *Econometrics*. New York: John Wiley & Sons.

STAT-6212 Statistical Inference-l 3(3+0)

Statistical inference is the process of drawing conclusions about populations or scientific truths from data. There are many modes of performing inference including statistical modeling, data oriented strategies and explicit use of designs and randomization in analyses. A key step in the Statistical Investigation Method is drawing conclusions beyond the observed data. Statisticians often call this "statistical inference. A practitioner can often be left in a debilitating maze of techniques, philosophies and nuance. This course presents the fundamentals of inference in a practical approach for getting things done. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Statistical estimation is concerned with the best estimating a value or range of values for a particular population parameter. It deals with the estimation of parameters, properties of good point estimator and its methods. It also discusses the parameter estimation of different probability distributions and their efficiency. Bayesian Statistics and its comparison with classical estimation approach are part of the contents.

Contents

1. Methods of Estimation,
2. Method of least squares,
3. Method of moments.
4. Minimum chi-square.
5. Maximum likelihood
6. Bayes methods.
7. Estimates based on order statistic.
8. Observations, Simultaneous confidence intervals.
9. Properties of a good estimator
10. Unbiased
11. Consistency
12. Sufficiency
13. Efficiency.
14. Completeness
15. Minimum Variance Unbiased Estimator.
16. Rao-Black well theorem
17. Lehmann sheffe theorem with applications.
18. Cramer-Rao Inequality.

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2019). *Introduction, to mathematical statistics* (7th ed.). New York: MacMillan Co.

2. Mood, A. M., Graybill, F. A. & Boes, D.C. (1997). *Introduction to the theory of statistics*. New York: McGraw Hill.

Suggested Readings

1. Lehmann, E. L. (1986).*Testing statistical hypotheses*. New York: John Wiley & Sons.
2. Hirai, A. S. (1973). *Estimation of statistical parameters*. Pakistan: IlmiKhana, Lahore.

STAT-6213 Quality Control & Quality Management 3(3+0)

This course offers applications of the statistical process control techniques that are an integral part of the corporate-wide quality control efforts. The course will discuss the methods of statistical quality control within a broader framework of quality assurance and management. The course will define the various aspects of quality and address the issues of planning for quality as they relate to survey operations and processes. Statistical methods for quality control will be discussed. The uses and applications of various quality tools such as Pareto analysis, cause & effect diagrams, flow charting, etc., for generating quality improvements will also be addressed. This course is mathematical in nature and will contain some theoretical formulas and statistical concepts. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical quality control, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with the construction of control charts for monitoring location and dispersion parameters. This covers the process capability analysis, process improvements using design of experiments and Taguchi method. Acceptance sampling plans along with the different International Standards Organization series are part of the contents.

Contents

1. Statistical quality control
2. Measurement and control of quality.
3. Control charts for $\overline{X}$, R and Sigma,
4. Charts for P, C and U.
5. O.C. curves associated with control charts.
6. CUSUM Charts
7. Leaf and Stem Plots
8. Box Plot
9. Producer's risk and consumer's risk
10. Acceptance sampling.
11. Single sampling plans
12. Double sampling plans
13. Introduction to multiple sampling plans
14. Intentional quality standards and their certification.
15. Quality management through quality circles, re-engineering etc
16. Case study.

Recommended Texts

1. Montgomery, D. (2012). *Introduction to Statistical Quality Control* (7th ed.). New Jersey: John Wiley and Sons.
2. Qiu, P. (2014). *Introduction to Statistical Process Control* (1st ed.). London: Chapman and Hall.

Suggested Readings

1. Juran, J. M., & DeFoe, J.A. (2010). *Juran's Quality Handbook* (6th ed.). New York: McGraw-Hill Education.
2. Ryan.T.P. (1989). *Statistical Methods for Quality Improvements*. New Jersey: John Wiley and Sons.

STAT-6214 Management & Operations Research 3(3+0)

Operational research is the application of scientific methods to the study of complex organizational problems. It is concerned with applying advanced analytical methods to make effective decisions in strategic planning or operational planning, and build more productive systems. This includes all key stages of solving real-world problems. Operational researchers and statisticians play a fundamental role in the modern world. The aim of this course is to fulfill the needs of society in the fields of Statistics and Operations and to understand different application areas of operations research like transportation problem, assignment model, sequencing models, dynamic programming, game theory, replacement models & inventory models. This is designed to impart basic and applied knowledge about Operation Research and its applications in different fields of marketing. This program is an ideal opportunity to provide your-self with the analytical and statistical skill set necessary for success in industry, business or in the public sector. Course also enlightens the significance of mathematical modeling based strategies based on both mathematical and applied nature of disciplines. The program for Operational Research and Statistics provides students with the ideal skill set in mathematical modeling, experimental design, statistical analysis, and numerical computation.

Contents

1. Historical study of operation research
2. Linear Programming.
3. Methods to solve LP models
4. Graphical Methods
5. Mathematical compuattions
6. The simplex methods.
7. Degeneracy and cycling
8. Artificial variables
9. Duality
10. The dual simplex method,
11. Sensitivity analysis.
12. Transportation
13. Methods of solving transportation
14. Assignment problems
15. Game theory
16. Problems of game theory

17. Network analysis
18. Queuing theory.

Recommended Texts

1. Taha, H.A. (2017). *Operation research: An introduction* (10th ed.). London: Pearson.
2. Bhatti, S.A. & Bhatti, N. A. (1998). *Operation research: An introduction*. Pakistan: A-one publishers.

Suggested Readings

1. Gupta, P.K. & Hira, D.S. (1994). *Operation research*. New Dehli: S. Chand & Co.
2. Hillier, F. & Lieberman, G. (1992). *Introduction to operation research*. Holden Day.

STAT-6215 Official Statistics 3(3+0)

Statistics play a vital role in the economy of a country. Methods and techniques for producing register-based statistics are discussed in depth. Examples of problems addressed are linking, matching, derived variables, missing data and estimation. Models for quality assessment of official statistics are introduced and quality differences between sample-based and register-based statistics are discussed. Here the aspects on reliability and accuracy are of special interest. The aim of the course is to provide the knowledge of officially use of statistics in different fields and organization. This focuses on the methods of data collection, data processing, presentation and publication of statistics. The course is designed for the use of statistics in administration and planning and different organizations like NADRA, State bank of Pakistan, Ministry of finance and bureau of statistics etc. This deals with design and planning of statistical investigation, role of sampling in generation of statistics, role of official statistics and different surveys conducted in Pakistan. Concepts and evaluation of GDP, GNP, balance of trade and payment, measurement of income distribution are also the part of the contents.

Contents

1. Design and planning of a Statistical Investigation. Data collection approach and operation; Role of sampling in generation of statistics. Sampling plans and survey designs.
2. Sources of Errors, types of Errors, methods of their control. Data processing, presentation, and publication of statistics.
3. Different modes of data dissemination. Official statistics, statistics systems and standards, sources of official statistics, their role, working and publication. Role of official statistics, official publications.
4. Setup of official organizations in Pakistan their role, working & publication, statistics division,
5. Federal Bureau of statistics, Agricultural Census Organization, Population Census Organization, Ministry of Food , and Agriculture and Livestock;
6. National Data Bade and Registration Authority (NADRA). Provincial Bureaus of statistics.
7. Financial statistics: Ministry of Finance, state Bank of Pakistan-Department of statistics, their working publications and responsibilities. Other organization's statistical output, National and International series, classification and standards.
8. Use of statistics in administration and planning.
9. Concepts and evaluation of GDP, GNP, NNP, balance of trade and payments.
10. Measurement of income Distribution,

11. Use of index numbers, and time series.

Recommended Texts

1. Kish, L. (1982). *Survey sampling*. New York: John Wiley & Sons.
2. Statistics Division (2005). *Activity report government of Pakistan*. Islamabad: Pakistan Bureau of Statistics

Suggested Readings

1. Statistical institute for Asia & Pacific SIAP. (1984). *Training of trainers in statistical operations and procedure part-1,II*. Tokyo: UNDP.
2. Hillier, F. & Lieberman, G. (1992). *Introduction to operation research*. New York: McGraw-Hill.

STAT-6216 Actuarial Statistics-l 3(3+0)

This course covers survival models and their estimation as well as applications in insurance and finance. Specific topics include: the concept of survival models and actuarial notation; estimation of lifetime distributions; multiple state models; maximum likelihood estimation of transition intensities; the binomial model of mortality and its estimation; models with transition intensities depending on age and duration; the census approximation and formulae; statistical comparison of crude rates with a standard table; graduation of crude estimates and tests of fidelity and smoothness; analysis of mortality/morbidity and the main forms of selection; models for projection of mortality. This deals with Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality. It provides Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. To developing multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws suggested course is helpful. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Contents

1. Utility theory, insurance and utility theory
2. Models for individual claims and their sums,
3. Survival function, curate future lifetime, force of mortality.
4. Life table and its relation with survival function, examples,
5. Assumptions for fractional ages
6. Some analytical laws of mortality, select and ultimate tables.
7. Multiple life functions, joint life and last survivor status,
8. Insurance and annuity benefits through multiple lives function evaluation for special mortality laws.
9. Multiple decrement models,
10. Deterministic and random survivorship groups, associated single decrement tables, central tables of multiple decrement, net single premiums and their numerical evaluations.
11. Distribution aggregate claims,
12. Compound Poisson distribution and its applications.

Recommended Texts

1. Klein, J. P. & Moeschberger, M. L. (2003). *Survival analysis: Techniques for censored and truncated data.* New York: Springer.
2. Bowers, N.L Gerber, H. U., Hickman, J.C. Jones, D.A. & Nesbitt, C.J. (1987). *Actuarial mathematic*. USA: Society of Actuarial.

Suggested Readings

1. Blackwell, D. & Graphic, M. A. (1966). *Theory of games and statistical decision*. New York: John Wiley & Sons.
2. Pitacco, E., Denuit, M., Haberman, S. & Olivieri, A. (2009). *Modelling longevity dynamics for pensions and annuity business.* Oxford University Press.

STAT-6217 Robust Methods 3(3+0)

The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of Robust Statistics with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Content includes: a review of the key concepts of basic statistics, estimation, and probability. Robust statistics are statistics with good performance for data drawn from a wide range of probability distributions, especially for distributions that are not normal. Robust statistical methods have been developed for many common problems, such as estimating location, scale, and regression parameters. It deals with the construction of objective functions of location and dispersion parameters along with M-estimators, E-estimator, R-estimator and W-estimator. It also discusses the performance measures, such as breakdown point, influence function and gross error sensitivity etc., of the estimators. This covers the M-estimator for scale, outliers and influential observations in regression analysis as well. In computer sessions, robust methods will be applied to real data sets and the results will be interpreted. Some properties of the estimators will be verified empirically, for instance by Monte Carlo simulation.

Contents

1. Introduction to Robustness.
2. Objective function.
3. M-estimator of location.
4. E-estimator and its functions
5. R-estimator and its functions
6. W-estimator. and its functions
7. Re desending M- estimators.
8. The Breakdown point of robust estimator Influence function.
9. M-estimator for scale.
10. Gross error sensitivity
11. Sensitivity Analysis
12. Contaminated normal distribution
13. Comparisons of usual and robust estimators
14. Monte Carlo simulatopn
15. Evaluation of breakdown point by simulation

16. Outliers and influential observations.
17. Outliers in Regression analysis.

Recommended Texts

1. Maronna, R., Martin, R. & Yohai, V. (2006). *Robust statistics: Theory and methods*. New York: John Wiley & Sons.
2. Rousseau, P.J. & Leroy, A.M. (1987). *Robust Regression and outlier detection*. New York: John Wiley & Sons.

Suggested Readings

1. Huber, P.J. (1981). *Robust statistics.* New York: John Wiley & Sons.
2. Stuart, A. & Ord, J .K. (1998). *Kendall's' advanced theory of statistics*. Vol. I. London: Charles Griffin.

STAT-6218 Statistical Inference-II 3(3+0)

Statistical inference is the process of using data analysis to deduce properties of an underlying distribution of probability. The goal is to use probability theory to make inferences about population parameters of interest. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. The fundamental principles of statistical inference procedures are confidence interval procedures and hypothesis testing; both are constructed on the sampling distribution. The course deals with testing of hypothesis, distribution free and randomization tests, interval estimation and scalar parameters. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Content includes: a review of the key concepts of estimation, and construction of Normal-theory confidence intervals; frequencies theory of estimation including hypothesis tests, methods of inference based on likelihood theory, including use of Fisher and observed information and likelihood ratio and sequential test.

Contents

1. Neyman Pearson Theorem.
2. Uniformly most powerful tests.
3. Test for binomial distribution
4. MPT for Poisson
5. UMPT for discrete distribution
6. UMPT for continuous distribution
7. Exponential families of distribution
8. Likelihood ratio tests
9. Generalized likelihood ration test
10. The sequential probability ratio test
11. Interval estimation and confidence tests.
12. Relation between testing and confidence intervals.
13. Asymptotic testing
14. Estimation

15. Confidence intervals.
16. Optimality criteria, consistency.

Recommended Texts

1. Hogg, R. M. & Craig, A. T. (2019). *Introduction to mathematical statistics* (7th ed.). New York: MacMillan Co.
2. Mood, A. M. Graybill, F. A. & Boes, D.C. (1997). *Introduction to the theory of statistics*. McGraw Hill.

Suggested Readings

1. Hogg, A.V. (1995). *Probability and statistical inference*. New York: McMillan Co.
2. Barlosznski, R. & NiewladomskaBugaj M. (1996). *Probability and statistical inference*. New York: John Wiley & Sons.

STAT-6219 Non-Parametric Methods 3(3+0)

The main aim of this course is to introduce the principles and applications of commonly used nonparametric methods and to compare these methods to their parametric counterparts through simulation studies. The course gives an introduction non-parametric statistics, starting with a repetition of the difference between the mean and the median and the influence of having data with a skewed distribution. Typical examples of such data within health economics are costs of stay or the length of stay. The course also covers simple non-parametric tests for comparing groups of observations. Prescribed course is concerned with the non-parametric approach instead of using the vast variety of parametric statistics test due to violating the assumption of normality in the data. Course also enlightens the significance of different supplementary tests those have no concern with the distribution of the data (should normally distributed) or central limit approach. This course based on the utilization of non-parametric tests specifically in such situation where fulfillment of assumptions relating to the sample (data) is quite difficult. Another direction of the course indicates the real life applications, problems and their solutions in an applied field of statistics.

Contents

1. Scales of measurements
2. Non-Parametric problems, when to use non-parametric procedures.
3. Parametric versus nonparametric tests
4. Trimmed and Winsorized means
5. One sample tests.
6. Binomial test, sigma test, Wilcoxan signed ranks test,
7. Rank sum Test
8. Kolmogrov-smirnov test,
9. Run test
10. Tests for two related samples.
11. Sign test, run test
12. Chi-square test
13. Test for two independent samples: MANN-Whitney test
14. Median test
15. Chi-square test

16. Wald-wolfwitz test

Recommended Texts

1. Gibbons, J.D. & Chakraborti, S. (2011). *Nonparametric statistical inference*. Berlin: Springer.
2. Annette, J. D. (1991). *Introduction to generalized linear models*. Chapman & Hall.
3. Anderson, E.B. (1990). *The statistical analysis of categorical data*. New York: Springer.

Suggested Readings

1. Conover, W.J. (1984). *Practical non-parametric statistics*. New York: John Wiley & Sons.
2. Sprent, P. (1984). *Applied non-parametric statistics.* New York: John Wiley & Sons.
3. Flennberg, S.E. (1980). *The analysis of cross classified categorical data.*

STAT-6220 Population Studies 4(3+1)

Population studies are broadly defined as the scientific study of human populations. This course is an introduction to demography and population studies. Demography concerns itself with the formal (quantitative) analysis of population size, distribution, structure, and change, whereas population studies deals with the sociological determinants (broadly speaking) and consequences of demographic phenomena. Some topics include: Population History, Population Age-Sex Structure, Fertility, Mortality and Population Health, Migration, Explanations of Nuptiality Change and Canadian Nuptiality Trends, Urbanization, Population and Resources, and Population Change and Policy Concerns. The main aim of this course is to report significant advances in methods of population analysis, conceptual and mathematical theories of demographic dynamics and behavior, and the use of these theories and methods to extend scientific knowledge and to inform policy and practice. It also deals with the fertility rates, mortality rates, migration rates and life tables. It provides the necessary skill to evaluate the impact and consequence of population growth on society. It gives the knowledge of population policy and population measures and to impart basic and applied knowledge about Population Studies and its applications in different fields.

Contents

1. The population and housing census Registration of vital events,
2. Demographic surveys Components of population growth, composition of population and vital events.
3. Types and sources of errors General testing procedures
4. Testing the accuracy of age and sex data
5. Fertility and mortality measures
6. Total and general fertility rates.
7. Estimation from incomplete Data Construction of complete and abridged life tables Different types of life tables.
8. Graphs of Ix, qx and ex. Description and uses of life table columns
9. Stationary population models Population estimates and projections Intercensual estimates.
10. Population projections through various methods.
11. Theory of demographic transition Stable and stationary population models, their applications and uses.

12. Malthusian and post Malthusian theories of growth.

Recommended Texts

1. Weinstein, J. & Vijayan, K. Pillai (2001). *Demography: The science of population*. Allyn & Bacon.
2. Hinde, A. (2014). *Demographic method*. (2nd ed.). Routledge.

Suggested Readings

1. United Nations (1998). *World population assessment*. New York: UNFPA.
2. Govt. of Pakistan, (1998). *National, provincial and district census reports and other supplementary reports with respect to 1998 census*. Islamabad: PCO.
3. United Nations (1996). *Added years of life in Asia*. Thailand: ESCAP.

STAT-6221 Numerical Methods 3(3+0)

Numerical methods are the fast solution for mathematical problems. Numerical methods are algorithms used for computing numeric data. They are used to provide 'approximate' results for the problems being dealt with and their necessity is felt when it becomes impossible or extremely difficult to solve a given problem analytically. Methods such as finite difference method (FDM), finite volume method (FVM), finite element method (FEM), boundary element method (BEM) etc are commonly used for treating PDE numerically. All numerical methods used to solve PDEs should have *consistency*, *stability* and *convergence*. Statistics and data analysis are an essential part of a modern engineer's toolkit. So are numerical methods for solving a variety of mathematical problems. This course is designed to enhance the problem solving skills of students using an extremely powerful problem solving tool namely numerical methods. The tool is capable of handling large system of equations, nonlinearities and complicated geometry that are common in practice and that are often impossible to solve analytically. This also focuses on numerical Differentiation, Integration and numerical solutions of ordinary and partial differential equations.

Contents

1. Approximation and Errors in computing: Introduction,
2. Significant digits, Inherent error, Rounding error,
3. Truncation error, Absolute and relative error, Error propagation.
4. Roots of Non Linear Equations and solution of system of Linear Equations: Bisection method,
5. False position Method, Newton-Raphson Method
6. Difference Operators & Interpolation: Forward and Backward difference operators and table, Interpolation with equidistant point,
7. Lagrange Interpolation Polynomial, Newton Interpolating Polynomial using divided Difference Table
8. Numerical Differentiation and Integration: Differentiating continuous functions, differentiating tabulated functions,
9. Higher order derivatives,
10. Richardson's Extrapolation, Newton – cotes integration formula,
11. Trapezoidal rule, Simpson's rule, Boole's rule and Weddle's rule, Romberg's Integration

12. Numerical Solution of Ordinary and Partial Differential Equations
13. Taylor series method,
14. Euler and modified Euler method

Recommended Texts

1. Grewal, B.S. (2014). *Numerical methods in engineering & science* (9th ed.). India: Khanna Publication.
2. Jain, M.K., Iyengar, S. R. K. & Jain, R.K. (2007). *Numerical methods for scientific and engineering computation* (5th ed.). India: New Age International Publishers.

Suggested Readings

1. Curtis, F. G. & Patrick, O. W. (2007). *Applied numerical analysis* (7th ed.). New York: Pearson Education.
2. Balagurusamy, E. (1999). *Numerical method* (1st ed.). New York: McGraw Hill.

STAT-6222 Time Series Analysis & Forecasting 3(3+0)

Time series analysis has many different objectives, depending on the field of application. These include forecasting future values of the series, extracting a signal hidden in noisy data, discovering the mechanism by which the data are generated, simulating independent realizations of the series to see how it might behave in the future (and hence, for example, to estimate the probability of extreme events like floods), and eliminating the seasonal component from data sets like the one in example 2 in order to reveal more clearly the underlying trend. So to fulfill the main objective of time series analysis the aim of this course is to impart the basic and applied knowledge about Time Series and its applications in different fields with an emphasis on practical aspects of the interpretation of statistically based conclusions in research. It deals with the method of data collection, description measures of data for interpretation of results, model selection, decision making and Forecasting. This course is designed for the modeling and forecasting of time series data. This focuses on the decomposition of time series, stationary data, models for stationary and non-stationary series, forecasting methods and properties of models like mean, variance, auto-covariance and auto-correlation function.

Contents

1. Stochastic Process
2. Stationary time-Series.
3. Auto-correlation and auto-covariance.
4. Estimate functions and standard error of the auto-correlation function (ACF).
5. Spectral Analysis:
6. Periodogram, spectral density functions,
7. Comparison with ACF.
8. Linear stationary models
9. Auto-regressive models
10. Moving average models
11. Mixed models.
12. Non-stationary models,
13. ARMA Models

14. ARIMA models
15. Co integration
16. Minimum mean square forecasting.

Recommended Texts

1. Chatfield, C. (1996). *The analysis of time series: An introduction.* London: Chapman and Hall.
2. Cox, D.R. Hinklev, D .V. & Nielsen, O .E. B. (1996). *Time series models- In econometrics, finances and other fields.* London: Chapman Hall.

Suggested Readings

1. Andy, P., West, M. & Harrison, P .J. (1994). *Applied bayesian forecasting and time series analysis.* New York: Chapman Hall.
2. Harvey, A. C. (1990). *Forecasting structural time series models and the kalmanfilter*. Cambridge: University Press.
3. Harvey, A.C. (1981). *Econometric analysis of time series*. London: Philip Allan.

STAT-6223 Multivariate Analysis 3(3+0)

Multivariate analysis is used to study more complex sets of data than what univariate analysis methods can handle. Essentially it is a tool to find patterns and relationships between several variables simultaneously. It lets us predict the effect a change in one variable will have on other variables. Multivariate analysis can reduce the likelihood of Type I errors. Sometimes, univariate analysis is preferred as multivariate techniques can result in difficulty interpreting the results of the test. This course is designed to enlighten the significance of multivariate analysis by entertaining the both mathematical and applied approaches of problems. This course deals with multiple variable analyses simultaneously. To impart skills on the data collection, description measures of data, interpretation of the results, model selection, decision making in the context of multivariate analysis. Nowadays, too accommodating, monitoring, sorting, and filtering, several variables in various fields like in manufacturing industries, social phenomenon, psychology, medical, information technology and biotechnology etc. simultaneously is a big challenge to the world. This is designed to enlighten the significance of multivariate analysis by entertaining the both mathematical and applied approaches of problems. Course also provides the simultaneous model structure, their assumptions and mathematical derivations of multivariate statistical designs.

Contents

1. Multivariate Normal Distribution.
2. Distribution of linear function of normal variates.
3. Distribution of Quadratic forms
4. MLE of Multivariate Normal Distribution
5. Wishart distribution.
6. Hotelling's T^2-distribution
7. Inferences about mean vector
8. Inferences about covariance matrices
9. Inferences about profiles
10. Canonical variates Analysis.
11. Discriminant Analysis

12. Principle Component Analysis
13. Factor Analysis.
14. Factor analysis versus principle component analysis
15. Cluster Analysis
16. MANOVA.

Recommended Texts

1. Richard A. J., & Dean .W. W. (1998). *Applied multivariate statistical analysis.* Prentice Hall.
2. Gnanadesikan, R. (1997). *Methods for data analysis of multivariate observations* (2nd ed.). New York: John Wiley & Sons.

Suggested Readings

1. Anderson, T.W. (1985). *An introduction to multivariate statistical analysis*. New York: John Wiley & Sons.
2. Chatfield, C. &Collin, A. J. (1980). *Introduction to multivariate analysis*. Chapman and Hall.

STAT-6224 Bio Statistics 3(3+0)

Using the tools of statistics, biostatisticians help answer pressing research questions in medicine, biology and public health, such as whether a new drug works, what causes cancer and other diseases, and how long a person with a certain illness is likely to survive. Biostatisticians use their quantitative skills to team with experts in other fields, from biologists and cancer specialists to surgeons and geneticists. New statistical tools and software are often needed to interpret the massive amounts of data and to detect correlations and causations. The basic aim of this course is to highlight the advance applications of probabilistic approaches in the concern of statistical paradigm. Course explores the importance of risk factors and effective decision making strategies. This course also classified according to their metric requirements (i.e., metric level, commensurability across the dimensions, and lexicographic ordering) in the system, is given. A brief introduction to process tracing techniques is followed by a review of results reported in process tracing studies of decision making.

Contents

1. Definition of Biostatistics,
2. The type of variables and observations in biological.
3. Health and medical sciences
4. Uniqueness in terms of behavior of variables their domain, and units.
5. Categorical. Numerical data
6. Censored data.
7. Population, Target populations and samples.
8. Role of sampling in biostatistics
9. Size of samples of various types of studies.
10. Proportions
11. Rates and rations;
12. Incidence, prevalence and odds.
13. Distributional behavior of biological variables (Binomial, Poisson and Normal).
14. Role of transformation for analysis of biological variables.
15. Probit Models

16. Logit transformations and their analysis,
17. P values, its importance and role.
18. Confidence interval
19. Simple and composite hypothesis testing.

Recommenced Texts

1. Zar, J. (2000). *Biostatistical Analysis.* (5th ed.). New York: John Wiley & Sons.
2. Shoukri, M. M. & Pause, C.C. (1998). *Statistical methods for health sciences*. (2nd ed.). Florida: CRC Press.

Suggested Readings

1. Daniel, W.W. (1996). *Biostatistics: A foundation for the health sciences* (6th ed.). New York: John Wiley & Sons.
2. Diggle, J.P. Liang, K. & Zeger, S. L. (1996). *Analysis of longitudinal data*. Clarendon Press.
3. Dunn, G. & Everit, B. (1995). *Clinical biostatistics*. London: Edward Arnold.

STAT-6225 Actuarial Statistics-II 3(3+0)

Statistics are all about processing data and extracting information. The information we seek is the parameters and distribution of the random variable that generated the data. Armed with this information we can answer questions about reality and optimize industrial processes. Statistics thus form the backbone of science and business and this course is designed to help you understand the components of this fundamental subject and how they all fit together. So Actuarial Statistics are a general term for the data used by actuaries in evaluating the risks of morbidity and mortality in partc ular groups, and projecting future financial liabilities of insurance policies and pensions. This course is designed for advance understanding of actuarial science in applied nature. How does it work with real life mechanism, this course is capable to answer. This course consists of Principles of compound interest: nominal and effective rates of interest and discount, continuous compounding. After studying this course student will be able to understand Life Insurance process, insurance payable at the moment of death and at the end of the year of death-level benefit insurance, recursions, commutation functions. Life annuities: a single payment, continuous life annuities, and complete annuities-immediate and apportion able annuities-due. Net premiums: continuous and discrete premiums.

Contents

1. Principles of compound interest: National and effective rated of interest and discount,
2. Force of interest and discount, compound interest accumulation factor, continuous compounding.
3. Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance,
4. Deferred insurance and varying benefit insurance, recursions, commutation functions.
5. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.
6. Net premiums, Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions accumulation type benefits.
7. Payment premiums, apportionable premiums, commutation functions,.

8. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on a apportionable of discounted continuous basis,
9. Reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Recommended Texts

1. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. & Nesbitt, C.J. (1997). *Actuarial mathematics.* (2nd ed.). USA: Society of Actuaries.
2. Spurgeon, E.T. (1972). *Life contingencies.* Cambridge University Press.

Suggested Readings

1. Neill, A. (1977). *Life contingencies*. Heinemann: Routlegde.
2. Blackwell, D. and Graphic, M. A. (1966). *Theory of games and statistical decision*. New York: John Wiley & Sons.

STAT-6226 Decision Theory 3(3+0)

Decision theory is an interdisciplinary approach to arrive at the decisions that are the most advantageous given an uncertain environment. Decision theory brings together psychology, statistics, philosophy, and mathematics to analyze the decision making process. Decision theory is closely related to game theory and is studied within the context of understanding the activities and decisions underpinning activities such as auctions, evolution, and marketing. Descriptive, prescriptive, and normative are three main areas of decision theory and each studies a different type of decision making. Descriptive decision theory: examines how irrational beings make decisions. Prescriptive decision theory: tries to provide guidelines for agents to make the best possible decisions given an uncertain decision making framework. Normative decision theory: provides guidance for making decisions given a set of values. Decision theory framework generally identifies three types of decision classes: Decisions under certainty: an abundance of information leads to an obvious decision. Decisions under uncertainty: analysis of known and unknown variables leads to the best probabilistic decision. Decisions under conflict: a reactive approach that involves anticipating potential consequences to the decision, prior to making a decision. The basic aim of this course is to highlight the advance applications of probabilistic approaches in the concern of statistical paradigm. Course explores the importance of risk factors and effective decision making strategies. This course also classified according to their metric requirements (i.e., metric level, commensurability across the dimensions, and lexicographic ordering) in the system, is given. A brief introduction to process tracing techniques is followed by a review of results reported in process tracing studies of decision-making.

Contents

1. The nature and concept of loss functions, parameters,
2. Decisions and sample spaces.
3. Risk loss
4. Average loss.
5. Admissibility and the class of admissible decisions.

6. Minimax principle and its application to simple decision problems.
7. Linear and quadratic losses and their uses in problems of estimation and testing hypotheses.
8. Asymptotically minimax procedure,
9. A prior distributions and conjugate priors.
10. Bayes' decision procedure,
11. Admissibility of Bayes
12. Maxmin procedures.

Recommended Texts

1. Anderson E.B. (1990). *The statistical analysis of categorical data.* USA: Springer.
2. Berger, J. O. (1985). *Statistical decision theory & bayesian analysis.* USA: Springer.

Suggested Readings

1. Blackwell, D. & Graphic, M. A. (1966). *Theory of games and statistical decision*. New York: John Wiley & Sons.
2. Bowers, N.L. Gerber, H.U. Hickman, J.C. Jones, D.A. & Nesbitt, C.J. (1997). *Actuarial mathematics*. USA: Society of Actuaries.

STAT-6227 Bayesian Statistics 3(3+0)

Bayesian statistics are a system for describing epistemological uncertainty using the mathematical language of probability. In the 'Bayesian paradigm,' degrees of belief in states of nature are specified; these are non-negative, and the total belief in all states of nature is fixed to be one. Bayesian statistical methods start with existing 'prior' beliefs, and update these using data to give 'posterior' beliefs, which may be used as the basis for inferential decisions. Bayesian analysis requires evaluating expectations of functions of random quantities as a basis for inference, where these quantities may have posterior distribution which are multivariate or of complex form or often both. This meant that for many years Bayesian statistics were essentially restricted to conjugate analysis, where the mathematical form of the prior and likelihood is jointly chosen to ensure that the posterior may be evaluated with ease. Numerical integration methods are based on analytic approximations. It deals with the estimation of parameters in different approach. It also discusses the parameter estimation of different probability distributions and their efficiency. Prior distribution, formulation of posterior distribution and predictive distribution estimation are part of the contents.

Contents

1. Prior information, prior distributions,
2. Methods of elicitation of prior distributions
3. Posterior distributions
4. The posterior means, medians
5. Bayes estimators under loss functions and variances of univariate
6. Bivariate posterior distributions
7. Non informative priors
8. Methods of elicitation of non informative factor, priors
9. Bayesian Hypothesis Testing
10. Bayes factor;
11. The highest density region;

12. Posterior probability of the hypothesis.

Recommended Texts

1. Bolstad, W.M. (2016). *Introduction to bayesian statistics* (3rd ed.). New York: John Wiley & Sons.
2. Berger, J. O. (2013). *Statistical decision theory and bayesian analysis* (2nd ed.). USA: Springer.

Suggested Readings

1. Hogg, R. M. & Craig, A. T. (2019). *Introduction to mathematical statistics* (7th ed.). New York: MacMillan Co.
2. De Groot, M. H. (2004). *Optimal statistical decisions*. New York: John Wiley & Sons.
3. Ferguson, T.S. (1967). *Mathematical statistics: A decision theoretic approach*. Academic Press.
4. Carlin, B.P. & Louis, T.A. (2008). *Bayesian method for data analysis*. CRC Press.

MPhil
STATISTICS

STAT-7101 Linear Models and Regression Analysis-I 3(3+0)

This course is designed for M.Phil. in Statistics students. In many areas of science, technology, social science and medicine one often wishes to explore the relationship between one observable random response and a number of 'factors' which may influence simultaneously the response. So, this course introduces students to statistical model building using the improve class of linear models. To study such cases, linear models and regression analysis are the main tools. The main goal of creating a model to predict a future value of the dependent variable. The process of finding this mathematical model that best fits the data involves regression analysis. Generally, regression analysis is a collection of methods for determining and using models that explain how a response variable (dependent variable) relates to one or more explanatory variables (predictor variables). This course will also enable the researchers to find out the factors which affect the response variable of a particular problem. The various components of the course will improve the research and analytical thinking abilities of the students, as well as their capacity and motivation for intellectual development. At the end some statistical software i.e. R and Mathematica may be considered to improve the computing skills of the students in fitting regression models.

Contents

1. Definition and forms of linear models.
2. Functionally related models
3. Mean related models and model classification.
4. Generalized Linear Models.
5. Least squares and unbiased estimation. Best Linear Unbiased Estimation.
6. Multiple Regression Analysis.
7. Various approaches of subset selection procedures,
8. Regression problems such as Heteroscedasticity, Autocorrelation, Multicollinearity.
9. Ridge Regression, Properties of the Ridge Estimator and Choice of Biasing Parameters k, Computational Shortcuts for ordinary Ridge estimators.
10. Predictions from Regression.

Recommended Texts

1. Dobson, A. J. & Barnett, A. (2008). *An introduction to generalized linear models.* (3rd ed.). Taylor and Francis.
2. Draper, N.R. & Smith, H. (2004). *Applied regression analysis*. New York: John Wiley & Sons.

Suggested Readings

1. Agresti, A. (2015). *Foundations of linear and generalized linear models*. New York: Johan Wiley & Sons.
2. Christensen, J. (2002). *Advanced linear modeling*. U.S.A: Springer.
3. Baltagi, B. H. (2011). *Econometrics* (5th ed.). U.S.A: Springer.

STAT-7102 Statistical Process Control 3(3+0)

The use of statistical techniques to control a process or production method and activities which monitors a process in real-time to prevent defects while a lot is being manufactured are known as statistical process control. SPC tools and procedures can help to monitor process behavior, discover issues in internal systems, and find solutions for production issues. This helps to ensure that the process operates efficiently, producing more specification-conforming products with less waste. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical process control, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. This course is designed for providing applicable knowledge of different control charts, EWMA and CUSUM charts, process capability study and process monitoring. The course deals with the construction of control charts for monitoring location and dispersion parameters under univariate and multivariate setups. It also discusses the performance measures, such as average run length and the probability of detection, of the control charts. This covers the process capability analysis, process improvements using design of experiments and Taguchy method. Acceptance sampling plans along with the different ISO series are part of the contents.

Contents

1. Introduction to statistical process control and its tools
2. Multivariate process monitoring through Hotelling T^2 charts.
3. Chi-square chart
4. Generalized variance chart.
5. Multivariate EWMA and CUSUM charts.
6. Robustness approaches for process monitoring
7. Nonparametric approaches for process monitoring
8. Some Bayesian structures for quality control,
9. Covariates and process improvement
10. Process capability study, Introduction of six sigma
11. Designed experiment and process monitoring
12. Acceptance sampling and acceptance sampling plans.
13. Advancements in techniques for quality improvement
14. Quality assurance
15. Taghuchi's methods for quality control, Evolutionary operation and process improvement
16. Introduction to statistical software's for SPC.

Recommended Texts

1. Montgomery, D.C., (2013). *Introduction to Statistical Quality Control*. (9^{th} ed.). John Wiley & Sons.
2. Oakland, J.S., (2007). *Statistical Process Control*. (6^{th} ed.), Butterworth-Heinemann, Elsevier Science Publisher.

Suggested Readings

1. Alwan, L.C., (2000). *Statistical process analysis.* McGraw-Hill.
2. Farnum, N.R. (1994). *Statistical quality control and improvement*. California: Duxbury.

STAT-7103 Linear Models and Regression Analysis-II (3+0)

This course contains various extensions of linear and generalized linear models and the validity of these models. These are, among others parametric nonlinear regression functions and methods connected to the good model selection and robust estimation with outliers. This course will also cover the regression diagnostics such as outlier and influence analysis. Some robust regression estimators for normal and non-normal errors are covers in this course in dealing with the outliers. Regression models are ubiquitous in applying as well as methodological statistical research. In all research dimensions, we are often interested in outcomes that do not follow a normal distribution, such as binary outcomes (survived/died, successful/unsuccessful therapy) and counts (number of infections/cases of cancer/complications at a hospital or in a county). Understanding the fundamentals of these models is critical for anyone in statistical research. So regression diagnostics for outlier and influential observations are the other core objectives of this course. After covering the theoretical concepts, then students will learn statistical software to solve the issues computationally. For this purpose, we consider R, Mathematica and other statistical software.

Contents

1. Outlier Diagnostics: The Hat Matrix and L S Residuals.
2. Single and Multiple-case Diagnostics,
3. Recent Developments, High-Breakdown Diagnostics.
4. Stein-Rule Shrinkage Estimator: Motivation for Shrinkage: Stein-Rule in the Regression Context, Properties of the Stein-Rule Estimator and its Extensions.
5. Robust Regression for Non-normal Errors,
6. Testing a Nonlinear Specification,
7. Measures of Nonlinearity.
8. Orthogonality, Distribution of Quadratic forms.
9. Resampling Techniques: Jackknifing, Bootstrapping.

Recommended Texts

1. Dobson, A. J. & Barnett, A. (2008). *An introduction to generalized linear models* (3rd ed.). Taylor and Francis.
2. Agresti, A. (2015). *Foundations of linear and generalized linear models*. New York: Johan Wiley & Sons.

Suggested Readings

1. Christensen, J. (2002). *Advanced linear modeling*. U.S.A: Springer.
2. Baltagi, B. H. (2011). *Econometrics* (5th ed.). U.S.A: Springer.
3. Draper, N.R. & Smith, H. (2004). *Applied regression analysis*. New York: John Wiley & Sons.

STAT- 7104 Advanced Statistical Inference 3(3+0)

Statistical inference is the process of using data analysis to deduce properties of an underlying distribution of probability. The goal is to use probability theory to make inferences about population parameters of interest. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. The course deals with testing of hypothesis, distribution free and randomization tests, interval estimation and scalar parameters. Statistical inference attempts to isolate the decision maker of his personal opinion and preference to achieve an objective conclusion that is supported by the data. This course also involves derivation of power functions of different tests for comparing and evaluation of the tests. Robust estimation, maximum likelihood estimates, and robust inference for location parameters are also the part of the course. Inferential statistics help to draw conclusions about populations by using small samples. Consequently, it provides enormous benefits because the entire population cannot be measured. Statistical inference is important in order to analyze data properly and proper data analysis is necessary to interpret research results and to draw appropriate conclusions.

Contents

1. Objective of statistical analysis and theory, criteria for the choice of families of models, the likelihood, sufficient statistics, some general principals of statistics inference,
2. Significance tests: simple null hypothesis and simple alternative hypothesis, some example, discrete problems, composite alternatives, two-sided tests
3. Local power, Multidimensional alternatives, composite null hypothesis, similar Region, invariants tests
4. Distribution– free and randomization tests: permutation tests, Rank test, Randomization tests, distance tests, Interval estimation: Scalar parameter, scalar parameter with nuisance parameters
5. Vector parameter, estimation of future observations
6. Point estimation: General considerations on bias and variance, Cramer–Rao inequality
7. Achievement of minimum variance and remove of bias, estimates of minimum mean squared error
8. Robust estimation, Asymptotic theory: Introduction, maximum likelihood estimates, large sample parametric significance tests, Robust inference for location parameters.

Recommended Texts

3. Hogg, A.V., McKean, J.W., & Craig, A.T. (2005). *Introduction to mathematical statistics* (6th ed.). USA: Pearson Prentice Hall.
4. Casella, G., & Berger, R. L. (2002). *Statistical inference.* (2nd ed.). USA: Duxbury Press.

Suggested Readings

1. Mood, A. M., Graybill, F. A. & Boes, D. C. (1997). *Introduction to the theory of statistics*. McGraw Hill.
2. Stuart, A. and Ord, J .K. (1998). *Kendall's advanced theory of statistics.* Vol. I. London: Charles Griffin.
3. Lehman, E.L. (1997). *Testing statistical hypotheses*. USA: Springer.

STAT-7105 Advanced Probability Theory 3(3+0)

Probability theory is the branch of mathematics that deals with modeling uncertainty. It is important because of its direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. A probability distribution is a statistical function that describes all the possible values and likelihood that a random variable can take within a given range. Therefore, decision processes must be able to deal with the problems of uncertainty. Uncertainty creates risk and this risk must be analyzed. In many situations large amounts of numerical data are available which requires statistical techniques for analysis. The course will give the student a deeper understanding of the foundations of probability theory, such as probability theory from a measure-theoretic perspective, convergences of distribution and probability measures, and conditional expectations. During the course, important theorems, such as uniqueness theorem, Kolmogorov strong law of large numbers, monotone convergence theorem and dominated convergence theorem, continuity theorem for characteristic functions. Lindeberg's CLT and its particular cases, Cramer's theorem on composition of convergence in distribution and convergence in probability will be investigated.

Contents

1. Algebra of sets, fields and sigma-fields, limits of sequences of subsets, sigma-field generated by a class of subsets, Borel fields.
2. Probability, measure on a sigma-fields, probability space, continuity of a probability measure.
3. Real and vector-valued random variables, distribution functions (d.f.) discrete r.v.s., r.v.s of the continuous type,
4. Decomposition of a.d.f, independence of two events and (n>2) events, sequence of independent events, independent classes of events.
5. Dynkin's theorem, independence of r.v.s, Borel zero-one law. Expectation of a real r.v. and of a complex-valued r.v. Linear properties of expectations, characteristic functions, their simple properties, uniqueness theorem.
6. Convergence of a sequence of r.v.s., convergence in distribution, convergence in probability, Kolmogorov strong law of large numbers (without proof)
7. Monotone convergence theorem and dominated convergence theorem, continuity theorem for characteristic functions.
8. Lindeberg's CLT and its particular cases
9. Cramer's theorem on composition of convergence in distribution and convergence in probability.

Recommended Texts

1. Hogg, R., Tanis E. & Zimmerman D. (2015). *Probability and statistical inference*. (9^{th} ed.). Prentice Hall.
2. Billingsley, P. (1986). *Probability and measure*. New York: John Wiley & Sons.

Suggested Readings

1. Feller, W. (1969). *Introduction to probability and its applications.* New York: John Wiley & Sons.
2. Loeve, M., (1978). *Probability theory* (4^{th} ed.). USA: Springer.
3. Stuart A. and Ord J. K., (1998). *Advanced Theory of Statistics*. Volume I: Distribution Theory. (6^{th} ed.). Edward Arnold.

STAT-7106 Multivariate Methods 3(3+0)

Multivariate analysis uses statistical tools to determine the relationships between factors. Essentially it is a tool to find patterns and relationships between several variables simultaneously. It lets us predict the effect a change in one variable will have on other variables. This course aims to provide advantageous features of multivariate structure over univariate study. This course covers various multivariate tools like MVN and MVN distribution, Wish art Distribution, and culture analysis. The course includes principle and factor component analysis which is a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables. It identify patterns in the correlation between variables. It also includes multivariate analysis of variance which is a procedure for comparing multivariate sample means. As a multivariate procedure, it is used when there are two or more dependent variables and is often followed by significance tests involving individual dependent variables separately. Advantages of multivariate analysis include an ability to glean a more realistic picture than looking at a single variable. Further multivariate techniques provide a powerful test of significance. The multivariate model is a popular statistical tool that uses multiple variables to forecast possible outcomes.

Contents

1. Multivariate Normal (MVN) Distribution
2. Conditional distributions, Linear combinations
3. Partitioning of multivariate matrices.
4. Assessing the MVN
5. Outliers detection
6. Wishart distribution and its properties
7. Hotelling's T^2 – Distribution.
8. Methods of Estimation
9. Maximum Likelihood and least squares
10. Multivariate Hypothesis testing. Likelihood ratio test
11. One sample and multi-sample hypotheses for mean vector.
12. One sample and multi-sample hypotheses for Covariance matrix

Recommended Texts

1. Johnson, R.A. & Wincher, D.W. (2004). *Applied multivariate statistical analysis*. London: Prentice Hall.
2. Anderson, T.W. (2003). *An introduction to multivariate statistical analysis*. New York: John Wiley & Sons.

Suggested Readings

1. Tabachnick, B.G. & Fidell, L.S. (1996). *Using multivariate statistics* (3^{rd} ed.). Harper Collins College, Publishers.

2. Hair, J.F., Anderson R.E., Jatham, R.L. & Black W.C. (1998). *Multivariate data analysis* (5th ed.). Pearson Education.
3. Flurry, B. (1997). *A first course in multivariate statistics*. Ne York: Springer.

STAT-7107 Multivariate Analysis 3(3+0)

Multivariate analysis uses statistical tools to determine the relationships between factors. Essentially it is a tool to find patterns and relationships between several variables simultaneously. It lets us predict the effect a change in one variable will have on other variables. This course is designed to enlighten the significance of multivariate analysis by entertaining the both mathematical and applied approaches of problems. This course deals with multiple variable analysis simultaneously. The course includes principle and factor component analysis which is a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables. It identifies patterns in the correlation between variables. It also includes multivariate analysis of variance which is a procedure for comparing multivariate sample means. As a multivariate procedure, it is used when there are two or more dependent variables and is often followed by significance tests involving individual dependent variables separately. Advantages of multivariate analysis include an ability to glean a more realistic picture than looking at a single variable. Further multivariate techniques provide a powerful test of significance. The multivariate model is a popular statistical tool that uses multiple variables to forecast possible outcomes.

Contents

1. Principal Component Analysis (PCA), PCA for standardized variables, PCA for variance covariance matrix and special structures, Interpretation of PCA
2. Decision about Components, Scree plot, Large sample inferences.
3. Factor Analysis (FA), Orthogonal FA, methods of estimation: PCA, MLE
4. Factor rotation and Factor scores.
5. Discriminant Analysis (DA)
6. Classification of population by Fisher approach, Evaluation of classification functions
7. Canonical Correlation (CC), identification of canonical variates, CC and its link to multiple regression.
8. Cluster analysis
9. Hierarchical methods, single, complete and average linkage, Non-hierarchical methods, K-means methods.
10. Path analysis
11. Multivariate Analysis of variance (MANOVA)
12. One-way MANOVA
13. two-way MANOVA.

Recommended Texts

1. Anderson, T.W. (2003). *An Introduction to multivariate statistical analysis*. New York: John Wiley & Sons.
2. Johnson, R.A. & Wincher, D.W. (2004). *Applied multivariate statistical analysis*. London: Prentice Hall.

Suggested Readings

1. Hair, J.F., Anderson R.E., Jatham, R.L. & Black W.C. (1998). *Multivariate data analysis.* (5th ed.). Pearson Education.
2. Flurry, B. (1997). *A first course in multivariate statistics*. New York: Springer.

STAT-7108 Time Series and Forecasting 3(3+0)

Time series analysis is used in order to understand the underlying structure and function that produce the observations. Time series refer to any group of statistical information collected at regular intervals of time. Time series analysis is used to detect the changes in patterns in these collected data. Forecasting and predicting for the future is a key factor in planning and development of any organization in this running world. As now, world has become a global village so our market has become much advance as compared to previous decades. Now the market demand is to plan for future based on existing and previous knowledge. In this condition empirical evidences are of much importance. It deals with the method of data collection, description measures of data for interpretation of results, model selection, decision making and Forecasting. This course is designed for the advance modelling and forecasting of time series data. This focuses on advancing time series techniques and forecasting methods. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.

Contents

17. Types of data, components of time series data
18. Stochastic processes
19. Stationary and non-stationary processes
20. Forms and tests of nonstationarity.
21. Purely random processes
22. Random walk models
23. Lag operator, Difference equations and their solutions
24. Smoothing and decomposition methods.
25. Univariate time series analysis (ARMA, ARIMA, Box-Jenkins approach, ARCH, GARCH etc.).
26. Time series modeling and diagnostic checking
27. State space models
28. Use of Kalman filter.
29. Multivariate time series analysis: Granger causality
30. Vector Autoregressive Models.
31. Transfer function and intervention analysis
32. Time series forecasting, Co-integration analysis
33. Vector error correction model and Johansen approach.

Recommended Texts

1. Asteriou, D. (2006). *Applied econometrics.* New York: Palgrave Macmillan.
2. Anderson, T. (1976). *The statistical analysis of time-series*. New York: John Wiley & Sons.

Suggested Readings

1. Box, G.E.P. & Jenkins, G.M. (1994). *Time-series analysis: Forecasting and control* (3rd ed.). USA: Prentice Hall, Englewood Cliffs.
2. Chatfield, C. (2003). *The analysis of time series-An introduction*. New York: Tylor & Francis.
3. Enders, W. (1995). *Applied econometric time series*. New York: John Wiley & Sons.

STAT-7109 Advanced Categorical Data Analysis 3(3+0)

This course is designed to introduce basic concepts and common statistical models and analyses for categorical data; to provide enough theory, examples of applications in a variety of disciplines (especially in social and behavioral science); and practice using categorical techniques and computer software so that students can use these methods in their own research; to attain knowledge necessary to critically read research papers that use such methods. This course is laser-focused on logistic regression modeling and how to interpret these models, rather than the theory behind them. Prescribed course is concerned with the applicable knowledge about statistics in the field of categorical nature of variables. Course is aimed at providing students with a formal treatment of categorical data specifically in the social sciences and decision making theories based on behavioral and attributional variables. This course also covers the brief concepts of advanced categorical methodologies comprising generalized linear modeling with their mathematical derivations. Course communicates the high skills to play the major role in statistics by using the multinomial response models and Poisson regression model. The course is heavily oriented with tools for analyzing categorical data with practical applications.

Contents

1. Introduction to categorical data analysis, Principles of likelihood-based inference, Sampling distributions for contingency tables
2. Measures of association for 2x2 tables.
3. Testing independence in contingency tables
4. Exact inference for two-way tables, Inferences for three-way tables.
5. Introduction to generalized linear models
6. Logistic Model building
7. Alternative link functions for binary outcome, Diagnostics, Exact methods
8. Conditional logistic regression.
9. Methods for analyzing matched case-control data
10. Multinomial response models for nominal data.
11. Multinomial response models for ordinal data
12. Poisson regression model, Poisson regression for rates
13. Log-linear models for contingency tables
14. Negative binomial models
15. Quasi-likelihood and Generalized Estimating Equations.

Recommended Texts

1. Agresti, A. (2010). *Analysis of ordinal categorical data*, (2nd ed.), John Wiley & Sons.
2. Anderson, E. B. (1994). *The statistical analysis of categorical data*. Berlin: Springer.

Suggested Readings

1. Anderson, E. B. (1994). *The statistical analysis of categorical data*. Berlin: Springer.
2. Bishop, Y. M., Fienberg, S. E. & Holland P. W. (2007). *Discrete multivariate analysis*. Berlin: Springer.

STAT-7110 Logical Reasoning and Research Methods 3(3+0)

Logical reasoning is the process of using a rationale, systematic, series of steps based on sound mathematical procedures and given statements to arrive at a conclusion. Logical thinking skills are important because they can help reason through important decisions, solve problems, generate creative ideas and set goals- all of which are necessary for developing the career. The aim of this course is to develop comprehensive understanding of propositions and arguments those are highly utilized in the statistical decision making strategies and the suitable terminologies of term validity and truth tables. This course imparts the knowledge of preparation of research design and necessary components related to research design. It deals with the data collection methods, sampling techniques and their designs and preparation of a research report. It consists of different case studies based on logical reasoning. Multidimensional scaling, preparation of research design, questionnaire and interview methods are also the part of the course. The course focuses on science and scientific attitude, theory and facts and formulation of research problems.

Contents

1. Propositions and arguments
2. Recognizing arguments
3. Validity and invalidity
4. Fallacies
5. Symbolizing arguments
6. Truth functions, truth tables
7. Proving validity and invalidity.
8. Science and scientific attitude, theory and fact
9. Sources and properties of hypothesis, formulation of research problems and its significance.
10. Preparation of research design, components of research design,
11. Questionnaires and interviews
12. Schedules and their constructions.
13. Data Collection methods.
14. Sampling techniques and their designs

Recommended Texts

1. Somekh, B. & Lewin, C. (2011). *Theory and methods in social research*: McGraw Hill.
2. Copi, I. M., Cohen, C. & McMohan, K. (2014). *Introduction to logic* (14th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Hurley, P. J. (2011). *A concise introduction to logic* (3rd ed.). Wad Worth Publishing Co.

2. Agresti, A. (2010). *Analysis of ordinal categorical data*, (2nd ed.), John Wiley & Sons.

STAT-7111 Survey Sampling 3(3+0)

Sample surveys are an important source of statistical data. A great many published statistics on demographic, economic, political and health related characteristics are based on survey data. Simple random sampling is a well-known method of sampling but, for reasons of efficiency and practical constraints, methods such as stratified sampling and cluster sampling are typically used by statistical authorities such as the Australian Bureau of Statistics and by market research organizations. The aim of this course is to cover sampling design and analysis methods that would be useful for research and management in many fields and to develop your understanding of the principles and methods used to design the survey sampling schemes. The aim of this course is to impart knowledge about survey sampling techniques and its applications. This course deals with the response, response error and response variance. Course is also concerned with both categorical and regression analysis in complex surveys and effects of survey design on regression analysis. This course deals with the basic concepts of sampling, requirements of a good sample, determination of sample size etc. Ratio and regression estimates of simple random sampling are also the parts of the contents.

Contents

1. Non-Sampling Errors, Observational Errors
2. Incomplete Sampling
3. Nonresponse, Effects of Non -response, Response and Response Variance.
4. Sources of Response Error
5. Detection, Control and Measurement of Response Error,
6. Scaling Methods, Types of Scales, General Procedure in Attitude Scaling
7. Rating Scales, Likert Scale, Guttman Scale
8. Sematic Differential.
9. A Survey of Super population Models. Randomization theory results for SRS Model for SRS, and model for ratio and Regression Estimation
10. Model for Stratified Sampling, Cluster Sampling
11. Models for unequal Probability Sampling, Complex Surveys
12. Variance Estimations in Complex Surveys.
13. Categorical Data Analysis in Complex Surveys
14. Regression Analysis for Complex Survey
15. Effects of Survey Design on Regression Analysis.

Recommended Texts

1. Mukhopadhyay, P. V. (2005). *Theory and methods of survey sampling*. Prentice-Hall.
2. Cochran, W.G. (1996). *Sampling techniques*. New York: John Wiley & Sons.

Suggested Readings

1. Raj, D. & Chandhok, P. (1998). *Sample survey theory.* New Dehli: Narosa Publishing.
2. Lessler, J.T. & Kalskeek, W. D. (1992). *Non-sampling errors in surveys*. New York: John Wiley & Sons.

STAT-7112 Survival Data Analysis 3(3+0)

This course will provide an introduction to the principles and methods for the analysis of time-to-event data. This type of data occurs extensively in both observational and experimental biomedical and public health studies, as well as in industrial applications. The course is designed to analyze data from studies in which individuals are followed up until a particular event occurs - e.g. death, cure, relapse - making use of follow-up data for those who do not experience the event, with proper attention to underlying assumptions and a major emphasis on the practical interpretation and communication of results. The content includes: Kaplan-Meier life tables; log rank test to compare two or more groups; Cox's proportional hazards regression model; checking the proportional hazards assumption; time-dependent covariates; multiple or recurrent events; and sample-size calculations for survival studies. Main objective of the course are, To identify characteristics of survival data and their implications for analysis, to compare groups using common statistical procedures, to analyze survival data and interpret results using Cox proportional hazards model, to assess models for fulfillment of proportional hazards & other aspects of model adequacy to analyze survival data and interpret results using parametric regression models.

Contents

1. Multiparameter analysis using large sample
2. Likelihood methods for response time data.
3. Survival function
4. Hazard function
5. Multipara meter models
6. Parameterization and regression-type models
7. Likelihood functions for censored data.
8. Kaplan-Meier (Product-limit) estimation
9. Testing based on maximum likelihood estimators
10. Likelihood ratios
11. Score tests.
12. Computational methods including the EM.
13. Algorithms
14. Partial likelihood methods for proportional hazards
15. Analysis of grouped data.

Recommended Texts

1. Collet, D. (2003). *Modeling survival data in medical research.* London: Chapman and Hall.
2. Hosmer, D. & Lemeshow, S. (1999). *Applied survival analysis: regression modeling of time to event data.* New York: John Wiley & Sons.

Suggested Readings

1. Lee, E. T. (2013). *Statistical methods for survival data analysis*. New York: John Wiley & Sons.
2. Lawless, J. F. (1982). *Statistical models and methods for lifetime data*. New York: John Wiley & Sons.
3. Bain, L. J. (1978). *Statistical analysis of reliability and life-testing models*. New York: Marcel Dekker.

STAT-7113 Applied Stochastic Models 3(3+0)

Stochastic processes are the natural tool to model real-world phenomena involving randomness and uncertainty. They offer a powerful mathematical framework to analyze complex problems in a variety of applied areas, ranging from business and industry to economics, finance, social sciences, and biology and computer science. Moreover, the use of stochastic processes to build advanced statistical models is central to the ongoing data science revolution. The main focus is on modeling aspects, which are completed by a description of some popular algorithms for simulation. Mathematical concepts are integrated with real-world applications and examples. Forecasting and predicting for the future is a significant factor for planning and development of any organization in this running world. Purpose of introducing this course is to handle stochastic process, predicting such types of process by using probabilistic approaches by using probability distribution techniques. Course is compiled by including the probability generating function, Markov processes, emigration process and some more advance techniques in this context. At the end of the course, students have bridged the gap between their elementary probability skills and the knowledge required to understand and use basic models based on stochastic processes.

Contents

1. Probability generating, functions
2. Compound distributions
3. Simple random walk
4. Branching processes.
5. Markov process
6. Discrete time Markov chains
7. Continuous time Markov chains
8. Birth-death process.
9. Immigration and emigration process
10. immigration-death processes
11. Renewal processes.
12. Markov renewal process
13. Ergodic theorem
14. Gaussian processes
15. Brownian motion.

Recommended Texts

1. Gikhman & Skorokhod (2007). *The theory of stochastic process III*. Berlin: Springer.
2. Cox, D. R. & Miller, H. D. (1965). *The theory of stochastic process*. London: Chapman and Hall.

Suggested Readings

1. Feller, W. (1968). *An introduction to probability theory and its applications* (3rd ed.). New York: John Wiley & Sons.
2. Melhi, J. (1982). *Stochastic processes.* New York: Wiley International Ltd.
3. Stirzaker, D. R. (1982). *Probability and random processes*. London: Oxford University Press.

STAT-7114 Spatial Data Analysis 3(3+0)

Spatial data refers to the shape, size and location of the feature. Spatial analysis is a process in which our model problems geographically, derive results by computer processing, and then explore and examine those results. Spatial analysis allows to solve complex location-oriented problems and to better understand where and what is occurring in the world. It goes beyond mere mapping to study the characteristics of places and the relationships between them. Spatial analysis lends new perspectives to decision making. The spatial statistics toolbox contain statistical tools for analyzing spatial distribution, processes, patterns and relationships. Spatial statistics include any of the formal techniques which study entities using their topological, geometric or geographic properties. The main objective of this course is to introduce spatial statistics and conceptual foundation of big data handling, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with Eigen function analysis of aerial unit configuration, spatial auto-correlation and spectral analysis. It also discusses the relationship between autoregressive terms. Spectral models Kriging are part of the content. The course focuses on data handling, Eigen function analysis and higher order autoregressive models.

Contents

1. Introduction to spatial statistics
2. Data handling
3. Data mining
4. Measuring the spatial data
5. Eigen function
6. Analysis of aerial unit configuration
7. Autocorrelation
8. Spatial auto-correlation
9. spectral analysis
10. Models of spatial auto-correlation
11. Autoregressive models
12. Higher order autoregressive models
13. Relationship between autoregressive terms
14. Kriging and its functions
15. Measures of Kriging
16. Spectral models Kriging.

Recommended Texts

1. Cressie, N. (2015). *Statistics of spatial data, revised edition*. New York: John Wiley & Sons.
2. Bartlett, M. (1975). *Statistical analysis of spatial pattern*. London: Chapman and Hall.

Suggested Readings

1. Griffith, D. (1988). *Advanced spatial statistics*. Kluwer: Bostan.
2. Ripley, B. (1988). *Statistical inference for spatial processes*. New York: John Wiley & Sons.
3. Upton, G. & Fingleton, B. (1985). *Spatial data analysis by example*. New York: John Wiley & Sons.

STAT-7115 Measure Theory 3(3+0)

A measure on a set is a systematic way to assign a number to each suitable subset of that set, intuitively interpreted as its size. In this sense a measure is a generalization of the concepts of length, area and volume. Measure theory is the formal theory of things that are measurable. This is extremely important to probability. Measurement theory is the study of how numbers are assigned to objects and phenomena, and its concerns include the kinds of things that can be measured, how different measures relate to each other, and the problem of error in the measurement process. Measurement theory shows that strong assumptions are required for certain statistics to provide meaningful information about reality. In statistics, the term measurement is used more broadly and is more appropriately termed scales of measurement. Course is aimed to cover the different measure those are frequently used in statistics like lebesgue and outer measure of the set of information. Course highlights the practical appliance of the measurable function and the Riemann integral of a bound function over a set of finite measure. Course also signifies the importance of integral of non-negative function and measurability of the outer function. Course extends the convergence theorems and bounded linear functional on Lp space representation theorems.

Contents

1. Lebesgue measure, introduction, outer measure
2. Measurable sets
3. Lebesgue measure, a non-measurable set.
4. Measurable functions. Labesgue Integral
5. The Riemann integral of a bounded function over a set of finite measure.
6. The integral of a non-negative function.
7. The general Labesgue. General measure
8. Integration, measure space
9. Measure functions, integration
10. General convergence theorems
11. Signed measure
12. Hahn decomposition theorem.
13. Outer measure and measurability
14. The extension theorems
15.

Recommended Texts

1. Roydon, H.L. (2010). *Real analysis* (4th ed.). New York: Collier Macmillan Co.
2. Barru, G.D. (1981). *Measure theory and integration*. Ellis, Harwood Ltd.

Suggested Readings

1. Khan, A.R. (1993). *Introduction to lebesgue integration*. Pakistan: Illmi Kitab Khana.

2. Folland, G.B. (1999). *Real analysis-modern techniques and their applications* (2nd ed.). New York: John Wiley & Sons.
3. Rudin, W. (1980). *Real and complex analysis*. McGraw Hill.

STAT-7116 Inference in Stochastic Processes 3(3+0)

A stochastic process can be defined as a collection of random variables that are indexed by some mathematical set, meaning that each random variable of the stochastic process is uniquely associated with an element in the set. A stochastic process is a collection of random variables defined on a common probability space, taking values in a common set S and thought of as time. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of inference in stochastic process, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Markov sequences, estimation of parameters based on likelihood and conditional least squares, auto-regressive series. It deals with the estimation of martingale strong law of large numbers, CLT for martingales parameters, Diffusion processes and their likelihood, properties of estimators. It also discusses the properties of estimators on the non-extinction path, asymptotic distribution theory. Elements of semi-parametric and non-parametric analysis, theory and applications of optimal estimating functions, estimation of transition and stationary density, intensity function of a counting process are part of the content.

Contents

1. Inference in Markov chains, estimation of transition probabilities
2. Testing for order of a Markov chain,
3. Estimation of functions of transition probabilities, parametric models and their goodness of fit
4. Markov sequences, estimation of parameters based on likelihood and conditional least squares, auto-regressive series.
5. Statement of martingale strong law of large numbers and CLT for martingales
6. CAN property of the MLE from a general sequence of dependent random variables, Fisher information. Applications to Markov chains and sequences.
7. Likelihood of Poisson and other Pure Jump Markov processes from first principles, CAN property of MLE's
8. Testing for a Poisson process, non-homogeneous processes.
9. Analysis of parametric Pure Jump processes, Birth-Death-Immigration processes, testing goodness of fit of such models.
10. Diffusion processes and their likelihood, properties of estimators (without proof) Branching processes
11. Inconsistency of MLE/moment estimators.

Recommended Texts

1. Bhat, B. R. (2000). *Stochastic models: Analysis and applications*. New Age International Publishers.
2. Basawa, I.V. & PrakasaRao, B. L. S. (1980). *Statistical Inference for stochastic processes.* Academic Press.

Suggested Readings

1. Adke, S. R. & Manjunath, S. M. (1984). *An introduction to finite markov processes.* Hoboken: Wiley Eastern.
2. Guttorp, P. (1991). *Statistical inference for branching processes*. New York: John Wiley & Sons.
3. Guttorp, P. (1995). *Stochastic modelling for scientific data*. USA: Springer.

STAT- 7117 Bayesian Analysis 3(3+0)

This course introduces the Bayesian approach to statistics, starting with the concept of probability and moving to the analysis of data. It deals with the philosophy of the Bayesian approach as well as how to implement it for common types of data. In particular, the Bayesian approach allows for better accounting of uncertainty, results that has more intuitive and interpretable meaning, and more explicit statements of assumption. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of Bayesian statistics, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. Bayesian procedures are concerned with the best estimating a value or range of values for a particular population parameter. It deals with the estimation of parameters in different approach. It also discuss the parameter estimation of different probability distributions and their efficiency. Prior distribution, formulation of posterior distribution and predictive distribution estimation is part of the content. Completion of this course will give an understanding of the concepts of the Bayesian approach, understanding the key differences between Bayesian and Frequentist approaches, and the ability to do basic data analyses.

Contents

1. Formulation of a decision problem
2. Randomized and non-randomized decision rules,
3. Benefits of Bayesian statistics
4. Comparison of Bayesian statistics
5. Classical statistics
6. Prior Distribution
7. Posterior Distribution.
8. Risk function, optimality of decision rules.
9. Utility theory
10. Loss function.
11. Subjective probability
12. Selection of prior distribution for Bayesian analysis.
13. Bayesian analysis for statistical inference problems of estimation
14. Testing hypotheses
15. Confidence interval and prediction.
16. Bayesian decision theory.
17. Admissible and minimax decision rules.
18. Complete class of decision rules.

Recommended Texts

1. Bolstad, W.M. (2013). *Introduction to bayesian statistics*. New York: John Wiley & Sons.

2. James, O. B. (2013). *Statistical decision theory and bayesian analysis* (2nd ed.). Berlin: Springer.

Suggested Readings

1. De Groot, M. H. (2004). *Optimal statistical decisions.* New York: John Wiley & Sons.
2. Ferguson, T.S. (1967). *Mathematical statistics: A decision theoretic approach*. USA: Academic Press.

STAT-7118 Optimization Techniques 3(3+0)

The course covers developments of advanced optimization models and solution methods for technical and economic planning problems. The basis of the course is the optimization process, from a real planning problem with interpretation of the solutions of the underlying optimization problem. In the modeling part we focus on problems with discrete elements, but also knowledge about important classes of optimization problems and their properties will be highlighted. Prescribed course provide applicable knowledge related to Statistics in the concern of convex sets, supporting and separating hyper-planes techniques. This course aimed to impart basic and applied knowledge about optimization and its applications in different fields of marketing to model the balanced and unbalanced transportation problems. This course highlights the Gomory cut method skills of branch and bound method. Course also enlightens the significance of mathematical modeling based strategies based on both mathematical and applied nature of disciplines on the Management, description measures of data for interpretation of results, and decision making. It also deals with constraint programming, local search, and mixed-integer programming from their foundations to their applications for complex practical problems in areas such as scheduling, vehicle routing, supply-chain optimization, and resource allocation.

Contents

1. Convex sets, supporting and separating hyper-planes, program and basic feasible solution, simplex algorithm and simplex method, two phase method, graphical solution, Charnes' M-technique.
2. Duality in linear programming, duality theorems,
3. Dual simplex method with justification, sensitivity and parametric LPP.
4. Transportation and assignment algorithms, balanced and unbalanced transportation problems, degeneracy
5. Hungarian method of assignment, transshipment problems.
6. Integer-linear programming
7. Gomory cut method, branch and bound method, fractional cut method
8. Network flows, maximal flow in the network, labeling technique, connection between network flow and transportation, matrix solution. Nonlinear programming.
9. Integer Programming
10. Goal Programming
11. Quadratic programming
12. Kuhn - Tucker conditions
13. Algorithms (Wolfe's Beale's and Fletcher's) for solving quadratic programming problem.

Recommended Texts

1. Sharma, J. K. (2009). *Operations research theory and methods* (4th ed.). New York: Macmillan.
2. Hadley, G. (1987). *Linear programming*. London: Addison Wesley.

Suggested Readings

1. Taha, H. A. (1992). *Operations research.* (5th ed.). New York: Macmillan.
2. Kambo, N. S. (1991). *Mathematical programming techniques*. Affiliated East-West Press Pvt. Ltd.

STAT-7119 Statistical Ecology 3(3+0)

Statistical ecology deals with the development of new methodologies for analyzing ecological data. Advanced statistical models and techniques are often needed to provide robust analyses of the available data. The system process is often a function of the demographic parameters of interest, such as survival probabilities, transition rates between states, and/or abundance, whereas the model parameters associated with the observation process are conditional on the underlying state of the system. This review focuses on a number of common forms of ecological data and discusses their associated models and model-fitting approaches, including the incorporation of heterogeneity within the given biological system and the integration of different data sources. Prescribed course concerns probabilistic approaches of the population dynamics and exponential and Compertz models. This signifies advance models related to survivorship and age structured models comprising constant hazard, monotone hazard and bath-tub hazard rates. Course also enlightens the practical appliance of the different indices and game theory in the discipline of ecological problems. This course based on the utilization of evolutionary stable strategies, some simple cases and mean variance tradeoff.

Contents

1. Population Dynamics: One species - exponential, logistic
2. Gompertz models. Two species - competition, coexistence, and predator - prey oscillation, Lotka - Volterra equations, isoclines.
3. Leslie matrix model for age structured populations.
4. Survivorship curves - constant hazard rate, monotone hazard rate and bath-tub shaped hazard rates
5. Population density estimation:
6. Capture recapture models, nearest neighbor models, line transect sampling.
7. Simpson’s index
8. Shannon - Weaver index
9. Diversity as average rarity
10. Optimal Harvesting of Natural Resources
11. Maximum sustainable yield, tragedy of the commons
12. Game theory in ecology.
13. Concept of Evolutionary stable strategy, its properties, simple cases such as Hawk Dove game
14. Foraging Theory.
15. Diet choice problem, patch choice problem, and mean variance tradeoff.

Recommended Texts

1. Gore A. P. & Paranjpe S. A. (2000). *A course on mathematical and statistical ecology*. Kluwer Academic Publishers.
2. Pielou, E. C. (1977). *An introduction to mathematical ecology.* New York: John Wiley & Sons.

Suggested Readings

1. Saber, G.A. F. (1982). *The estimation of animal abundance and related parameters* (2nd ed.). C. Griffin
2. Clark, C. W. (1976). *Mathematical bio-economics: the optimal management of Renewable resources.* New York: John Wiley & Sons.
3. Maynard, S. J. (1982). *Evolution and the theory of games.*Cambridge: Cambridge University Press.

STAT-7120 Medical Statistics 3(3+0)

Medical statistics is the study of human health and disease. Its applications ranging from biomedical laboratory research, to clinical medicine, to health promotion, to national and global systems of health care to medicine and the health sciences, including public health, forensic medicine, epidemiology and clinical research. It is the science of summarizing, collecting, presenting and interpreting data in medical approach and using this data estimate the magnitude of associations and test hypotheses. It has a main role in medical investigations. Statisticians help researchers design studies, analyze data from medical experiments, decide what data to collect, help interpret the results of the analyses, and collaborate in writing articles to describe the results of medical research. Medical statisticians design and analyze studies to identify the real causes of health issues as distinct from chance variation. It explores the heterogeneity of effects, their interactions, sensitivity and specificity of the applied statistical terminology. This course also signifies the practical appliance of the hazard models, survival analysis and cross-control study designs. The goal is to provide students, to the community with high skills to play the major role in statistics by using the knowledge of biological variables and their communicating results of epidemiological studies.

Contents

1. Study designs in epidemiology.
2. Measures of disease occurrence and association
3. Variation and bias.
4. Identifying non-causal association
5. Confounding.
6. Defining and assessing heterogeneity of effects, interaction.
7. Sensitivity and specificity of diagnostic test, Cohort Study designs, statistical power and sample size computations.
8. Log-linear models, 2xK and 2x2x2 contingency tables
9. Logistic model.
10. Analysis of binary data.
11. Cross-control study designs, matched case-control studies.
12. Survival data: Proportional hazards model, multivariate survival data.
13. Causal Inference
14. Longitudinal data.
15. Communicating results of epidemiological studies

16. Ethical issues in epidemiology.

Recommended Texts

1. Selvin, S. (2004). *Statistical analysis of epidemiological data*. Oxford: Oxford University Press.
2. Diggle, P. J., Heagerty, P., Liang, K., & Zeger, S. L. (2002). *Analysis of longitudinal data.* Oxford:Oxford University Press.

Suggested Readings

1. Piantadosi, S. (1997). *Clinical trials: A methodologic perspective.* New York: John Wiley & Sons.
2. Agresti, A. (1990). *Categorical data analysis*. New York: John Wiley & Sons.
3. Clayton, D. & Hills, M. (2013). *Statistical methods in epidemiology*. Oxford University Press.

STAT-7121 Analysis of Clinical Trials 3(3+0)

Clinical trials are experiments designed to evaluate new interventions to prevent or treat disease in humans. The interventions evaluated can be drugs, devices, surgeries, behavioral interventions, community health programs or health delivery systems. The course will explain the basic principles for design of randomized clinical trials and how they should be reported. The first part of the course contains terminology used in clinical trials and several common designs used for clinical trials, such as parallel and cross-over designs. The second half of the course, includes how clinical trials are analyzed and interpreted. Finally, the course reviewed the essential ethical consideration involved in conducting experiments on people. The aim of this course is to impart knowledge about clinical trials and existence of bias and random error of clinical studies occurred during the conduction of clinical trials. This course deals with different types of data management and case report forms. The course provides the mathematical and conceptual formation of cross-over design, longitudinal and factorial designs utilized for both single stage and multi-stage phase II trials. Course also enlightens the mathematical strategies of categorical outcomes of phase I – III trials.

Contents

1. Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies
2. Conduct of clinical trials, overview of Phase I-IV trials
3. Multi-center trials
4. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.
5. Design of clinical trials: parallel vs. cross-over designs
6. Cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials
7. Sesign of Phase I trials, design of single-stage and multi-stage
8. Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bio-equivalence trials.
9. Reporting and analysis
10. Analysis of categorical outcomes from phase I - III trials
11. Analysis of survival data from clinical trials.

12. Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data
13. Meta-analysis of clinical trials.

Recommended Texts

1. Marubeni, E. & Valsecchi, G. (2004). *Analyzing survival data from clinical trials and observational studies.* New York: John Wiley & Sons.
2. Jennison, C. & Turnbull., B. (1999). G*roup sequential methods with applications to clinical trails*. CRC Press.

Suggested Readings

1. Friedman, L., Furburg, C., & Demets, D. (1998). *Fundamentals of clinical trials*. USA: Springer.
2. Fleiss, J. (1989). *The design and analysis of clinical experiments*. New York: John Wiley & Sons.

STAT-7122 Stochastic Models in Finance 3(3+0)

Stochastic modeling is a form of financial model that is used to help make investment decisions. This type of modeling forecasts the probability of various outcomes under different conditions, using random variables. Stochastic modeling presents data and predicts outcomes that account for certain levels of unpredictability or randomness. In the financial services sector, planners, analysts, and portfolio managers use stochastic modeling to manage their assets and liabilities and optimize their portfolios. This course gives an easy introduction to interest rates and related contracts. The course includes the basic facts from stochastic calculus that will enable you to engineer a large variety of stochastic interest rate models. The course introduces fundamental stochastic tools for derivative asset pricing and portfolio theory. The ability to price and hedge derivative products and to properly manage asset portfolios is of paramount importance in the financial industry. The existing techniques to carry this out require a good command of the concepts in stochastic models that will be presented in this course. The course deals with the binomial model, behavior of stock prices, condition expectations, and estimation volatility.

Contents

1. Derivatives: forward and future contracts.
2. Markets, prices, arbitrage and hedging.
3. Options markets, properties of stock option prices. American and European options.
4. Binomial model: One-step and two-step models
5. Binomial trees. Risk neutral valuation.
6. Behavior of stock prices:
7. Conditional expectation
8. Martingale
9. Brownian Motion
10. Markov property
11. ITO Process, ITO Lemma.
12. Black Scholes model
13. Distribution of returns, volatility
14. Black-Scholes-Merton differential equation.
15. Estimating volatility.

16. Options on stock indices, currencies and futures.
17. Greek Letters and hedging.
18. Value at risk.

Recommended Texts

1. Lamberton, D. & Lapeyre, B. (2008). *Introduction to stochastic calculus applied to finance*. New York: Chapman and Hall/CRC.
2. Neftci, S. N. (2000). *An introduction to the mathematics of financial derivatives*. USA: Academic Press.

Suggested Readings

1. Watsham, T. J. & Parramore, K. (1997). *Quantitative methods in finance*. UK: Thomson Learning.
2. Bingham, N.H. & Kiesel, R. (2004). *Risk-nuetral valuation*. USA: Springer.

STAT-7123 Genetic Data Analysis 3(3+0)

Genetic analysis is the overall process of studying and researching in fields of science that involves genetics and molecular biology. The base system of analysis revolves around general genetics. Basic studies include identification of genes and inherited disorders. Statistical genetics is a scientific field concerned with the development of statistical methods for drawing inferences from genetic data. The term is most commonly used in the context of human genetics. Genetic analysis often requires the interpretation of numbers in various phenotypic classes. In such cases a statistical procedure called the chi-square test is used to help in making the decision to hold onto or reject the hypothesis. This course is aimed to the analysis of discrete nature based on genetic data on morphological characters and the brief descriptions of the morphological allozymes and DNA sequences. Course highlights the applications of maximum likelihood estimation and development of statistical techniques for characterizing genetic disequilibrium and diversity. Course deals with the variations, alignments and similarities between DNA sequences. Development of statistical techniques for characterizing genetic disequilibrium and diversity and measures of population structure and genetic distance is also the part of the course.

Contents

1. Analysis of discrete data
2. Illustrated with genetic data on morphological characters allozymes
3. Fragment length polymorphisms
4. Restriction fragment length polymorphisms
5. DNA sequences.
6. Maximum likelihood estimation, including iterative procedures.
7. Numerical resembling
8. Characterizing genetic disequilibrium
9. Development of statistical techniques for characterizing genetic disequilibrium and diversity
10. Development of statistical techniques for characterizing genetic diversity.
11. Measures of population structure
12. Genetic distance.

13. Construction of phylogenetic trees.
14. Finding alignments and similarities between DNA sequences.
15. Locating genes with markers.

Recommended Texts

1. Ewens, W. (2004). *Mathematical population genetics*. Berlin: Springer.
2. Li, C. C. (1976). *First course on population genetics*. California: Boxwood Press.

Suggested Readings

1. Nagylaki, T. (1992). *Introduction to theoretical population genetics*. Berlin: Springer.
2. Durbin, R., Eddy, S., Krogh, A. & Mitchison, G. (1998). *Biological sequence analysis: probabilistic models of proteins and nucleic acids*. Cambridge University Press.
3. Elandt-Johanson, R. C. (1975). *Probability models and statistical methods in genetics*. New York: John Wiley & Sons.

STAT-7124 Generalized Linear Models 3(3+0)

This course deals with statistical models for the analysis of quantitative and qualitative data. The statistical methods studied are the general linear model for quantitative responses (including multiple regression, analysis of variance and analysis of covariance), regression models for binary data (including logistic regression and probit models), models for count data (including Poisson regression and negative binomial models) models for continuous and positively skewed data (Gamma regression and Inverse Gaussian regression models. The course will be a mix of theory, computing and data analysis, depending on student's backgrounds. The aim of the course is to give more emphasis on statistical modelling. Starting from the linear regression framework, results and techniques in the field of generalized linear models will be developed. This course is based on the theory in exploratory data analysis and further in statistical modelling. Upon successful completion, students will have the knowledge and skills to: Communicate the role of generalized linear modelling techniques (GLMs) in modern applied statistics and implement methodology and explain the underlying assumptions for GLMs and perform diagnostic checks whilst identifying potential problems and Perform statistical analysis using statistical software, incorporating underlying theory and methodologies.

Contents

1. Introduction: background, review of linear models in matrix notation, model assessment, some pre-required knowledge
2. The exponential family of distributions: Definition and examples. Mean and variance, variance function and scale parameter.
3. Generalized linear models (GLM): linear predictor, link function, canonical links, maximum likelihood estimation, iterative reweighted least squares and Fisher scoring algorithms, significance of parameter estimates, deviance, Pearson and deviance residuals
4. Pearsons chi-square test and the likelihood ratio test, Wald test.
5. Binary and Binomial data analysis: distribution and models, logistic regression models, odds ratio
6. One- and two-way logistic regression analysis.
7. GLM for Counts data analysis: Poisson regression
8. Negative binomial regression estimation and inferences

9. GLM for continuous response models: Gamma and Inverse Gaussian response models, estimation and inferences.

Recommended Texts

1. Agresti, A. (2015). *Foundations of linear and generalized linear models.* New York: John Wiley & Sons.
2. McCullegh P. & Nelder J.A. (1990). *Generalized linear models.* New York: Chapman and Hall.
3. Hardin, J.W. & Hilbe, J.M. (2012). *Generalized linear models and extensions* (3rd ed.). Stata Press Publication.

Suggested Readings

1. Myers, R. H., Montgomery, D. C., Vining, G.G. & Robinson, T. J. (2010). *Generalized linear models with applications in engineering and the sciences* (2nd ed.). New York: John Wiley & Sons.
2. Annette, J. D. (2001). *An introduction to generalized linear models*. Text in Statistical Science.
3. Atkinson, A. C. (1985). *Transformations and regression:* Clarendon, Oxford.

STAT-7125 Analysis of Repeated Measures 3(3+0)

Repeated measure design is a research design in which subjects are measured two or more times on the dependent variable. Repeated measure ANOVA compares means across one or more variables that are based on repeated observations. A repeated measure ANOVA model can also include zero or more independent variables. Repeated measures designs are very important branch of design and analysis of experiments. These designs are useful for analyzing numerical results obtained under repetitive experiments over the same subject over the time. Repeated measures design aims to evaluate the effect of variability between groups under subjects are used throughout the experiment. Repeated measures designs can be very powerful because they control for factors that cause variability between subjects. This course consists of advance techniques for analyzing repeated measures such as Multifactor repeated measures designs and statistical power measuring sequential effect. The course deals with the introduction of repeated measures designs, models and assumptions, test of trend analysis, models with interactions and applications of repeated measure designs. It also includes multi factor experiments in repeated measure designs, two and three factors experiments with repeated measures. Measures of association and statistical power in multifactor repeated measure designs are also the part of the contents.

Contents

1. Introduction of repeated measures designs
2. Models and assumptions, variants- covariance structure, box's correction
3. Huynh-Feldt (HF) condition
4. Circularity assumption
5. Necessary and sufficient conditions for circularity
6. Mauchley sphere city test, trend analysis.
7. Test of trend analysis
8. Models with interaction
9. Measures of association and power in univariate repeated measure design, application of repeated measure in basic design and analysis of co-variance.

10. Multi factor experiments in repeated measure designs
11. two factors experiment with one factor repeated measure
12. Three factor experiments with repeated measure
13. Controlling sequence effect
14. Unequal group size.
15. Measures of association
16. Statistical power in multifactor repeated measure designs.

Recommended Texts

1. Montgomery, D.C. (2001). *Design and analysis of experiment*. New York: John Wiley & Sons.
2. Stevens, J. (1996). *Applied multivariate statistics for the social sciences*. (3rd ed.). New Jersey: Lawrence Erlbaum Associates.

Suggested Readings

1. Weinfurt, K. P. (1995). *Repeated measure analysis*. In L.G. Grimm.
2. Cochran, W. G., & Cox, G. M. (1992). *Experimental designs*. New York: John Wiley and Sons.

STAT-7126 Design of Experiments-Factorial Experiments 3(3+0)

The course will examine how to design experiments, carry them out, and analyze the data they yield. Various designs are discussed and their respective differences, advantages, and disadvantages are noted. In particular, factorial and fractional factorial designs are discussed in greater detail. The course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions. Both designs and statistical analysis issues are discussed. Particular attention will be paid to: understanding the process of designing an experiment including factorial and fractional factorial designs; examining how a factorial design allows cost reduction, increases efficiency of experimentation, and reveals the essential nature of a process. This course aims how to manage factorial experiments, how to analyze these experiments under limited resources and material by providing a wide range of information about the concept of blocking and controlling features of designs. This course is composed of different resolution of design, replicated design, response surface methodology, steepest methods and advance robust designs like cross arrayed designs and Taguchi methods.

Contents

1. A review and analysis with unequal subclass numbers, 2n, 3n and mixed factorial experiments
2. Blocking factorial design
3. Estimation of model parameters
4. Fractional replication and alias structure
5. Resolution III, IV and V design.
6. Unreplicated factorial designs
7. Lenth's method
8. Danial method
9. Series of experiments in time and space
10. Response surfaces methods (RSM)
11. Analysis of Response surfaces methods (RSM)/designs, 1st order and 2nd order model, Method of steepest ascent

12. Blocking in RSM. Saturated designs and their analysis.
13. Nested Designs: two stage and general-m stage
14. Robust designs
15. Taguchi methods.

Recommended Texts

1. Montgomery, D. C. (2012). *Design and analysis of experiments* (8th ed.). New York: John Wiley & Sons.
2. Boniface, D. R. (1995). *Experimental design and statistical methods*. London: Chapman and Hall.

Suggested Readings

1. Garcia-Diaz, A, D. T. & Auth, J. (1995). *Principles of experimental design and analysis*. London: Chapman and Hall.
2. Harold, R. L. (1992). *Analysis of variance in experimental design*. Berlin: Springer.
3. Cochran, W. G. & Cox, G. M. (1992). *Experimental designs*. New York: John Wiley & Sons.

STAT-7127 Non-Linear Estimation 3(3+0)

Nonlinearity is a relation between data points that cannot be condensed into a neat linear graph. Nonlinear modeling is empirical or semi-empirical modeling which takes at least some nonlinearity into account. The reason to use the nonlinear models is because the relationships between the dependent and independent parameters are not linear. Nonlinear models are widely used in many applications such as in dose response studies conducted in agricultural sciences, toxicology and other biological sciences. Nonlinear estimation involves the fitting of nonlinear models by least square. This course introduces some non-linear statistical models, their parameter's estimation and some stability transformations of the variables. This course emphasizes both the theoretical and practical aspects of statistical non-linear estimation and analysis. This course also signifies the applications of non-linear modeling and importance of rare events adopted methods like kernel smoothing, additive methods and unweighted least square methods. Course also enlightens the practical applications of the minimum risk estimates and minimax deviation methods. Analysis of the non-linear models and their comparisons will be evaluated by using computational techniques and through statistical software.

Contents

1. Models: Linear and non-linear models, their importance
2. Parameters and estimation using ML method
3. Comparisons of different methods
4. Transformations of parameters, inference
5. Different transformations
6. Stable transformations
7. Computing Methods for Non-linear Modelling
8. Confidence intervals for parameters and functions.
9. Applications of non-linear Modelling
10. Smoothing techniques
11. Kernal smoothing methods
12. Additive methods

13. Unweighted least square method
14. Bayesian estimation.
15. Minimum risk estimate
16. Minimax deviation method
17. Projection and its types
18. Projection method with bounded parameters.

Recommended Texts

1. Seber, G. A. F. & Wild, C. J. (2003). *Non-linear regression*. New York: John Wiley & Sons.
2. Ross, G. J. S., (1990). *Non-linear estimation.* Berlin: Springer.

Suggested Readings

1. Kotz, S. & Johnson, N. (1985). *Encyclopedia of statistical sciences (Non-linear Models, Non-Linear Regression)*. New York: John Wiley & Sons.
2. Ralkowsky, D. A. (1984). *Non-linear regression modelling*. New York: Dekker.

STAT-7128 Applied Logistic Regression 3(3+0)

Logistic regression is the appropriate regression analysis to conduct when the dependent variable is dichotomous. Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more nominal, ordinal, interval, or ratio level independent variables. Logistic model is used to model the probability of a certain class or event existing such as pass/fail, win/lose, alive/dead, or healthy/sick. Given a certain factor, logistic regression is used to predict an outcome which has two values such as 0 or 1. Logistic regression is a predictive modeling algorithm that is used when the Y variable is binary categorical. This course introduces the regression methods for analyzing data based on nominal and ordinal scale response. This course highlights both the theoretical and the mathematical derivations of Non-iterative weighted and discriminant functional analysis method. Course focuses on techniques for estimating dichotomous polytomous and continuous variables. Model-building strategies and methods of estimating logistic regression methods are also defined of various types. The goal is to help the students to develop a solid theoretical background in cohort studies, case studies and matched case studies.

Contents

1. Concept of simple regression and Logistic regression
2. Fitting simple and multiple Logistic Regression (LR)
3. Models using MLE
4. Weighted Least Squares
5. Non-iterative weighted Least Squares
6. Discriminant functional analysis methods
7. Dichotomous variables
8. Polytomous
9. Continuous Independent Variables.
10. Multivariate Case
11. Interaction
12. Confounding,
13. Estimation of odds ratios in the presence of interaction.

14. Model-building Strategies
15. Methods for Logistics Regression.
16. Application of Logistic Regression with different sampling methods
17. Cohort studies
18. Case studies and matched case studies.

Recommended Texts

1. Jiang, J. (2007). *Linear and generalized linear mixed models and their applications*. Berlin: Springer.
2. Lindsey, J. K. (1997). *Applying generalized linear models*. Berlin: Springer.

Suggested Readings

1. McCullagh, P. & Nelder, J. A. (1989). *Generalized linear model* (2nd ed.). London: Chapman and Hall.
2. Hosmer, D. W. & Hemeshow (1989). *Applied logistic regression*. New York: John Wiley & Sons.
3. Cox, D. R. & Oakes, D. (1984). *Analysis of survival data*. London: Chapman and Hall.

STAT-7129 Bayesian Decision Theory 3(3+0)

Decision theory is an interdisciplinary approach to arrive at the decisions that are the most advantageous given an uncertain environment. Decision theory brings together psychology, statistics, philosophy, and mathematics to analyze the decision-making process. This course introduces the Bayesian approach to statistics in decision theory, starting with the concept of probability and moving to the analysis of data. We will learn about the philosophy of the Bayesian approach as well as how to implement it for common types of data. The main aim of this course is to provide a strong mathematical and conceptual foundation in the methods of Bayesian Decision Theory, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with the estimation of parameters in different approach. Prior distribution, formulation of posterior distribution and predictive distribution estimation is part of the content. It deals with the utility theory, loss function and development of the loss function from the utility theory. It also discusses the Bayes estimators and Bayes predictors under different distribution. Risk, Types of risk and choice of a sample size under posterior Bayes risk is part of the content.

Contents

1. Utility theory; The utility of money
2. Rewards
3. Consequences
4. The loss functions
5. Development of the loss function from the utility theory
6. Certain standard loss functions for inference
7. Predictive problems
8. Bayes estimators
9. Bayes predictors
10. Bayesian hypothesis testing under the different loss functions.
11. Decision function
12. Multivariate loss functions with Bayesian estimation.

13. Risk; Types of risk
14. Choice of a sample size under posterior Bayes risk.

Recommended Texts

1. Robert, C. P. (2007). *The bayesian choice: A decision theoretic motivation* (2nd ed.). Berlin: Springer.
2. Berger, J.O. (1985). *Statistical Decision Theory and Bayesian Analysis.* Springer-Verlag: New York.

Suggested Readings

1. West, M. and Harrison, J. (1997). *Bayesian Forecasting and Dynamic Models*. (2nd ed.), Springer-Verlag, New York.
2. Hagan A. (1994). *Kendall's Advanced Theory of Statistics,* (V2B) Bayesian Inference. University Press: Cambridge.
3. Black-well and Grishick, M. A. (1996). *Theory of Games and Statistics Decisions*. New York: John Wiley & Sons.

STAT-7130 Advanced Operations Research 3(3+0)

Operational Research is the application of scientific methods to the study of complex organizational problems. It is concerned with applying advanced analytical methods to make effective decisions in strategic planning or operational planning, and build more productive systems. This includes all key stages of solving real-world problems. Operational researchers and statisticians play a fundamental role in the modern world. Operations Research (OR) is a discipline that helps to make better decisions in complex scenarios by the application of a set of advanced analytical methods. Research by providing quality and effective educational programs to achieve the ambitions of the development plans of the society, with continued efforts at improving these programs and maintaining the quality of scientific research. Prescribed course covers the knowledge related to Statistics in the concern of advanced operations research. Course aimed at special techniques based on maximal flow model, PERT and critical path method. Course also enlightens the quadratic programming, wolfe's method and its applications in different fields of marketing. The course is designed to fulfill the needs of society in the fields of Statistics and Operations and to understand different application areas of operations research like separable convex programming, network analysis and non-linear programming techniques.

Contents

1. Linear programming: simplex algorithm
2. Sensitivity analysis, duality theory.
3. Network analysis: shortest route problem, minimal spanning tree algorithm
4. Maximal flow model
5. PERT, critical path method (CPM)
6. Integer Programming: the branch and bound technique, functions with N possible values.
7. Non-linear programming techniques.
8. Quadratic programming
9. Wolfe's method
10. Beale's method, separable convex programming

11. Piece-wise linear programming.
12. Queuing theory
13. Sequencing.
14. Inventory management
15. Inventory control and techniques
16. Some advanced topics in programming.

Recommended Texts

1. Taha, H. A. (2002). *Operations Research*. London: Prentice Hall.
2. Krajewski, L. J. & Ritzman, L.P. (2001). *Operations management: strategy and analysis*. London: Prentice Hall.

Suggested Readings

1. Bhatti, S. A. & Bhatti, N. A. (1998). *Operations research, an introduction*. Publisher: A-one Publisher.
2. Hillier, F., & Lieberman, G. (1998). *Introduction to operations research*. London: McMillan.

STAT-7131 Numerical Analysis and Stochastic Simulation 3(3+0)

To explore complex systems, physicists, engineers, financiers and mathematicians require computational methods since mathematical models are only rarely solvable algebraically. Numerical methods, based upon sound computational mathematics, are the basic algorithms underpinning computer predictions in modern systems science. This course is designed for the students of M.Phil. in Statistics. The field of advanced simulation contains powerful tools and techniques to study stochastic models and other objects which defy a direct mathematical analysis. This course gives a broad treatment of the important aspects of stochastic simulation and its applications to e.g. queuing, reliability, manufacturing, risk analysis, and financial models. Aside from the fundamental mathematical interests, this course is thus also recommended for students wishing to make a career in business, finance, operations research, etc. At the end of the course students will be able to demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. Apply numerical methods to obtain approximate solutions to mathematical problems. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations. Analyze and evaluate the accuracy of common numerical methods.

Contents

1. Error analysis
2. Bazier and B Spline curves.
3. Guassian Quadrature
4. Adaptive integrators,
5. Multiple integration.
6. Cubic splines, Boundary value problem.
7. Numerical solution of partial differential equations
8. Approximation of function.

9. Stochastic simulation
10. Generating uniform random variables
11. Partial and general methods for non-uniform random variables
12. Testing random numbers.
13. Building simulation models

Recommended Texts

3. Toral, R. & Colet, P. (2014). *Stochastic numerical methods: An introduction for students and scientists.* New York: John Wiley & Sons.
4. Ross, S. M. (2002). *Simulation* (3rd ed.). Academic Press
5. Crawley, M. J. (2012). *The R book* (2nd ed.). New York: John Wiley & Sons.

Suggested Readings

1. Velten, K. (2009). *Mathematical modeling and simulation.* New York: John Wiley & Sons.
2. Vasishth, S. & Bore, M. (2010). *The foundations of statistics: A simulation-based approach.* USA: Springer.
3. Morgan, B. J. T. (1984). *Elements of simulation*. London: Chapman and Hall.

STAT-7132 Mixture Distributions 3(3+0)

A mixture distribution is the probability distribution of a random variable that is derived from a collection of others random variables as follows first a random variable is selected by chance from the collection or according to given probabilities of selection and then the value of the selected random variable is realized. Mixture distribution is a useful way to show how variables can be differentially distributed. Mixture distribution is able to capture a wide variety of complex distribution, these distributions are particularly applicable to situations when the quantity is determined by two stage experiments, 1st a mixture component is chosen and then the value is determined from the appropriate mixture component. The main objective of this course is to provide a strong mathematical and conceptual foundation in the methods of mixture distribution, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions in research. It deals with the estimation of mixing parameters: graphical methods, method of moments, maximum likelihood, Bayesian, minimum distance of distribution functions, minimum distance of transforms and numerical decomposition of mixtures. It also discusses modality: structure and assessment, sequential problems and procedures: unsupervised learning problems. Mixing and component parameters for dynamic linear models are part of the contents.

Contents

1. Statistical Applications, Mathematical aspects of mixture distributions.
2. Identifiability
3. Multimodality
4. Negative mixing weights
5. General properties of distributions.
6. Estimating mixing parameters
7. Graphical methods
8. Method of moments

9. Maximum likelihood
10. Bayesian, minimum distance of distribution functions, minimum distance of transforms and numerical decomposition of mixtures.
11. Determining number of components of a mixture. Informal techniques, formal techniques for special cases and general formal techniques.
12. Modality: structure and assessment

Recommended Texts

1. Geoffrey, J. M. & David, P. (2001). *Finite mixture models.* New York: John Wiley & Sons.
2. Bruce, L. (1995). *Mixtures models: Theory, geometry and applications.* Institute of Mathematical Statistics.

Suggested Readings

1. Ferguson, T.S. (1967). *Mathematical statistics: A decision theoretic approach*. Academic Press.
2. Titterington, D. M., Smith, A. F. H. & Markov, U. E. (1986). *Statistical analysis of finite mixture distributions*. New York: John Wiley & Sons.
3. Everitt, B. S. & Hand, D. J. (1981). *Finite mixture distributions*. London: Chapman & Hall.

STAT-7133 Mathematical Demography 3(3+0)

Demography is the study of statistics such as births, death, income or the incident of disease which illustrates the changing structure of the human population. Demography is defined as the composition of a particular human population. Mathematical demography is the subfield of demography that is concerned with developing and refining measures and methods for studying population compositions and change. Sample data is known commonly used by demographer and statistical methods are commonly used in conjunctions with mathematical methods. The main objective of this subject is to reported significant advances in methods of population analysis, conceptual and mathematical theories of demographic dynamics and behavior, and the use of these theories and methods to extend scientific knowledge and to inform policy and practice. Create awareness about population matters, environment, and supply and demand of essential commodities. The course also includes life tables, that is a table which shows for each age what the probability is that a person of that age will die. Langrage estimates projections by application of the straight line, logistic, exponential and polynomial curve are also the part of course. The course focuses on the development and applications of population growth models and estimation of age.

Contents

1. Population Growth Models, Development and Application of Lotka Integral Equation
2. Smoothing of age data by various methods,
3. Estimations of age at first marriage,
4. Child mortality
5. Adult mortality
6. Fertility rate
7. Gross reproduction rate
8. Net reproduction rate
9. Life tables

10. Construction of abridged life tables and decrement life tables,
11. Lagrange estimates
12. Projections by application of straight line, logistic
13. Exponential curves
14. Gumpertz and Polynomial curves
15. Component method
16. Path Analysis for decomposition of effect of factors affecting and dependent variable.

Recommended Texts

1. Preston, S. H., Patrick, H. & Michel, G. (2001). *Demography: Measuring and modeling population process*. Oxford: Blackwell Publishers.
2. Nathan, K. & Cawell, H. (2004). *Applied mathematical demography.* Berlin: Springer.

Suggested Readings

1. Shryok H. & Seigal J. S. (1994). *The methods and materials of demography,* (Condensed ed.). New York: US Bureau of the Census.
2. Feotal, U. N. (1954). *Infant, and early childhood mortality* (Vol. I & II). New York: UN DESA Population Division.

STAT-7134 Multilevel Modeling 3(3+0)

Multilevel models are statistical models of parameters that vary at more than one level. An example could be a model of student's performance that contains measures for individual students as well as measures for classrooms within which the students are grouped. Multilevel modeling is an approach that can be used to handle clustered or group data multilevel modeling provides a useful framework for thinking about problems with this type of hierarchical structure. Multilevel recognize the existence of such data hierarchies by allowing for residual components at each level of the hierarchy. Course also signifies the relative efficiency of multilevel modeling strategies instead of traditional regression analysis and estimation of two and multilevel parameters and the brief interpretation of the parameters. Course imparts the advance knowledge of the effect of sample size on the properties of the multilevel model estimates and applications of multilevel models to overcome the real life applications. The course focuses on the scope of multilevel models in various fields and estimation of parameters in multilevel models. Sample size estimation for multilevel models and effect of sample size on the properties of multilevel model estimates are also the part of the contents.

Contents

1. Introduction to multilevel modeling,
2. Scope of multilevel models in various fields
3. Traditional regression models
4. Comparison of multilevel models with traditional regression models
5. Two level random effect multilevel models and interpretation of parameters
6. Techniques of estimations
7. Estimation of parameters
8. Estimation of parameters in multilevel models
9. Intra-class correlation
10. Concept of intra-class correlation in multilevel (ML) models

11. Fitting multilevel models
12. Criteria for the goodness of the ML models
13. Sample size estimation for ML models

Recommended Texts

1. Anthony, S., & Stephes, W. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). California: Boston: Sage publication Inc.
2. Goldstein, H. (2010). *Multilevel statistical models* (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Goldstein, H. (1995). *Multilevel statistical models* (2nd ed.). New York: John Wiley & Sons.
2. Hox, J. J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). London: Routledge Publisher.
3. Kreft, I., & Dc Leeuus, J. (1998). *Introducing multilevel modeling thousand oaks*. California: Sage Publication Inc.

URCS-5121 Introduction to Statistics 3(3+0)

This is the general Statistics course designed for under graduate programs of arts and social sciences. Statistics is an integral part of arts and social science research. We live in a world where there is no shortage of numerical data and there is increasing demand for people who know how to make sense of it independent of the field of work. The goal of this course is to turn the students into one of such category. In this course, students will learn the basics of descriptive and inferential statistics and the most commonly used statistical techniques found in arts and social science research. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student. While more focus will be given on the statistical analysis with the help of some statistical softwares SPSS, Excel etc. Moreover, the teacher will also focus on interpretation of statistical data results which are obtained from the statistical softwares. So these activities will improve the analytical and research activities of arts and social science students.

Contents

1. Introduction to Statistics: Descriptive and Inferential Statistics, Limitations of Statistics, Scope of Statistics, Variable, Data, Types of Variable and Data, Scales of Measurements.
2. Display of Data: Tabulation of Data, Graphical Display, Histogram, Bar Charts, Pie Chart, Stem and Leaf Plots.
3. Measures of Central Tendency: Mean Median, Mode, Box Plot, and Application in Real Life.
4. Measures of Dispersion: Range, Quartile Deviation, Mean Deviation, Variance and Standard Deviation, Coefficient of Variation, Z-score and their Application.
5. Normal Distribution: Normal Distribution and its Application,
6. Sampling and Sampling Distribution.
7. Hypothesis Testing: z test, t-test, Chi-square test
8. Regression Analysis: Simple Linear Regression, Multiple Regression.

9. Correlation Analysis: Simple correlation, multiple correlation, partial correlation, partial correlation.
10. Test of independence between qualitative variables
11. All the observational analysis will be carried out using MS Excel and SPSS.

Recommended Texts

1. Weiss, N. A. (2017). *Introductory statistics* (10th ed.). England: Pearson Education.
2. Mann, P.S. (2016). *Introductory statistics* (9th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Ross, S. M. (2010). *Introductory statistics* (3rd ed.). New York: Academic Press.
2. Dunn, D.S. (2001). *Statistics and data analysis for the behavioral sciences.* New York: McGraw Hill
3. Chaudhry, S. M. & Kamal, S. (2010). *Introduction to statistical theory part I &II*. Pakistan: Ilmi Kitab Khana.

STAT-5122 Statistics for Economics-I 3(3+0)

This course is designed for under graduate programs of Economics. Statistical analysis is a basic requirement in order to analyze the phenomenon related to all sectors. This course aims to produce skills related to descriptive as well as time series analysis. Use of descriptive and time series analysis has vital importance to analyze and decision-making theories related to economics and business statistics. This course also covers the correlation and regression concepts and applications in economics and business. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student. While more focus will be given on the statistical analysis with the help of some statistical softwares SPSS, Excel etc. Moreover, the teacher will also focus on interpretation of statistical data results which are obtained from the statistical softwares. So these activities will improve the analytical and research activities of arts and social science students.

Contents

1. What is Statistics?:Definition of Statistics, applications of statistics in economics, Population, sample Descriptive and inferential Statistics, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Measurement scales, Editing of Data. Exercises.
2. Presentation of Data: Introduction, basic principles of classification and Tabulation, Constructing of a frequency distribution, Relative and Cumulative frequency distribution, Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram, Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Historigram, Ogive for Discrete Variable. Types of frequency curves. Exercises.
3. Measures of Central Tendency: Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode, Relative Merits and Demerits of various

Averages. properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.

Recommended Texts

1. Moy, R.L., Chen, L-S., & Kao, L.J. (2015). *Study guide for statistics for business and financial economics*. USA: Springer.
2. Anderson, D. R., Sweeney, D.J. & Williams, T. A. (2011). *Essentials of statistics for business and economics* (6th ed.). USA: South-Western Cengage Learning.

Suggested Readings

1. Muhammad, F. (2005). *Statistical methods and data analysis* Pakistan: KitabMarkaz, Bhawana Bazar.
2. Walpole, R. E. (1982). *Introduction to statistics* (3rd ed.). New York: Macmillan Publishing Co.
3. Chaudhry, S.M. & Mamal, S. (1998). *Introduction to statistical theory.* Lahore: Ilmi Kutab Khana.

STAT-5123 Statistics for Economics-II 3(3+0)

This course is designed for under graduate programs of Economics. Statistical analysis is a basic requirement in order to analyze the phenomenon related to all sectors. This course aims to produce skills related to sampling, testing of hypothesis. Inferential statistics has vital importance to analyze and decision-making theories related to economics and business statistics. This course also covers the tests of association of qualitative variables and applications in economics and business. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student. While more focus will be given on the statistical analysis with the help of some statistical softwares SPSS, Excel etc. Moreover, the teacher will also focus on interpretation of statistical data results which are obtained from the statistical softwares. So these activities will improve the analytical and research activities of arts and social science students.

Contents

1. Sampling and Sampling Distributions: Introduction, sample design and sampling frame, bias, sampling and non sampling errors, sampling with and without replacement, probability and non-probability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions. Exercises.
2. Hypothesis Testing: Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, acceptance and rejection regions, general procedure for testing of hypothesis. Exercises.
3. Testing of Hypothesis- Single Population: Introduction, Testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, Exercises
4. Testing of Hypotheses-Two or more Populations: Introduction, Testing of hypothesis and confidence intervals about the difference of population means and proportions for small and large samples, Analysis of Variance and ANOVA Table. Exercises
5. Testing of Hypothesis-Independence of Attributes: Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes. Exercises.

Recommended Texts

1. Moy, R.L., Chen, L-S., & Kao, L.J. (2015). *Study guide for statistics for business and financial economics*. USA: Springer.
2. Anderson, D. R., Sweeney, D.J. & Williams, T. A. (2011). *Essentials of statistics for business and economics* (6th ed.). USA: South-Western Cengage Learning.

Suggested Readings

1. Muhammad, F. (2005). *Statistical methods and data analysis* Pakistan: KitabMarkaz, Bhawana Bazar.
2. Walpole, R. E. (1982). *Introduction to statistics* (3rd ed.). New York: Macmillan Publishing Co.
3. Chaudhry, S.M. & Mamal, S. (1998). *Introduction to statistical theory*. Lahore: Ilmi Kutab Khana.

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STAT-5124 Introduction to Statistics 2(2+0)

This course is designed for under-graduate level students of chemistry department. Statistical analysis is a basic requirement in order to analyze the phenomenon related to chemical sciences. This course aims to provide statistical tools to analyze the chemical data foe better interpretations. Use of graphical, descriptive, inferential statistics and regression has vital importance to analyze and decision-making theories related to chemical sciences. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student. While more focus will be given on the statistical analysis with the help of some statistical software's SPSS, Excel etc. Moreover, the teacher will also focus on interpretation of statistical data results which are obtained from the statistical software's. So, these activities will improve the analytical and research activities of arts and social science students.

Contents

1. Introduction to Statistics: Descriptive and Inferential Statistics, Scope of Statistics related to chemical sciences, Variable, Data, Types of Variable and Data, Precision, Error, Accuracy.
2. Display of Data: Tabulation of Data, Graphical Display, Histogram, Bar Charts, Pie Chart, Stem and Leaf Plots.
3. Measures of Central Tendency: Mean Median, Mode, Box Plot, and Applications in chemistry.
4. Measures of Dispersion: Range, Variance and Standard Deviation, Coefficient of Variation, Z-score and their Applications.
5. Probability and Probability Distributions : Binomial, Poisson and Normal Distribution and their Applications
6. Testing of Hypothesis: Univeriate, Bivariate testing and Multiple sample comparison
7. Correlation and Regression Analysis: Simple and multiple Linear Regression, Multiple Regression, Fitness of Model.
8. Data analysis using MS Excel and Minitab.

Recommended Texts

1. Shardt,Y.A.W. (2015). *Statistics for chemical & process engineers: A modern approach*. Germany: Springer.
2. Walpole, R. E. (1982). *Introduction to statistics* (3rd ed.). New York: Macmillan Publishing Co.
3. Chaudhry, S.M. & Mamal, S. (1998). *Introduction to statistical theory.* Lahore: Ilmi Kutab Khana.

Suggested Readings

1. Spiegel, M.R., Schiller, J.L. & Sirinivasan, R.L. (2000). Probability and statistics (2nd ed.). New York: McGraw Hill.
2. Clark, G.M & Cooke, D.(1998). A Basic course in statistics (4th ed.). London: Arnold.
3. Weiss, N. A. (2017). *Introductory statistics* (10th ed.). England: Pearson Education.

STAT-5125 Theory of Error Analysis 3(3+0)

This course is designed for under-graduate level of Physics students. Statistical analysis is a basic requirement in order to analyze the phenomenon related to all sectors. This course aims to produce skills related to descriptive as well as inferential statistical analysis of the theory of error analysis. This also deals with correlation and fitting of least square methods of error propagation. This course enables the students to improve their computational skills which support further in their research activities. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student. While more focus will be given on the statistical analysis with the help of some statistical software's SPSS, Excel etc. Moreover, the teacher will also focus on interpretation of statistical data results which are obtained from the statistical software's. So, these activities will improve the analytical and research activities of arts and social science students.

Contents

1. Preliminary Description of Error Analysis, How to Report and Use Uncertainties, Discrepancy, Comparison of Measured and Accepted Values, Comparison of Two Measured Numbers, Checking Relationships with a Graph, Significant Figures and Fractional Uncertainties, Multiplying Two Measured Numbers,
2. Propagation of Uncertainties, The Square-Root Rule, Independent Uncertainties in a Sum, Arbitrary Functions of One Variable, General Formula for Error Propagation, Statistical Analysis of Random Uncertainties, Random and Systematic Errors,
3. The Mean and Standard Deviation, Standard Deviation of the Mean, probability concepts, Probabilities in Dice Throwing,
4. The Normal Distribution and its properties , Binomial Distribution and its Properties, The Poisson Distribution and its Properties, The Chi-Squared Test for a Distribution, Degrees of Freedom and Reduced Chi Squared, Probabilities for Chi Squared, Limiting Distributions, Justification of the Mean as Best Estimate, Justification of Addition in Quadrature, , Acceptability of a Measured Answer, Rejection of Data, Chauvenet's Criterion, Weighted Averages,
5. Covariance and Correlation, Covariance in Error Propagation, Coefficient of Linear Correlation, Least-Squares Fitting, Calculation of the Constants A and B and their uncertainty, Least-Squares Fits to Other Curves.

Recommended Texts

1. Hughes, I. & Hase, T., (2010). *Measurements and their uncertainties: A practical guide to modern error analysis* **(**1st ed.) Oxford University Press.
2. Bevington, P. (2003). Data reduction and error analysis for physical science (3rd ed.). McGraw Hill.

Suggested Readings

1 Roe, B., P. (1992). *Probability and statistics in experimental physics*. USA: Springer.
2 Taylor,J. (1982). *An introduction to error analysis.* California: University Science Books.

STAT-5126 Statistics for Agricultural Sciences (3+0)

This course is designed for undergraduate programs of agriculture sciences. The objective of this course is to impart basic and applied knowledge about statistics for collection, presentation, analysis and interpretations of data related to agriculture issues. After completing this course agriculture students will be able to understand the general concepts of basic statistics, to conduct agriculture surveys, to understand design of experiments, and other statistical tools. These statistical concepts are further will be helpful to complete a research related to agriculture sciences. Moreover, over students will also learn some statistical software's such as Minitab, SPSS and Design Expert to improve their computational and analytical skills. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student. While more focus will be given on the statistical analysis with the help of some statistical software's SPSS, Excel etc. Moreover, the teacher will also focus on interpretation of statistical data results which are obtained from the statistical software's. So, these activities will improve the analytical and research activities of arts and social science students.

Contents

1. Definition and importance of Statistics in Agriculture.
2. Data, Different types of data and variables
3. Classification and Tabulation of data.
4. Frequency distribution, Graphical representation of data.
5. Measure of Central tendency and Measure of Dispersion. Calculation of averages, Range, variance, Standard deviation and coefficient of variation.
6. Regression and Correlation Analysis: Simple and Multiple regression, correlation cases.
7. Sampling and its types: Probability and non-Probability Sampling, Simple random sampling, stratified random sampling, Systematic sampling, Sampling and non-sampling error
8. Sampling distribution of mean and difference between two means.
9. Inference Theory: Estimation and testing of hypothesis, Type-I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test.
10. Test of association of attributes using χ^2 (chi-square) Testing hypothesis about variance.
11. ANOVA and its assumptions, One-way ANOVA, Two-way ANOVA.

Recommended Texts

1. Muhammad, F. (2000). *Statistical methods and data analysis*. Pakistan: Ilmi Kitab Khana.
2. Rao, G. N. (2007). *Statistics for agricultural sciences* (2nd ed.). BS Publication.

Suggested Readings

1. Lawal, B. (2014). *Applied statistical methods in agriculture, health and life sciences*. USA: Springer.
2. Sahu, P. K. (2016). *Applied statistics for agriculture, veterinary, fishery, dairy and allied fields.* USA: Springer.
3. Crawshaw, J. & Chambers, J. A. (1994). *Concise course in A. level statistic with world examples.* USA: Springer.

STAT-5127 **Business Statistics** **3 (3+0)**

This course designed for under graduate programs of business administration and commerce education. Statistics is how we gather, analyze, present and interpret data. In the business community, managers must make decisions based on what will happen to such things as demand, costs, and profits. These decisions are an effort to shape the future of the organization. Business Statistics refers to the application of statistical tools and techniques to business and managerial problems for the purpose of decision making. This course will introduce you to statistical analysis and how it relates to business. The course will enable the students to understand the basic concepts of statistics in descriptive form and learn the quantitative techniques to solve complex business problems. This course will also enable the students to find the reasons of business issues with the help regression analysis. This course is a pre-requisite for inferential statistics course. This course will also covers the knowledge of some statistical softwares such as SPSS, Minitab etc. This computational learning will improve the analytical skills of students

Contents

1. Introduction: Statistics and its Importance, Types of statistics, variables and its types, data its types, scale of measurements
2. Graphical representation of data
3. Measures of central tendency
4. Measures of variability
5. Moments and skewness
6. Simple Linear Regression
7. Multiple regression
8. Correlation: Simple, Multiple, Partial and Rank correlation
9. Index numbers
10. Time series analysis
11. Probability
12. Discrete Probability Distributions
13. Continuous Probability Distributions
14. Normal Probability Distribution
15. Computer applications in Statistics

Recommended Text

1. Wathen, S., Marchal, W. & Lind, D. (2017). *Statistical techniques in business and economics*. New York: McGraw-Hill
2. Sharma, J. K. (2012). *Business statistics*. India: Pearson Education India.

Suggested Reading

1. Berenson, M., Levine, D., Szabat, K. A. & Krehbiel, T. C. (2012). *Basic business statistics: Concepts and applications*. AU: Pearson Education.
2. Black, K. (2009). *Business statistics: Contemporary decision making*. UK: John Wiley & Sons.
3. Wegner, T. (2010). *Applied business statistics: Methods and Excel-based applications*. Juta and Company Ltd.

STAT-5128 **Statistical Inference** **3(3+0)**

This course is based on different statistical concepts and techniques that are useful in business management. The goal is to provide students, to the community with high skills to play the major role in science and technology by statistical ideas and methods. This course enables the students, to develop a proper understanding of Statistical applications in business administration and commerce. The course explores the basic concepts of statistical theory and its applications for decision-making in business and solving business management problems. Students are introduced to the fundamental concepts involved in using sample data to make inferences about populations. Included are the study of estimation and hypothesis testing, finite probability, probability distributions, statistical inferences from large and small samples, multiple regression, and multiple correlation. A particular emphasis is placed on developing the ability to interpret the numerical information that forms the basis of decision-making in business. Most of the examples are drawn from a variety of business and commerce applications. It examines aspects of business and marketing with regards to basic statistical analysis. Students will be provided with the theoretical concepts, tools and methods of statistics as well as the opportunity to work through example problems.

Contents

1. Inferential Statistics and its importance
2. Sampling Theory
3. Estimation Theory.
4. Testing of Hypothesis: One sample Tests, Two Sample Tests, Multiple sample tests
5. Testing Regression and correlation coefficients
6. Analysis of Variance.
7. The Chi-Square Distribution,
8. Chi-square test for single and multiple population variance testing
9. Testing of independence
10. Goodness of fit test
11. Contingency table
12. F-test for two variances
13. Computer applications in Statistics

Recommended Texts

1. Levin, R. I., & Rubin, D. S. (2011). *Statistics for management* (7th ed.). India: Pearson Education.
2. Anderson, D. R., Sweeney, D. J., & Williams, T. A. (2010). *Essentials of statistics for business and economics* (6th ed.). Cengage.

Suggested Readings

1. Berenson, M. L., Levine, D. M., & Krehbiel, T. C. (2011). *Basic business statistics: Concepts and applications* (12th ed.). India: Pearson Education.
2. Özdemir, D. (2016). *Applied statistics for economics and business* (2nd ed.). USA: Springer I.
3. Barrow, M. (2006). *Statistics for economics, accounting and business studies* (4th ed.). India: Pearson Education.

STAT-5121 **Biostatistics** **3(3+0)**

This course is designed for under graduate programs of science and medical disciplines. Biostatistics is the application of statistical methods (summarizing data and drawing valid inferences based on limited information) to biological systems, more particularly, to humans and their health problems. This course deals with statistical concepts and terminology and basic analytic techniques. The purpose of the course is to give students an introduction to the discipline, an appreciation of a statistical perspective on information arising from the health arena and basic critical appraisal skills to assess the quality of research evidence. This course is also explores the importance of risk factors and effective decision making strategies. The course covers several statistical tools for analyzing biological data through statistical methods with practical applications. This course will also focus on the knowledge of statistical softwares such as Minitab, R etc. for the analysis of biological data. This course will help the students to improve their analytical skills and support for further research.

Contents

1. Definition of Biostatistics, and its importance
2. The type of variables and observations in biological, Health and medical sciences
3. Uniqueness in terms of behavior of variables their domain, and units.
4. Categorical. Numerical data, Censored data.
5. Population, Target populations and samples.
6. Role of sampling in biostatistics
7. Size of samples of various types of studies.
8. Proportions, rates and ratios
9. Incidence, prevalence and odds.
10. Measures of central tendency: Mean, Median, Mode
11. Measures of dispersion: Variance, Standard deviation, CV, MD
12. Distributional behavior of biological variables (Binomial, Poisson and Normal).
13. Probit Models
14. Logit transformations and their analysis,
15. Confidence interval
16. Hypothesis testing: Z-test, t-test, F-test and Chi-square test
17. Analysis of variance
18. Regression Analysis

Recommenced Texts

1. Zar, J. (2000). *Biostatistical analysis* (5^{th} ed.). Ne York: John Wiley and Sons.
2. Shoukri, M.M , & Pause, C.C. (1998). *Statistical Methods for Health Sciences* (2^{nd} ed.). Florida: CRC press.

Suggested Readings

1. Daniel, W.W. (2010). *Biostatistics: A foundation for the health sciences* (6^{th} ed.). New York: John Wiley & Sons.
2. Diggle, P., Diggle, P. J., Heagerty, P., Liang, K. Y., Heagerty, P. J., & Zeger, S. (2002). *Analysis of longitudinal data*. Oxford: Oxford University Press.

STAT-6231 **Biostatistics** **3 (3+0)**

This course is designed for graduate programs of sciences. Biostatistics provides an introduction to selected important topics in biostatistical concepts and reasoning. This course represents an introduction to the field and provides a survey of data and data types. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types. While there are some formulae and computational elements to the course, the emphasis is on interpretation and concepts. Some statistical software will also be part of this course to analyze biostatistical data and improve the analytical skills of the students

Contents

1. Introduction objectives and scope: i. Definition ii. Characteristics iii. Importance and limit iv. Population and samples
2. Frequency distribution: i. Variable types ii. Formation of frequency table from raw data iii. Summation, notation and statistical inference iv. Data transformation.
3. Measures of central tendencies and dispersion: i. Arithmetic Mean ii. Median iii. Mode iv. Range v. Variance vi. Standard deviation vii. Standard error of the mean viii. Mean deviation.
4. Organizing and describing data (Standard distributions): i. Random sampling and the binomial distribution ii. Probability, Types of Probabilities, Random variables, combining probabilities, Probability distributions Binomial distributions. iii. Poisson and normal distributions, properties and applications.
5. Basic experimental design: i. Concept and design ii. Principles of experiments iii. Observational studies iv. Planning of experiments v. Replication and randomization vi. Field plot technique vii. Layout and analysis of completely randomized design viii. Randomized complete block design ix. Latin square x. Factorial design xi. Treatment comparison
6. Tests of significance: i. T-test: (Basic idea, confidence limits of means, significant difference of means. ii. Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table). iii. F-test: Introduction and application in analysis of variance. Iv. LSD test, Duncan's New Multiple Range test (for comparison of individual means). Bonferroni test

Recommenced Texts

1. Zar, J. (2000). *Biostatistical analysis* (5^{th} ed.). New York: John Wiley & Sons.
2. Shoukri, M.M. & Pause, C.C. (1998). *Statistical methods for health sciences* (2^{nd} ed.). Florida: CRC press.

Suggested Readings

1. Daniel, W.W. (2010). *Biostatistics: A foundation for the health Sciences* (6^{th} ed.). New York: John Wiley & Sons.
2. Diggle, J.P. Liang, Kung Y. & Zeger, S. L. (1996). *Analysis of longitudinnal data.* Clarendon press.
3. Dunn, G. & Everit, B. (1995). *Clinical biostatistics*. London: Edward Arnold.

STAT-7151 Statistical Methods for Agricultural Research-I 3(3+0)

This course designed for MSc (Hons)/MPhil programs of agriculture sciences. This course provides the applied statistics background for survey and experimental work in Agriculture. Case studies and critical examples are used to work through commonly experienced research problems (from sampling designs to the ethical consideration) and to explain how they may be approached, solved or prevented with statistical means. The importance of statistical science in agriculture is obvious, where the collection, analysis and interpretation of numerical data are concerned. Statistical principles apply in all areas of experimental work and they have a very important role in agricultural experiments. Statistics plays an important role in experimentation. While many scientific problems could be solved by different statistical procedures. Furthermore, some statistical softwares knowledge will be provided to the students to improve their analytical skills. These activities are further supports the student's research.

Contents

1. Importance of Statistics in agriculture research.
2. Selection of statistical tools based on scale of measurements.
3. Analysis of Count and Frequency data.
4. Measures of central tendency and dispersion.
5. Some concepts of hypothesis testing. T, Z, Chi-square and F tests. Contingency Tables.
6. Diversity Indices.
7. Concept of ANOVA and its types.
8. Correlation Analysis: Simple correlation, multiple correlation, and Partial correlation.
9. Regression Analysis: Simple and multiple regression.
10. Generalized linear models: logistic regression, Poisson regression, Gamma regression, Inverse Gaussian regression.
11. Non-linear regression.
12. Dose Response Curves.

Recommended Texts

1. Montgomery, D. C. (2017). *Design and analysis of experiments* (9th ed.). New York: John Wiley & Sons.
2. Rao, G. N. (2007). *Statistics for agricultural sciences* (2nd ed.). Hoboken: BS Publication.

Suggested Readings

1. Lawal, B. (2014). *Applied statistical methods in agriculture, health and life sciences*. USA: Springer.
2. Sahu, P. K. (2016). *Applied statistics for agriculture, veterinary, fishery, dairy and allied fields.* USA: Springer.
3. Gbur, E. E., Stroup, W. W., McCarter, K. S., Durham, S., Young, L. J., Christman, M., West, M. & Kramer, M. (2012). *Analysis of generalized linear mixed models in the agricultural and natural resources sciences*. USA: Soil Science Society of America.

STAT-8131 Statistical Methods for Agricultural Research-II 3(3+0)

This course designed for PhD programs in agriculture sciences. Modern agricultural production is characterized by some particularities and many different activities. So, it arises different problems and different nature of agricultural materials data which require different approaches to the use of statistical methods. Statistics is a discipline which mainly deals with data quantifications. Even in the case of nonnumerical data, statistical methods use transformations to change nonnumerical data to numerical data, with the aim of achieving some level of quantification to make conclusions about the matter of interest. Many data in agriculture are of numerical character which are accompanied with the existence of the variability of data. Statistics can be used as a tool for agricultural research. For these reasons "statistics can, however, help the research worker to design his experiments and to evaluate objectively the resulting numerical data". So this course is mainly focus on advanced design of experiment tools which will be helpful to find out the factors of output related to agriculture experiments. Moreover, students will also learn some statistical softwares like Minitab, R, Design Expert etc. to analyze their experimental data. The knowledge of statistical software will improve the computational and analytical skills of the students.

Contents

1. Basic principles of experimental design.
2. Layout analysis of CRD, RCBD, Latin Square Designs.
3. Estimation of Missing Observations in RCBD and Latin Square Design.
4. BIBD, PBIBD, Split plot Designs and its variations.
5. Multiple comparison tests.
6. Effect of violation of assumptions of underlying ANOVA.
7. Factorial Experiments, 2^n, 3^n… P^n.
8. Mixed levels factorial experiments.
9. Confounding and its types. Fractional replication. Application and construction of contrasts.
10. Response surface methodology.
11. Introduction of multivariate analysis.
12. Principle component analysis
13. Factor analysis
14. Cluster Analysis
15. Correspondence analysis.

Recommended Texts

1. Muhammad, F. (2000). *Statistical methods and data analysis*. Pakistan: Ilmi Kitab Khana.
2. Montgomery, D. C. (2017). *Design and analysis of experiments* (9^{th} ed.). New York: John Wiley & Sons.

Suggested Readings

1. Box, G. E. P., W. G. & Hunter, J. S. (1978). *Statistics for experimenters.* New York: John Wiley & Sons.
2. Dillon, W. R. & Goldstein, M. (1984). *Multivariate analysis: Methods and applications. New York:* John Wiley & Sons.
3. Cox, D. R. (2000). *The theory of the design of experiments*. London: Chapman and Hall.

STAT-7152 Statistical Methods for Social Research 3(3+0)

This course is designed for the MSc (Hons) and MPhil program of agriculture-extensions. This course will cover the social research tools because agriculture extension program try measures qualitative factors in terms of agriculture surveys which are related to qualitative behaviors of farmers. The course will present a foundation for when, how, and why different statistical techniques are utilized to answer social research questions. Course content will include descriptive and inferential statistics, as well as measurements of association between variables. To impart the knowledge of statistical software used to analyze the data. To improve the students' skills for selecting appropriate tools for analysis of their research data. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student.

Contents

1. Basics of Statistics, Importance of Statistics in Social Research
2. Scale of measurements
3. Graphical representation of data
4. Some descriptive measures: Mean, median, mode, Variance, Standard deviation, CV, Quartiles, Quartile Deviation
5. Sampling and its types
6. Testing of Hypothesis about mean with Normal, t and F Distribution
7. Basic principles of experimental design
8. CRD, RCBD, and Latin Square Design used in educational research
9. Non-parametric Methods for testing of hypotheses

Recommended Texts

1. Rao, G.N. (2007). *Statistics for agricultural sciences* (2nd ed.). Hyderabad: BS Publication
2. Steel, R.G.D., Torrie, J.H. & Dicky, D.A. (2009). Principles and procedures of statistics: A biometerical approach (3rd ed.). USA: McGraw Hill.
3. Dillon, W. R. & Goldstein, M. (1984). Multivariate analysis: Methods and applications. New York: John Wiley & Sons.

Recommended Readings

1. Gomez. K.A. & Gomez A.A. (1976). *Statistical procedures for agricultural research*. The international Rice Research Institute.
2. Johnson, R.A. & Wichern, D.W. (2007). *Applied multivariate statistical analysis* (6th ed.). Pearson Education International.
3. Agresti. A. (2002). An Introduction to categorical data analysis. New York: John Wiley & Sons.

STAT-8132 Advanced Statistical Methods for Social Research 3(3+0)

This course is designed for PhD in Agriculture Extensions and provides a thorough grounding in advanced quantitative methods such as regression and multivariate analysis, taught within an applied social science framework. It covers research methods, design and statistical analysis for social science research questions. At the end of this course students will be able to impart the knowledge of statistical softwares such as SPSS, Minitab and R used to analyze the data, and to improve the students' skills for selecting appropriate tools for analysis of their research data. The training of statistical softwares will improve analytical skills of students to complete their research activities. The course is designed to give the students an in depth understanding of how these statistical techniques work but minimizing the mathematical burden on the student.

Contents

1. Basics of Statistics, Importance of Statistics in Social Research
2. Scale of measurements
3. Descriptive Statistics
4. Sampling and its types
5. Selecting an appropriate sampling technique and sample size
6. Correlation Analysis: Simple correlation, Multiple Correlation, Partial Correlation, Rank Correlation
7. Regression Analysis. Linear model, Generalized linear model, nonlinear model
8. Analysis of contingency tables with ordered variables
9. kendall's coefficient of concordance
10. Nonparametric methods in social sciences
11. Introduction to Multivariate analysis
12. Hotelling T^2
13. Principal Component analysis
14. Factor analysis
15. Canonical correlation and cluster analysis
16. Data analysis through different statistical softwares

Recommended Texts

1. Rao, G.N. (2007). Statistics for agricultural sciences (2^{nd} ed.). India: BS Publication,
2. Cohen, J., Cohen, P., West, S.G. & Aiken, L.S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. London: Routledge.

Suggested Readings

1. Hinton, P.R. (2013). *Statistics explained: A guide for social sciences students*. London: Routledge.
2. Howell, D. (2012). *Statistical methods for psychology*. Boston: Cengage Learning.
3. Gravetter, F. & Wallnau, L. (2013). *Essentials of statistics for the behavioral sciences.* London: Cengage Learning.