CURRICULUM FOR TWO-YEAR ASSOCIATE DEGREE / BS (4-YEAR) IN STATISTICS

2023 AND ONWARDS

DEPARTMENT OF STATISTICS

UNIVERSITY OF MALAKAND

www.uom.edu.pk

Incharge
Department of Statistics
University of Malakand

Assistant Registrar
(Academics)
University of Malakand 05-Dec-2023

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Scheme of Studies for 2-Year Associate Degree/BS (4-Year) in Statistics

	Codes	Name of Subject	Cred. Hrs.
		Semester I	
Gen-Ed-2	PHYS 111/ GS 117	Basic Physics/ General Science	3
Gen-Ed-3	ECON 111/ SOC 116	Fundamental of Economics/ Introduction to Sociology	2
Gen-Ed-4	ENG 101	Functional English	3
Gen-Ed-6	QR 101	Quantitative Reasoning-I (Mathematics)	3
Gen-Ed-9	CS 110	Introduction to Information and Communication Technologies	3(2+1)
Major	STAT 111	Introductory statistics	3
		Teaching of the Holy Quran with translation (non-credit)	17
		Semester II	
Gen-Ed-5	ENG 102	Introduction to Expository Writing	3
Gen-Ed: 6:	QR 102	Quantitative reasoning-II (Statistics)	3
Gen-Ed-7	ISL 112/ ETH 118	Islamic Studies (compulsory for Muslim) /Ethics (for Non-Muslim)	2
Gen-Ed-08	PSC 111	Ideology and constitution of Pakistan	2
Gen-Ed-10.	MGT 215	Entrepreneurship	2
Major	STAT 112	Introduction to Probability and Probability Distributions	3
		Teaching of the Holy Quran with translation (non-credit)	**15**
		Semester III	
Gen-Ed-01	ISL 113	سیرت رسول ﷺ اور اس کی عصری معنویت Seerah and its Contemporary Application /any course from arts and humanities for non-Muslim	2
Gen-Ed- 11	SOC 114	Civic and community Engagements	2
Major	STAT 213	Basic Statistical Inference	3
Major	STAT 215	Introduction to Regression Analysis and Experimental Design	3
Major	STAT 216	Applied Statistics	3
Major	STAT 214	Linear Algebra	3
		Teaching of the Holy Quran with translation (non-credit)	**16**
		Semester IV	
Major	STAT 220	Numerical Methods	3
Major	STAT 225	Statistical packages	3
Major	STAT 226	Statistical Quality Control	3
Major	STAT 224	Non-Parametric Methods	3
Inter-Disp-I	MATH 105	Discrete Mathematics	3

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		Teaching of the Holy Quran with translation (non-credit)	**15**
		Semester V	
Major	STAT 317	Probability & Probability Distribution-1	3
Major	STAT 318	Sampling Technique-I	3+1
Major	STAT 320	Regression Analysis	3+1
Major	STAT 321	Design and Analysis of Experiment-I	3+1
		Teaching of the Holy Quran with translation (non-credit)	**15**
		Semester VI	
Major	STAT 322	Probability and Probability Distribution-II	3
Major	STAT 323	Sampling Techniques-II	3+1
Major	STAT 324	Econometrics	3+1
Major	STAT 325	Design & Analysis of Experiment-II	3+1
Major	STAT 326	**Field Experience/Internship:**	3
		Teaching of the Holy Quran with translation (non-credit)	**18**
		Semester VII	
Major	STAT 427	Statistical Inference-1	3
Inter-Disp-II	CS 324	Artificial intelligence	3
Major	STAT 429	Research Methodology	3
Inter-Disp-III	STAT 449	Data Analysis in R	3
Inter-Disp-IV	SE 472	Machine learning	3
Major	STAT 440	Survival Analysis	3
		Teaching of the Holy Quran with translation (non-credit)	**18**
		Semester VIII	
Major	STAT 430	Population Studies	3
Major	STAT 431	Statistical Inference-II	3
Major	STAT 448	Bayesian Statistics	3
Major	STAT 428	Applied Multivariate	3+1
Major	STAT 500	Capstone Project/thesis	3
		Teaching of the Holy Quran with translation (non-credit)	**16**
		Total	**130**

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). All such courses approved by the Syndicate are available on the university website. For any query the office of the Registrar Academics may be approached for clarification/guidance.

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List of Major Courses:

Introductory statistics	STAT 111
Introduction to probability and probability distributions	STAT 112
Basic statistical inference	STAT 213
Linear algebra	STAT 214
Introduction to regression & design	STAT 215
Applied statistics	STA 216
Inferential Statistics	STAT 217
Numerical Methods	STAT 220
Official statistics	STAT 221
Bio-Statistics	STAT 222
Exploratory Data Analysis and Visualization (EDAV)	STAT 223
Non- Parametric Methods	STAT 224
Statistical packages	STAT 225
Statistical Quality Control	STAT 226
Probability & probability distribution-I	STAT 317
Sampling technique-I	STAT 318
Regression analysis	STAT 320
Design & analysis of experiment-I	STAT 321
Probability and probability distribution-ii	STAT 322
Sampling techniques-ii	STAT 323

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Econometrics	STAT 324
Design & analysis of experiment-ii	STAT 325
Statistical inference-1	STAT 427
Applied multivariate analysis	STAT 429
Population studies	STAT 430
Statistical inference-ii	STAT 431
Research project/ internship	STAT 499
Operation Research	STAT 433
Stochastic Process	STAT 434
Reliability Analysis	STAT 435
Time Series and Forecasting	STAT 436
Decision Theory	STAT 437
Robust Methods	STAT 438
Survival Analysis	STAT 440
Data Mining	STAT 442
Actuarial Statistics-I	STAT 443
Actuarial Statistics-II	STAT 444
Mathematical Models and Simulation	STAT 445
Categorical Data Analysis	STAT 446
Bayesian Statistics	STAT 448
Data Analysis in R	STAT 449

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Mechanism for field work

Statistical Fieldwork compulsory course for students in Statistics program that counts towards the degree requirements. To receive a grade and academic credits for this course, students are expected to engage in an approved off-campus internship in the Pakistan. The statistical fieldwork should provide students an opportunity to apply their statistical skills and gain practical knowledge on how statistics can be applied to solve real-world challenges.

The field experience of six to eight weeks (preferably undertaken during semester or summer break) must be graded by a faculty member in collaboration with the supervisor in the field. This is a mandatory degree award requirement of 3 credit hours for all undergraduate/equivalent degree programs.

The field work should be done in departments where data can be collected and analyzed like bureau of Statistics, Bank, Hospitals, etc. After completion of filed work, a short report should be submitted in Department. The report of field work should be evaluated by departmental semester committee, and will assign grade/marks accordingly.

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DETAILS OF THE COURSES FOR BS (4-YEARS) PROGRAM IN STATISTICS

The proposed outlines for BS (4-Years) program in Statistics are as follows:

BS Statistics (4-Years)		
INTRODUCTORY STATISTICS		
STAT 111	**Marks 100**	**Cr. Hr. 03**

Learning Objectives:
- To have introduction of statistics as a field of knowledge and its scope and relevance to other disciplines of natural and social sciences.
- To equipped and prepare students for advance courses in the field of statistics.
- To achieve the capability of critical thinking about data and its sources; have idea about variables and their types and scale measures.
- Be able to calculate and interpret descriptive statistics (able to classify, tabulate, describe and display data using software).

Learning Outcomes:
- Acquire the basic knowledge of the discipline of Statistics.
- Understand and differentiate between the types of data and variables.
- Evaluate and interpret basic descriptive statistics. Display and Interpret data graphs.

Course Contents:

Introduction: What is Statistics? Descriptive and Inferential Statistics, Introduction to basic terms, Measurability and Variability, Data and Data types (grouped and ungrouped data), Variables and Variable types, Measurement scales (Nominal, Ordinal, Interval, and Ratio)

Graphic Presentation of Data: what is Graphs? Pareto Diagram, Stem and Leaf Displays, Bar-Graph, Histograms, Pie-Chart, Box and Whisker Plots and their Interpretation.

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Numerical Descriptive Statistics: Measure of Central Tendency (Arithmetic Mean, Geometric Mean, Harmonic Mean, Median and Mode), Measure of Position (Quartiles and Percentiles), Measure of Dispersion (Range, Quartile Deviation, Mean Deviation, Variance and Std. Deviation), Skewness and Kurtosis

Probability: Nature of Probability, Probability of Events, Simple Sample Spaces, Rules of Probability, Mutually Exclusive Events, and Addition Rule, Independence, the Multiplication Rule, and Conditional Probability, Bayes' Rule

Books Recommended

   i.   Johnson, R and Kuby, P. (2004) "Elementary Statistics" 9th Edition Brooks/Cole, a division of Thomson Learning, Inc. USA
  ii.   Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.
 iii.   Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

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BS Statistics (4-Years)		
INTRODUCTION TO PROBABILITY DISTRIBUTIONS		
STAT 112	**Marks 100**	**Cr. Hr. 03**

Learning Objectives:

• Understand basic concepts of probability, conditional probability, independence etc.

• Be familiar with some of the more commonly encountered random variables, particularly the Binomial and Normal random variable.

• Be able to calculate first two moments of common random variables i.e. means and variances.

• Be able to apply the concepts of random variables to scientific applications. Computation of uncertainty using probability techniques.

Learning Outcomes:

• Acquire the basic knowledge of probability and probability distribution.

• Understand the concepts of basic techniques of measuring the uncertainty problem.

• Analyze the problem of genetics finance and telecommunications by using probability techniques.

Course Contents:

Introduction: Random Variables (Discrete and Continuous), Probability mass and density functions, Distribution function, Joint, marginal and conditional probability Distribution. Mathematical Expectations. Mean and Variance of a random variable.

Discrete Probability Distribution: Bernoulli trials. Applications and fitting of Binomial, Poisson, Hypergeometric, Negative Binomial and Geometric distributions.

Continuous Probability Distribution: Normal Distribution, Standard Normal Curve, Normal approximation to binomial and Poisson distributions.

Books Recommended

i. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.

ii. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

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iii. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

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BS Statistics (4-Years)		
BASIC STATISTICAL INFERENCE		
STAT 213	**Marks 100**	**Cr. Hr. 03**

Learning Objectives:

• To understanding of basic techniques of sampling and estimation, their properties and application

• To select a sample from a given population and use it to make inferences about the population and its parameter

• To test, deduce and infer the validity of different types of hypotheses and models built on the basis of the raw data collected in diverse problem-situations.

Learning Outcomes:

• Acquire the knowledge of the sampling distributions and their properties.

• Derive the appropriate estimators for parameters using best estimation procedure.

• Use appropriate sampling distributions for interval estimation and hypotheses testing.

• Apply appropriate inferential procedures to handle the practical situations.

Course Contents:

Introduction: Inferential Statistics, Estimation and Testing of Hypothesis,

Estimation: Types of Estimation (Point and Interval), Properties of a Good Estimator, Interval Estimation of population mean and proportion (large and small samples). Interval estimation for the differences of two population means and proportions (for independent and dependent samples). Interval estimation for population variance. Sample size estimation to estimate population mean and proportion.

Hypothesis Testing: Nature of Hypothesis Testing, Types of errors. General Procedure for Testing Hypothesis. Power of Test. Hypothesis Testing for Population Mean, Proportion (Large and small samples). Testing hypothesis for the differences of two population means and proportions (for independent and dependent samples).

Chi-Square Tests: Chi-Square distribution, Testing population variance, Goodness of fit test, test of association of two categorical variables.

Books Recommended

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i.   *Johnson, R and Kuby, P. (2004) "Elementary Statistics" 9th Edition Brooks/Cole, a division of Thomson Learning, Inc. USA

ii.   Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums Outlines Series. McGraw Hill. NY.

iii.   Walpole, R.E., Myers, R.H. and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

iv.   Chaudhry, S.M. and Kamal, S. (1996), "Introduction to Statistical Theory" Part II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

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BS Statistics (4-Years)		
INTRODUCTION TO REGRESSION ANALYSIS AND EXPERIMENTAL DESIGN		
STAT 215	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- To provide foundations of regression analysis.
- To provide basic knowledge and art of statistical data analysis
- To predict and draw inference about the parameters of the parameters of population.

Learning Outcomes:

- Explore more adequately the connection between theories of regression.
- Analysis of real world problems.
- Prediction of dependent variable.

Course Contents:

Regression and Correlation: Historical Origin of the Term Regression, The Modern Interpretation, Statistical Versus Deterministic Relationships, Regression Versus Causation, Regression Versus Correlation, The meaning of term 'linear'. Simple Linear regression, linear correlation: simple, partial and multiple correlation. Inference regarding correlation coefficient. Coefficient of determination.

Design and Analysis of Experiment: The concept of Experiment, Basic Principles, Guidelines for Designing Experiments, A brief history of Statistical Design. Basic definitions of terms, Treatment, Experimental Units, Sampling Units, Experimental Error, Yields, Block, Replication, Repetition, Random Assignment. General Concept of ANOVA models, Fixed and Random effect models. One-Way and Two-Way Analysis of Variance (ANOVA). Decomposition of total sum of squares, Multiple comparison tests; least significant difference and Duncans multiple range test, Tukey test and Least significant difference test.

Books Recommended

i. *Gujrati, D. (2003). "Basic Econometrics", 4th Edition International Edition McGraw Hill, New York.

ii. Montgomery, D.C. (2007). "Design and Analysis of Experiments", 5th Edition, John Wiley, New York.

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iii.   Chaudhry, S.M., and Kamal, S., (1996), "Introduction to Statistical Theory" Part I, II, 6th ed, Ilmi Kitab Khana, Lahore, Pakistan.

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BS Statistics (4-Years)		
APPLIED STATISTICS		
STAT 216	**Marks 100**	**Cr. Hr. 03**

Course Contents:

Sampling: Introduction to Applied Statistics, Need for Sampling, Probability and Non-Probability sampling, Simple Random sampling, Stratified, Systematic and Cluster sampling. Census and Sample surveys, Sampling and Non-Sampling Errors.

Index numbers: Construction and uses of index numbers, un-weighted index numbers (simple aggregative index, average of relative price index numbers). Weighted index numbers (Laspayers, Paaches and Fishers ideal index numbers). Consumer price index (CPI) and Sensitive Price Indicators.

Time Series Analysis: Brief overview, time plot and components of time series, descriptive analysis of time series data.

Vital Statistics: Meaning of vital statistics, registrations of Birth and death in Pakistan. Uses of vital statistics, short comings of vital statistics, rates and ratios (Sex ratio, child women ratio, birth and death ratio, population growth rate, classification of natal rates, death rates or mortality rates, crude death rate, specific death rate, infant mortality rate, case fatality rate, fertility rates, crude birth rate, specific birth rate, standardized death rate, reproduction rates, gross reproduction rate, net reproduction rate, morbidity or sickness rates, marriage rates, divorce rates etc. general; fertility rate, total fertility rate.)

Books Recommended

i. *Chaudhry, S.M. and S. Kamal, (1996), "Introduction to Statistical Theory" Part I, II, 6th Ed, IImi Kitab Khana, Lahore, Pakistan.

ii. Cochran, W.G. "Sampling Techniques".3rd Ed.

iii. *Pollard, A.H.. Yousuf, F. and Pollard G.M. (1982), "Demographic Techniques", Pergamon Press, Sydney.

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BS Statistics (4-Years)		
STATISTICAL PACKAGES		
STAT 225	Marks 100	Cr. Hr. 03

Course Objectives:

- To understand basics of data analysis through Minitab, SPSS and R.

- To learn visualization of data through Minitab, SPSS and R.

- To learn basic programming in R.

Learning Outcomes:

- Understand the data presentation and analysis using Minitab and SPSS.

- Learn basic programming in R for statistical data analysis.

- Describe concepts as they are implemented in real world data.

Course Contents:

Introduction: Introduction to Statistical Packages and Programming Languages, Usefulness and Shortcomings, SPSS vs Minitab vs R

SPSS and Minitab: Data Input, Descriptive Statistics, General Linear Model, Regression and Correlation, Compare Means, Random Number Generation, Variables Transformation, and Graphs in SPSS and Minitab.

R Programming: Data Input- Data Types, Importing Data, Keyboard Input, Exporting Data, Viewing Data, Variable Labels, Value Labels, Missing Data, Date Values **Data Management-** Creating New Variables, Operators, Built-in Functions, Control Structures, User-defined Functions, Sorting Data, Merging Data, Aggregating Data, Reshaping Data, Subsetting Data, Data Type Conversion **Statistics-** Descriptive Statistics, Frequencies & Crosstabs, Correlations, t-tests, Regression, ANOVA. **Graphs-** Creating a Graph, Histograms and Density Plots, Dot Plots, Bar Plots, Line Charts, Pie Charts, Boxplots, Scatterplots.

Note: Use of any other statistical package based upon the availability of the Software.

Books Recommended

i. Ryan, Barbara F.; Joiner, Brian L. and Cryer, Jonathan D.(2005) MINITAB Handbook, 5th Edition, Duxbury Press, California.

ii. Quick R website https://www.statmethods.net/graphs/index.html

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iii. Marques de Sá, Joaquim P.(2003) Applied Statistics using SPSS, STATISTICA and MATLAB

BS Statistics (4-Years)		
PROBABILITY AND PROBABILITY DISTRIBUTIONS-I		
STAT 317	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- This course is designed to give students a conceptual knowledge of discrete random variables and probability theory.
- This course provides the fundamentals of probability theory in different disciplines.
- This course helps to model the uncertain behavior from the real life scenario.

Learning Outcomes:

- Understand the basic concepts and applications of probability.
- Investigate the nature of stochastic process and apply suitable probability distributions for the random variable generated from such process.
- Find probabilities using probability distributions.
- Use probability concepts and laws in decision analysis.

Course Contents:

Basic Functions and Inequalities: Distribution function, Probability mass and density functions. Location, scale, and shape parameters. Joint and conditional distributions for two and more random variables, Marginal and conditional distributions, Mathematical expectation and its properties, Conditional Expectation, Moments, Stochastic independence, Moment Generating Function, Comulant Generating function of distributions Characteristic function, Factorial Moments, Cummulants, L moments and their relationships. Probability Generating Function, Relation between Moments and Cumulants.

Discrete Probability distributions: Discrete Uniform, Bernoulli, Binomial, Multinomial, Negative Binomial, Geometric, Hypergeometric, Poisson, Discrete Weibull distributions with properties (mean, variance, moments, generating functions)

Books Recommended

i.   Forbes, C., Evans M., Hastings, N., Peacock, B. (2010) "Statistical Distributions" 4th Edition, Jhon Wiely and Sons Inc.. Hobokon, New Jersey.

ii.   Hirai, A.S. (1998), "A Course in Mathematical Statistics", Ilmi Kutab Khana, Lahore.

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iii.   Mood, A.M, Graybill, F.A. and Boss, D.C. (1997), "Introduction to the Theory of Statistics", McGraw Hill, New York.

iv.   Khan, M. K., (1996). "Probability with Applications", Maktiba Ilmi, Lahore.

v.   Hogg, R.M. and Craig, A.T. (1995), "Introduction to Mathematical Statistics". Prentice Hall, Engle wood Cliffs, New Jersey.

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BS Statistics (4-Years)		
SAMPLING TECHNIQUES-I		
STAT 318	Marks 100	Cr. Hr. 3+1

Course Objectives:

- To introduce the concept and scope of sampling.

- To determine the sample size for conducting a survey.

- To learn ratio and regression estimations.

- To understand the concept of simple and stratified random sampling techniques.

Learning Outcomes:

- Use and implement of sampling designs.

- Apply the simple random sampling and the stratified random sampling appropriately in real world problems.

- Estimate the population parameters by using simple and stratified random sampling techniques.

Course Contents:

Introduction of Sampling, advantages of sampling, requirements of a good sample, bias, sampling and non-sampling errors, Steps and problems involved in planning and conduct of census and their sources, sample surveys, Selection and estimation procedures. Description and properties of simple random sampling. Sampling for proportions and percentages. Estimation of variances, standard errors and confidence limits. Sample size determination under different conditions. Description and properties of stratified random sampling. Formation of strata, Different methods of allocation of sample size. Systematic sampling, Ratio sampling, Product sampling, and Regression methods of estimation in simple and stratified random sampling.

Field Data Collection (Study Tour): Practical of this course shall include visits of the students to various national statistical organizations and a report submitted to this office.

Books Recommended

i. Sampath, S. (2005) "Sampling Theory and Methods", Second Edition, Narosa Publishing house, Chennai, India

ii. Ferguson, T.S. (1996), "A Course in large Sample theory, Chapman & Hall, London.

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iii. Singh, R. and Singh N, (1996), "Elements of Survey Sampling", Kulwar Academic Publisher, Dodrecht.

iv. Kish, L. (1992). "Survey Sampling", John Wiley, New York.

v. Cochran, W.G. (1977), "Sampling Techniques", 3rd ed, John Wiley and Sons, New York.

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BS Statistics (4-Years)		
REGRESSION ANALYSIS		
STAT 320	Marks 100	Cr. Hr. 3+1

Course Objectives:

- To understand the basic assumptions of regression analysis.

- To handle the problems arising from the violation of assumptions.

- To understand the estimation techniques of parameters.

- To give the concept of nonlinear regression analysis.

Learning Outcomes:

- Students would have enough knowledge of regression analysis.

- Students will be able to understand the concept of basic assumption of regression and how to overcome these problems.

- It developed the skills of students to analyze the real phenomena of regression models.

Course Contents:

Linear regression and its assumptions, Least squares estimators, Maximum Likelihood Estimator, Tests of significance for regression model and regression parameters. Confidence interval for regression parameters, Test of linearity of regression, Use of extraneous information in linear regression model. Residual analysis, Brief description of outliers and influential observations. Brief Introduction of Generalized Linear Models (GLMs), the Logistic Regression model fit and uses, Polynomial regression, Orthogonal polynomial, Orthogonal regression analysis and Specification of models.

Books Recommended

i. Gujrati, D. (2003). "Basic Econometrics", 4th Edition International Edition McGraw Hill, New York.

ii. Draper, N.R. and Smith, H. (2004)." Applied Regression Analysis", John Wiley. New York.

iii. Baltagi, B. H. (1999). "Econometrics", 2nd Edition, Springer Varlog.

iv. Johnston, J. and Di. Nardo, J., (1997). "Econometric Method", 4th Edition, McGraw Hill, New York.

v. Ryan, P. T. (1996) "Modern Regression Methods", John Wiley and sons Inc. New York.

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vi.   Montgomery, D.C., and Peck E.A. (1992)."Introduction to linear Regression Analysis", 2nd Edition, John Wiley and sons Inc. New York.

vii.   Koutsoyiannis, A. (1980), "Theory of Econometrics", Macmillan. N.Y.

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BS Statistics (4-Years)		
DESIGN AND ANALYSIS OF EXPERIMENTS-I		
STAT 321	Marks 100	Cr. Hr. 3+1

Course Objectives:

- This course provides the fundamentals of experimental designs and their uses in different disciplines.

- To provide basic and advanced learning of investigation for conclusions through planning and designing of experiments.

- To train students through innovative instruction in design theory and methodology that will help them in addressing the significance of experimental design in statistics and across the universal disciplines.

Learning Outcomes:

- Understand the basic concepts and applications of experimental design.

- Decide appropriate design for given scenario.

- Analyze the data generated from different designs and interpret the results.

Course Contents:

Introduction to experimental design and its terminology; Planning and designing of experiment and research; Aspects of experimental design, basic principles of experimental design, fixed and random effects. Analysis of variance (ANOVA), estimation of model parameters. Checking model adequacy, Inference beyond ANOVA multiple comparisons, Contrast analysis, orthogonal polynomial contrasts and trend analysis. Basic experimental designs; completely randomized design, randomized complete block design and Latin square design. Relative efficiency of these designs. Incomplete block designs (IBD), balanced incomplete block designs (BIBD) and partially balanced incomplete block designs (PBIBD). Intra-block and Inter-block analysis of IBD.

Practical: Analysis of experimental data in Computer Lab

Books Recommended

i. Montgomery, D.C. (2007). "Design and Analysis of Experiments", 5th Edition, John Wiley, New York.

ii. Clarke, G.M. (1994). "Statistics & Experimental Design". Edward Arnold.

iii. Dean, A. and Voss, D. (1999) "Desing and Analysis of Experiments" Springer

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iv.   Cochran, W.G. and Cox, G.M. (1957). "Experimental Design", John Wiley, New York.

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BS Statistics (4-Years)		
NON-PARAMETRIC METHODS		
STAT 224	Marks 100	Cr. Hr. 03

Course Contents:

Introduction: Introduction to non-parametric methods and its assumption, advantages and disadvantages of non-parametric tests. Difference between Rank and Run. **Test for single sample:** The Sign test, Wilcoxon Signed Rank test, Runs test for randomness, Kolmogorov Smironov test for goodness of fit (One sample), Lilliefors test for normality. **Tests based on two samples (Independent/dependent):** Wilcoxon signed rank tests for paired observation, Wilcoxon Rank Sum test for independent samples, Binomial test for proportion and large samples proportion, Wold-Wolfowitz test for randomness, Kolmogorov Smironov test for goodness of fit (Two samples), Mann Whitney U test for two samples, Median test for independent samples. **Tests based on two or more samples:** Kruskal Wallis test alternative for ANOVA**,** Friedman two-way ANOVA by ranks**,** Median test alternative to Chi-square test for independence**,** Mann Whitney U test for 2 x k contingency table**,** Durbin test for treatment effect**,** Cochran test for binary responses. **Test for checking variability:** Mood test for comparison of standard deviation**,** Moses test for equal variability**,** Siegel-Tukey for equal Variances. **Test for Association:** Thiel's-Kendall test**,** Spearman rank correlation coefficient**,** Kendall tua test**,** Kendall's Coefficient of Concordance**,** Tukey Quick test for trends**,** Cox Stuart test for trends

Recommended Books:

i.   J. S David (2004) "Handbook of Parametric and Non Parametric Statistical Procedures" 3rd edi . Chapman & Hall London

ii.   I P Sprent, N.C. Smeeton (2001) "Applied nonparametric statistical methods" 3rd ed. Chapman & Hall London

iii.   W.W Danial (1990) "Applied Non-Parametric Statistics" 2nd edi Boston PWS-Kent publishing Company

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BS Statistics (4-Years)		
PROBABILITY AND PROBABILITY DISTRIBUTIONS-II		
STAT 322	Marks 100	Cr. Hr. 03

Course Objectives:

- This course is designed to give students a conceptual knowledge of continuous random variables and probability theory.

- This course provides the fundamentals of probability theory in different disciplines.

- This course helps to model the uncertain behavior from the real life scenario.

Learning Outcomes:

- Understand the basic concepts and applications of probability.

- Investigate the nature of stochastic process and apply suitable probability distributions for the random variable generated from such process.

- Find probabilities using probability distributions.

- Use probability concepts and laws in decision analysis.

Course Contents:

Continuous Probability Distributions: Properties and Application of Continues Uniform, Normal, Log-Normal, Exponential, Gamma, Beta, Weibull, Cauchy, Laplace, Logistic, Pareto, Rayleigh. Distributions of functions of random variables using Cumulative Dist. Function (CDF), Moment Generating Function (MGF) and Transformation methods, Bivariate Normal distribution.

Sampling Distributions: Chi-square, t and F distributions and their derivations and properties. Central limit Theorem, Weak and Strong Laws.

Order statistics: Distributions of rth and s^{th} order statistics.

Books Recommended

i. Thomas A. Seveini (2005) "Elements of Distribution Theory" Cambridge University Press, Cambridge.

ii. Hirai, A.S. (1998), "A Course in Mathematical Statistics", Ilmi Kutab Khana, Lahore.

iii. Fridett, B. & Gray, L. (1997). "A Modern Approach to Probability Theory" Birkhallser, Boston.

iv. Freund, J. E. (1997). "Mathematical Statistics", Prentice Hall, New Jersey.

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v.   Mood, A.M, Graybill, F.A. and Boss, D.C. (1997), "Introduction to the Theory of Statistics", McGraw Hill, New York.

vi. Hogg, R.M. and Craig, A.T. (1995), "Introduction to Mathematical Statistics". Prentice Hall, Engle wood Cliffs, New Jersey.

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BS Statistics (4-Years)		
SAMPLING TECHNIQUES-II		
STAT 323	**Marks 100**	**Cr. Hr. 3+1**

Course Objectives:

- To understand the concept of systematic, cluster, multistage and multiphase sampling techniques.
- Comparison among different sampling techniques.
- To learn ratio and regression estimations.
- To understand the non-response, their sources, and randomized response technique.

Learning Outcomes:

- Use and implement of systematic and cluster sampling designs.
- Apply the multistage and multiphase sampling appropriately in real world problems.
- Estimate the population parameters by using systematic and cluster sampling techniques.

Course Contents:

Sampling Procedures: Systematic sampling, Cluster Sampling, Efficiency of systematic sampling compared with simple random sampling, stratified random sampling and cluster sampling. Sub sampling, Probability Proportion to Size (PPS)-Sampling, Double Sampling, Multistage and Multiphase sampling. Comparison of different sample designs. **Sampling Error:** Sources of Sampling and non-sampling errors, Non-response and their sources and bias, Hansen Hurwitz Technique, Randomized Response Techniques (RRT).

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

Note: Practical's of this course shall include visits (study tour) of the students to various national statistical organizations and a report submitted to this effect.

Books Recommended

i.   Sampath, S. (2005) "Sampling Theory and Methods", Second Edition, Narosa Publishing house, Chennai, India

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

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iii. Cochran, W.G. (1977), "Sampling Techniques", John Wiley and Sons, 3rd ed, New York.

iv. Various publications of Pakistan Bureau of Statistics, Population Census Organization, State Bank of Pakistan, Pakistan Meteorology Department.

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BS Statistics (4-Years)		
ECONOMETRICS		
STAT 324	**Marks 100**	**Cr. Hr. 03+1**

Course Objectives:

- The purpose of this course is to introduce students to the main concepts and tools used in econometrics.

- In particular, to learn when and how to apply regression analysis. Learn the basic assumptions and techniques used to run estimations and make inferences in the context of a linear equation framework.

- To learn to recognize specification and data problems. Also additional tools to handle time series data.

- Each topic will be approached with a mix of intuitive explanations, theoretical characterization and proofs.

- And practical applications, including interpretation of regression output.

Learning outcomes:

- Conduct basic statistical and econometric analysis. Explain and interpret econometric results.

- Explain econometric concepts and results intuitively, conduct independent data analysis and inquiry using the tools of statistics and econometrics.

- Conduct Research with econometrics, derive econometric results mathematically.

Course Contents:

Introduction to Econometrics and types. Autocorrelation, Multicollinearity, and Heteroscedasticity Problems, detection and solution. The Ridge regression. Lagged variables. Autoregressive models. Dummy variables. Errors in Variables. Instrumental variables, System of simultaneous linear equations, Identification-Estimation method, Indirect and two-stage least squares methods, restricted least squares. Test of identifying restrictions. Estimation with stochastic regressor, generalized least squares estimators.

Books Recommended

i. Draper, N.R. and Smith, H. (2004). "Applied Regression Analysis", John Wiley, New York.

ii. Baltagi, B. H. (1999). "Econometrics", 2nd Edition, Springer Varlog.

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iii. Gujrati, D. (2003). "Basic Econometrics", 4th Edition International Edition McGraw Hill, New York.

iv. Johnston, J. and Di. Nardo, J., (1997). "Econometric Method", 4th Edition, McGraw Hill, New York.

v. Montgomery, D.C., and Peck E.A. (1992). "Introduction to Linear Regression Analysis", 2nd Edition, John Wiley and sons Inc. New York.

vi. Koutsoyiannis, A. (1980), "Theory of Econometrics", Macmillan.

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BS Statistics (4-Years)		
DESIGN AND ANALYSIS OF EXPERIMENTS-II		
STAT 325	Marks 100	Cr. Hr. 3+1

Course Objectives:

- This course provides the advanced knowledge of experimental designs and their uses in different disciplines.

- To provide basic and advanced learning of investigation for conclusions through planning and designing of experiments.

- To train students through innovative instruction in design theory and methodology that will help them in addressing the significance of experimental design in statistics and across the universal disciplines.

Learning Outcomes:

- Understand the basic concepts and applications of experimental design.

- Decide appropriate design for given scenario.

- Analyze the data generated from different designs and interpret the results.

Course Contents:

Introduction to Factorial Designs: Basic Definitions and Principles, The advantages of Factorials, The Two-Factor Factorial Design, The General Factorial Design.

The 2^k Factorial Design: The 2^2, 2^3, and General 2^k Design, A single Replicate of 2^k Design, Blocking, Confounding and Fractional Replication in the 2^k Factorial Design.

The 3^k Factorial Design: The 3^2, 3^3, and General 3^k Design, Confounding in the 3^k Factorial Design, Fractional Replication of the 3^k Factorial Design.

Nested and Split-Plot Designs: The Two-Stage Nested Design, Designs with both Nested and Factorial Factors, The Split-Plot Design, The Split-Plot Designs, The Split-Split-Plot Design, The Strip-Split-Plot Design.

Balanced Incomplete Block Design (BIBD). Lattice designs, lattice square and Youden squares, PBIBD with recovery of intra-block information Analysis of Covariance (ANCOVA). Confounding in factorial experiments, complete and partial confounding.

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Books Recommended

i. Montgomery, D.C. (2007). "Design and Analysis of Experiments", 5th Edition, John Wiley, New York.

ii. Steel, G. D., Terrie, and Dickey A. (1997). "Principles and Procedures of Statistics: A Biometrical Approach" 3rd Edition, McGraw Hill, New York.

iii. Myers, R.H. and Montgomery, D.C. (1995). "Response Surface Methodology; Process & Product Optimization Using Design", John Wiley.

iv. Cochran, W.G. and Cox, G.M. (1957). "Experimental Design", John Wiley, New York.

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BS Statistics (4-Years)		
POPULATION STUDIES		
STAT 430	Marks 100	Cr. Hr. 03+1

Course Contents:

Testing the accuracy of demographic data: Types and sources of errors. General testing procedures. Testing the accuracy of age and sex data.

Basic demographic measures: Fertility and mortality measures. Mortality rates. Total and general fertility rates. Estimation from incomplete Data.

Life tables: Construction of complete and abridged life tables. Different types of life tables. Graphs of l_x, q_x and d_x. Description and uses of life table columns. Population Models: Theory of demographic transition. Stable and stationary population models, their applications and uses.

Population estimates and projections, Inter-censal estimates, Population projections through various methods.

Census and its types, Census in Pakistan. Consequences of Pakistan Population explosion.

State of Population in Pakistan. Development of demographic profile in Pakistan. Recent demographic parameters. Current and future demographic activities in Pakistan.

Books Recommended

i. Govt. of Pakistan (1998). *"National, Provincial and District census reports and other supplementary reports with respect to 1998 census";* PCO, Islamabad.

ii. Hind, A., (1998). *"Demographic method",* Arnold.

iii. R. Ramakumar. (1986). *"Technical Demography".* Wiley Eastern Limited.

iv. Keyfitz N. (1983). *"Applied Mathematical Demography",* Springer Verlag N.Y.

v. Pollard, A.H., Yousaf, F and Pollard, G.M. (1982). *"Demographic Techniques",* Pergamon Press, Sydney.

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BS Statistics (4-Years)		
STATISTICAL INFERENCE-I		
STAT 427	Marks 100	Cr. Hr. 03

Course Objectives:

- To introduces students to the basic theory behind the development and assessment of statistical analysis.

- To understand the techniques in the areas of point and interval estimation, as well as hypothesis testing.

- To apply the statistical techniques to real data and draw conclusions.

Learning Outcomes:

- Explain the notion of a parametric model and point estimation of the parameters of those models. Explain and apply approaches to include a measure of accuracy for estimation procedures and our confidence in them by examining the area of interval estimation.

- Asses the plausibility of pre-specified ideas about the parameters of a model by examining the area of hypothesis testing.

- Explain and apply the idea of non-parametric statistics, wherein estimation and analysis techniques are developed that are not heavily dependent on the specifications of an underlying parametric model.

- Understand the computational issues related to the implementation of various statistical inferential approaches.

Course Contents:

Estimation of Parameters. Properties of Estimators: Unbiasedness, Consistency, Sufficiency, Efficiency, Completeness. Cramer-Rao inequality, Rao-Blackwell and Lehmann-Scheffe Theorems. Methods of Estimation: Least-Squares, Moments, Maximum likelihood, Minimum Chi- square and Bayes' method.

Recommended Books:

i. Casella, G. and Berger, R. (2002) "Statistical Inference" Second Edition, Duxbury Thomson Learning Inc. USA

ii. Mood, A.M., Graybill, F.A. and Boss, D.C. (1997). "Introduction to the Theory of Statistics". McGraw Hill, New York.

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iii. Hogg, R.V. and Craig, A.T. (1996). "Introduction to Mathematical Statistics". Prentice Hall, New Jersey.

iv. Lindgren, B.W. (1998). "Statistical Theory". Chapman and Hall, New York.

v. Stuart, A. and Ord, J.K. (1998). Kendall's' "Advanced Theory of Statistics" Vol. II. Charles Griffin, London.

vi. Bickel, P.J., and Docksum, K.A. (2001), Mathematical Statistics, Vol I, Prentice Hall, N.J., 2nd ed.

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BS Statistics (4-Years)		
APPLIED MULTIVARIATE ANALYSIS		
STAT 428	**Marks 100**	**Cr. Hr. 3+1**

Course Objectives:

- This course provides the fundamental knowledge of multivariate data and its applications in different fields of life.

- This course will introduce the students to different multivariate techniques through real world problems.

- This course will develop the skill in students to estimate the parameters and drive inference in multivariate cases.

Learning Outcomes:

- Understand the basic concepts and applications of multivariate techniques.

- Unable to decide which multivariate technique to be used for the given scenario.

- Analyze the multivariate data and interpret the results correctly.

Course Contents:

Preliminaries: Introduction to Multivariate Analysis. Objects and Variables. Data Matrix. Summary Statistics. Some Basic Properties of Random Vectors. Mahalanobis Distances and Angles, Multivariate Normal Distribution

Estimation: Introduction. Maximum Likelihood Estimation of the Mean Vector and the Covariance Matrix.

Basic Multivariate Sampling Distributions: Distribution of Quadratic Forms Cochran's Theorem. The Wishart Distribution and its properties. The Hotelling T^2 Distribution. Distributions of Sample, Partial and Multiple Correlation Coefficients (Extensive derivations not required).

Principal Component Analysis: Introduction. Definition and Properties of Principal Components. Sampling Properties of Principal Components. Discarding of Variables. Interpretation of the Results.

Factor Analysis Introduction: The Factor Model. Principal Factor Analysis. Maximum Likelihood Factor Analysis. Factors Scores. Relationship between Factor Analysis and Principal Component Analysis.

Discriminant Analysis: Introduction. Discrimination When the Populations are known. Discrimination under Estimation. Fisher's Linear Discriminant Function.

Cluster Analysis: Introduction. A Probabilistic Formulation. Hierarchical Methods. Distances and Similarities.

Books Recommended

i. Anderson, T.W. (2003). "An Introduction to Multivariate Statistical Analysis", John Wiley, New York.

ii. Afifi, A. A. and Clark Virginia (2000). "Computer Aided Multivariate Analysis", Lifetime learning publications, Belmont California.

iii. Flurry B. (1997). "A First Course in Multivariate Statistics", Springer Valerg, New York.

iv. Johnson, R.A. and Wincher, D.W. (2002). "Applied Multivariate Statistical Analysis", 5th Edition, Pearson Education, Inc.

v. Morrison, F. (1990). "Multivariate Statistical Methods", McGraw Hill, New York.

vi. Chatfield, C. and Collins, A.J. (1980). "Introduction to Multivariate Analysis", Chapman and Hall, London.

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BS Statistics (4-Years)		
RESEARCH METHODOLOGY		
STAT 429	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- To understand some basic concepts of research and its methodologies

- To identify appropriate research problems

- To select and define appropriate research problems and parameters

- To organize and conduct research in more appropriate manner

Learning Outcomes:

- Understand general definition of research design

- Solve the problems in the fields of qualitative and quantitative research

- Plan and conduct research using an appropriate research design, keeping in view the ethical issues in the research

- Critically review and develop a complete research project

Course Contents:

Definition of Research, Types of Research, Selection of Problem, Search of References, Literature Review, Formation of Hypothesis and Procedure for its Testing, Research Methodology, Planning of Experiments to Test Hypothesis Objectivity, Principals of Experimental Design, Steps in Experimentation, Administering the Questionnaires, Collection of Data, Data Analysis to Determine Functional Relationship Between Variables, Levels of Significance, Interpretation of Results, Components of Scientific Reports and Various Methods of Data Presentation, Preparation of Scientific Reports, Publication Procedures. Qualitative Research: Content analysis.

Practical:

Survey of Literature on a Given Topic, Collection of References from Various Sources. Collection of Primary and Secondary Data, Arrangement of Primary and Secondary Data, Preparation of Scientific Report for Publication, Studying and reviewing standard survey questionnaires and preparation of a sample questionnaire and a scientific report

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Books Recommended

    i.   Singh Y. K. (2006) "Fundamental Research Methodology and Statistics" New Age International (P) Ltd Publishers, India

   ii.   Bougie, R. Sekeran (2016) "Research Methods for Business" 7th Edition, John Wiley & Sons Ltd.

  iii.   Andrew, C.O. and P.E. Hildebrand. (1993) "Applied Agricultural Research", Foundations and Methodology, Western Press.

  iv.   Hashmi, N. (1989) "Style Manual of Technical Writings", USAID/NARC, Islamabad.

   v.   Gimbaled, J. and W.S. Acuter (1988) "MLA handbook for Writers of Research Papers", McGraw the Modern Language Association of America.

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BS Statistics (4-Years)		
STATISTICAL INFERENCE-II		
STAT 431	Marks 100	Cr. Hr. 03

Course Objectives:

• To develop an advanced-level understanding and working knowledge of statistical inference.

• To provide an introduction to the rudiments of statistical inference for population parameters based on a general decision theoretic framework covering estimation and test of hypothesis.

• To introduce some nonparametric methods and their applications.

Learning Outcomes:

• A foundation for understanding probability-based statistical inference material presented in other courses.

• The understanding of the concepts of testing, size and power of a test.

• The understanding of and derivation of the properties of tests based on different criterion functions.

Course Contents:

Interval Estimation: Pivotal and other methods of finding confidence interval, confidence interval in large samples, shortest confidence interval, optimum confidence interval. Bayes' Interval estimation.

Tests of Hypotheses: Simple and Composite hypotheses, Critical Regions. Neyman-Pearson Lemma, Power functions, Uniformly most powerful tests, Locally most Powerful Test. Deriving tests of Hypothesis concerning parameters in normal, exponential, gamma and uniform distributions. Randomized Tests. Unbiased tests, Likelihood ratio tests and their asymptotic properties. Sequential Tests: SPRT and its properties, A.S.N. and O.C. functions.

Books Recommended

i.   Casella, G. and Berger, R. (2002) "Statistical Inference" Second Edition, Duxbury Thomson Learning Inc. USA

ii.   Stuart, A and Ord, J.K. (1998). Kendall's' "Advanced Theory of Statistics" Vol. II. Charles Griffin, London.

iii. Lindgren, B.W. (1998). "Statistical Theory". Chapman and Hall, New York.

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iv. Mood, A.M. Gray Bill, F.A. and Boss, D.C. (1997). "Introduction to the Theory of Statistics". McGraw Hill, New York.

v. Lehman, E.L. (1997). "Testing Statistical Hypotheses". Springler - Volga, New York.

vi. Hogg, R.V. and Craig, A.T. (1996). "Introduction to Mathematical Statistics". Prentice Hall, New Jersey.

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BS Statistics (4-Years)		
PROJECT		
STAT 500	Marks 100	Cr. Hr. 03

Note: An independent research project/internship will be assigned and completed by each students. At the end of the project/internship, it will be mandatory for students to submit his/her project/research/internship report for evaluation. Submission of report/thesis is compulsory.

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BS STATISTICS (4-Years) ELECTIVE COURSES

BS Statistics (4-Years)		
OPERATIONS RESEARCH		
STAT 433	Marks 100	Cr. Hr. 03

Course Objectives:

- To introduce students to the techniques of operations research.

- To provide students with basic skills and knowledge of operations research and its application in industry.

- To introduce students to practical application of operations research with emphasis on the industrial data.

- To effectively use relevant statistical software for data analysis.

Learning Outcomes:

- Identify and develop operations research models from the verbal description of the real system.

- Understand the mathematical tools that are needed to solve optimization problems.

- Apply operations research techniques to summarize the industrial data.

- Demonstrate the usage of statistical software for solving problem and analyzing the relevant data.

Course Contents:

History and definition of O.R. Introduction to linear programming. Formulation of LP model. Graphical solution of two variables. Standard Form. Simplex method. Duality theory; Sensitivity Analysis, Primal and dual form. Gaussian elimination. Transportation Problem, Assignment problem. Introduction to CPM and PERT techniques. Queuing Models, Inventory models, Dynamic programming and simulation models.

Books Recommended:

   i.   Taha, H.A. (1998). "*Operations Research*". Macmillan. London.

  ii.   Hillier, F.S. and Lieberman G. J. (1996). "*Introduction to Operations Research*", Holden Day.

 iii.   Gupta, P.K. & Hira, D.S. (1994). "*Operations Research*". S. Chand & Co., New Delhi.

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iv.   Bazarra, N.M., Jarvis J.J. and Sherali, H.D. (1990) "*Linear Programming and Network Flows*", John Wiley & Sons, 2nd ed.

 v.   Ravindran, A., Philips, D.J and Sillerg, J.J. (1987). "*Operations Research: Principles and Practice*" John Wiley.

vi.   Bronson, R. (1983). "*Operations Research* – Schaums' Outline Series" – McGraw Hill.

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BS Statistics (4-Years)		
STOCHASTIC PROCESS		
STAT 434	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- This course aims to provide an understanding of stochastic processes and the ability to analyze certain aspects of these processes.

- Accordingly, the course starts by reviewing probability theory, conditional probability, independence and certain properties of random variables, and continues by examining stationary processes.

- Furthermore, Markov chains in discrete and continuous time as well as Possion processes are investigated in detail.

Learning Outcomes:

- Define probability models, concept and properties of random variables, random processes, Markov processes and Markov chains,

- Explain properties and functions of random processes with stochastic mathematical models, - formulate discrete and continuous time random processes, stationary random processes.

- Devise solutions with probability models for Poisson processes, discrete and continuous time Markov chains.

Course Contents:

Introduction. Generating Functions. Laplace Transforms. Difference Equations. Differential - Difference Equations. Introduction to Stochastic Processes. The Random Walk in one and two Dimensions. The Classical Gambler's Ruin Problem. Expected Duration of the Game. Markov Chains: Definition. Higher Transition Probabilities. Classification of States and Chains. Markov processes with Discrete State Space. Poisson Process and its Generalization. Pure Birth and Death Processes. Markov Processes with Discrete State Space (Continuous Time Markov Chains). Markov Processes with Continuous State Space. Introduction to Brownian motion. The Wiener Process. Diffusion Equations for the Wiener Process.

Books Recommended

i.   Ross, S. (1996). "*Stochastic Process*", 2nd Edition, John Wiley, New York.

ii.   Feller, W. (1992). "An *Introduction to Probability Theory and its Applications",* John Wiley, New York.

iii.   Srinivasin, S.K. and Mehta, K.M. (1988). "*Stochastic Processes".* Tata McGraw Hill.

iv.   Karlin, S.A. and Taylor H.M. (1984). *"A first course in Stochastic Process",* Academic Press London.

v.   Hole, P.G., Port, S. and Stone, C.L. (1984). "*An Introduction to Stochastic Process",* John Wiley, New York.

vi.   Cox, D.R.and Miller H.D. (1984). "*The Theory of Stochastic*

vii.   Medhi, J. (1982), "*Stochastic Processes",* Wiley Eastern Ltd.

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BS Statistics (4-Years)		
RELIABILITY ANALYSIS		
STAT 435	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- To learn to analyze complete and censored reliability data with and without covariates.

- To learn some key methods in reliability modeling.

- To learn the probability and statistical methods covered in the Reliability Analysis.

- To have the working knowledge to determine the reliability of a system and suggest approaches to enhancing system reliability.

Learning Outcomes:

- Analyze the interference between strength and stress, or life data for estimating reliability

- Apply the appropriate methodologies and tools for enhancing the inherent and actual reliability of components and systems, taking into consideration cost aspects.

- Specify life test plans for reliability validation.

Course Contents:

Basic concepts of reliability. Structural reliability. Lifetime distributions (Failure models): Hazard rate; Gamma, Weibull, Gumball, Log-Normal and Inverse Gaussian Distribution. Stochastic fatigue-rate models. Point and interval estimation. Fatigue-life model. Testing reliability hypothesis. Monte-Carlo, distribution-free and Bayes' methods in reliability. System reliability; series and parallel systems. Failure models, (k-out-of-m) New-better-than used models. Inferences for these models. Accelerated life testing.

Books Recommended

i. Achintya Haldar, Sankaran Mahadevan (2000). *Reliability Assessment Using Stochastic Finite Element Analysis*".

ii. Crowder, M.J. (1994). "*Statistical Analysis of Reliability Data*".

iii. Lee, J. Bain, Bain Bain, (1991). "*Statistical Analysis of Reliability and Life-Testing Models*".

iv. Gertsbakh, I.B. (1989). "*Statistical Reliability Theory*". Marcel Decker. New York.

v. Lawless, J.F. (1982). "*Statistical Model and Methods for Lifetime Data*".

vi. Gertsbakh, I.B. (1988). "*Statistical Reliability Theory*".

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vii. Mann, N.R., Scheefer, R.E. and Singapoor wel, N.D. (1974). *Methods for Statistical Analysis of Reliability*, John Wiley & Sons.

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BS Statistics (4-Years)		
	TIME SERIES ANALYSIS AND FORECASTING	
STAT 436	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- Learn basic analysis of time series data.

- Compute and interpret ACF/PACF and a sample spectrum.

- Derive the properties of ARIMA models and choose an appropriate ARIMA model for a given set of data and fit the model using an appropriate package

- Compute forecasts for a variety of linear methods and models.

Learning Outcomes:

- Demonstrate understanding of the concepts of time series and their application to various fields of sciences.

- Apply ideas to real time series data and interpret outcomes of analyses and forecast.

- Use various advanced time series econometric methods, estimation methods and related econometric theories.

- Interpret time series models' estimates and analyze the results.

Course Contents:

Time series analysis: concepts and components, Stochastic Process, Stationary Time-Series, Exponential smoothing techniques, auto-correlation and auto-covariance, estimates functions and standard error of the auto-correlation function (ACF) and Partial autocorrelation function (PACF), Periodogram, spectral density functions, comparison with ACF, Linear stationary models: Auto regressive, Moving Average (ARMA) and mixed models, Non-stationary models, general ARIMA notation and models, minimum mean square forecasting. ARIMA Seasonal Models.

Books Recommended

i. Cox, D. R., Hinckley D.V. and Nielsen O.E.B. (1996). "*Time Series Models - In Econometrics, finances and other fields*"; Chapman & Hall, London.

ii. Chatfield, C. (1996). "*The Analysis of Time Series: An Introduction*", Chapman and Hall, London.

iii. Andy, P, West M. and Harrison, P. J. (1994). "*Applied Bayesian Forecasting and Time Series Analysis*," Chapman & Hall New York.

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iv.   Brock well P.J. and Davis R.A. (1991). "*Time Series Theory and Methods",* Springer Verlag New York.

v.   Harvey, A.C. (1990). "*Forecasting Structural Time Series Models and the Calamander",* Cambridge University Press, Cambridge.

vi.   Daggle, P.J. (1990), "*Time Series: A Biostatistical Introduction"*, Clarendon Press, Oxford.

vii.   Bovas, A. and Johannes, L. (1983), "*Statistical Methods for Forecasting",* John Wiley. New York

viii.   Priestley, M.B. (1981), "*Spectral Analysis and Time Series",* Academic Press, London.

ix.   Box, G.E.P. and Jenkins, G.M. (1999). "*Time Series Analysis*: *Forecasting and Control",* San Francisco.

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BS Statistics (4-Years)		
DECISION THEORY		
STAT 437	**Marks 100**	**Cr. Hr. 03**

Course Contents:

The nature and concept of loss functions, parameters, decisions and sample spaces. Risk and average loss. Admissibility and the class of admissible decisions. Minimax principle and its application to simple decision problems, linear and quadratic losses and their uses in problems of estimation and testing hypotheses. Asymptotically minimax procedure. A prior distributions and conjugate priors. Bayes' decision procedure, admissibility of Bayes' and minimax procedures.

Books Recommended

i. Berger, J. O. (1985). "*Statistical Decision Theory & Bayesian Analysis*", Springer Verlag.

ii. * Lindgren, B.W. (1971). "*Elements of Decision Theory*, Macmillan", New York.

iii. Blackwell, D. and Graphic, M.A. (1966). "*Theory of Games and Statistical Decision*", John Wiley, New York.

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BS Statistics (4-Years)		
ROBUST METHODS		
STAT 438	Marks 100	Cr. Hr. 03

Course Objectives:

• The objectives of this course is to provide an introduction to both basic and advanced analytical tools for robust models. This course also aims to promote a critical perspective on the use of statistical information.

• Beginning with simple statistical methods, the course builds to more robust analytical techniques such as multivariate linear regression and estimators.

• Emphasis is placed on theoretical understanding of concepts as well as the application of key methodologies used in different research fields.

Learning Outcomes:

• Explain the importance, techniques and biases of estimators in context

• Explain the concept of outliers in regression model and other influential observations

• Construct and interpret various statistical hypothesis tests.

Course Contents:

Introduction to Robustness. Objective function. M-estimator of location. E-estimator, R-estimator and W-estimator, Redesending M-estimator's The Breakdown point of Robust estimator Influence function. M-estimator for scale. Outliers and influential observations. Outliers in Regression analysis.

Books Recommended

i. Rousseau, P.J. and Leroy, A.M. (1987). "*Robust Regression and outlier detection*", John Wiley. New York.

ii. Hamper, T.R. Brochette, E.M. Rousseau, P.J. and Satchel, W.A. (1986). "*Robust Statistics*", "*The approach Based on Influence functions*", John Wiley New York.

iii. Huber, P.J. (1981). "*Robust Statistics*", John Wiley, New York.

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BS Statistics (4-Years)		
OFFICIAL STATISTICS		
STAT 221	Marks 100	Cr. Hr. 03

Course Objectives:

- To understand the official, demographic and social statistics.

- To understand the scope and organization of official statistics,

- To understand the planning and administration statistics.

Learning Outcomes:

- The versatility to work effectively in a broad range of analytic, scientific, government, financial, technical and other positions.

- A broad overview of the fundamental issues underlying the organization of official statistics.

- To recognize the importance of statistical thinking.

Course Contents:

Design and planning of a Statistical Investigation. Data collection-approach and operation; Role of sampling in generation of Statistics, Sampling plans and survey Designs. Sources of Errors, Types of Errors, methods of their control. Data processing, presentation, and publication of Statistics. Different modes of Data Dissemination. Official Statistics, Statistical systems and standards, Sources of official statistics, their role, working and publication. Role of Official Statistics, Official Publications. Setup of official organizations in Pakistan their role, working & publication, Statistics Division, Federal Bureau of Statistics, Agricultural Census Organization, Population Census Organization, Ministry of Food, Agriculture and Livestock; National Data Base and Registration Authority (NADRA). Provincial Bureaus of Statistics. 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. Use of Statistics in administration and planning. Concepts and evaluation of GDP, GNP, NNP, Balance of Trade and payments. Measurement of Income Distribution, use of Index Numbers and time series. Deflation and Inflation of series. National sample surveys and censuses conducted in Pakistan.

Assignment: Visit of major Statistical Organizations will be a part of the course. An assignment will have to be submitted on any topic given by the course Incharge.

Books Recommended:

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i. Kish, L. (1992). "*Survey Sampling*", John Wiley, New York.

ii. Statistics Division, "*Activity Report*" *(1988-89).Government of Pakistan*, Islamabad.

iii. Statistical Institute for Asia & Pacific SIAP (1984). "*Training of Trainers in Statistical Operations and Procedures*" Part-I, II UNDP, Tokyo.

iv. Hansen M.H. (1980). "*Progress and Problems in Survey Methods and Theory*". *IIIustrated by the work of U.S. Bureau of the Census, U.S. Department of Commerce*; A Monograph.

v. Murthy, M.N. (1979). "*Quality of Data, Country Course on Sample Surveys*", Karachi.

vi. Statistics Division (1979). "*Retrospect, Perspective and Prospect*", Islamabad.

vii. State Bank of Pakistan (1966). "*Deptt. of Statistics-A Chronicle*".

viii. Zarkovich S.S. (1966) "*Quality of Statistical Data, Food and Agricultural Organization*", The U.N. Rome.

ix. NIPA (1962) "*Administrative uses of Statistics*", NIPA Res. Sr.No.2 Karachi.

x. Yates F. (1960), "*Sampling Methods for Census and Surveys*", Charles Griffin. FAO Year Books.

xi. Various Publications of FBS, PCO, ACO, "*State bank of Pakistan, Ministry of Finance*" etc.

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BS Statistics (4-Years)		
SURVIVAL ANALYSIS		
STAT 440	Marks 100	Cr. Hr. 03

Course Objectives:

- To introduce the basic concepts of survival analysis

- Describe and explain how survival analysis can be applied in different fields

- To learn the usage of appropriate statistical software for survival data analysis

Learning Outcomes:

- Understand the basic concepts and ideas of survival analysis

- Derive properties and methods for standard survival time distributions

- Perform and interpret simple non-parametric survival analyses using software

- Apply and interpret semi-parametric regression models for survival data using software

Course Contents:

Introduction to survival analysis with some important basic definition of statistical quantities, terminologies and notation of survival and hazard function, Censored Data and its three types, truncation ; importance and scope of the survival analysis.

Describing the probability distributions of the survival and hazard functions. Basic layout of the survival problem both manually and computer based presentation of survival data. Computation of the descriptive measures for survival data both graphically and empirically.

Estimation of the survival function, survival probabilities. Estimation of the survival functions from possibly censored samples by means of the Kaplan-Meier estimator, the Nelson-Aalen estimator and the kernel density estimator or the Ramlau-Hansen estimator and comparisons of k independent survival functions by means of the generalized log-rank test and related alternative approaches.

The Proportional Hazards Model, the likelihood function, the Partial Likelihood Function, identification of Significant Covariates, estimation of the Survivorship Function with Covariates. Cox's semi-parametric models. Evaluation of the assumptions of Cox proportional hazard model. Introduction to estimation of Stratified Cox's procedures for single and multiple variable adequacy Assessment of the Proportional Hazards Model.

Books Recommended

i.   Lee, E.T. (1997). "*Applied Survival Analysis"*, John Wiley and Sons, New York.

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ii. Muller, R.G. and Xian Zhou (1996). "*Survival Analysis with long-term Survivors*", John Wiley. New York.

iii. Burkett, M. (1995). "*Analyzing Survival Data from Clinical Trials and Observational Studies*"; John Wiley New York.

iv. Parmer M.K.B. & Macklin D. (1995). "*Survival Analysis: A Practical Approach*"; John Wiley New York.

v. Collett, D. (1994). "*Modeling Survival Data in Medical Research*". Chapman & Hall, London.

vi. Lee, E.T. (1992). "*Statistical Methods for Survival Data Analysis*"; John Wiley. N.Y.

vii. Eland Johnson, R. C. and Johnson N. L. (1989), "*Survival Models & Data Analysis*". John Wiley N.Y.

viii. Turkey, J. (1987). "*Exploratory Data Analysis*", John Wiley, New York.

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BS Statistics (4-Years)		
BIOSTATISTICS		
STAT 441	Marks 100	Cr. Hr. 03

Course Objectives:

- To discuss and explain what biostatistics is and how it is used in Biological Sciences

- To recognize and give examples of different types of data arising in Biological Sciences

- To use statistical techniques to summarize the Biological data

- To apply statistical software to analyze and evaluate Biological data

Learning Outcomes:

- Understand the diverse applications of statistical tools in biological science.

- Demonstrate an understanding of the central concepts of modern statistical theory in Biological Sciences.

- Acquire the understanding of the appropriate usage of software for Biological sciences.

- Analyze and communicate the results of statistical analysis accurately and effectively.

Course Contents:

Introduction to the basic concepts and terminology of Biostatistics, types of variables, populations, target populations and sampled population: Role of sampling in biostatistics, Sample size estimation. Contingency table analysis, Fisher's exact test, 2x2 tables, Three way tables, rxc test for independence, Simpson's paradox, Confounding, G-Test. Proportions, rates and ratios; incidence, prevalence, Odds Ratio, Relative Risk, Rate Ratio, Sensitivity and specificity. Distributional behavior of biological variables (Binomial, Poisson and Normal), Role of transformation for analysis of biological variables, Probit and Logit transformations and their analysis, p values, its importance and role. Confidence Interval in simple and composite hypothesis testing.

Books Recommended

i.   Zar, J. (2000). "*Biostatistical Analysis*", 5th Edition, John Wiley and Sons.

ii.   Shoukri, M. M. & Pause, C. A. (1998). "*Statistical Methods for Health Sciences*". 2nd Edition, CRC Press, Florida.

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iii. Daniel, W.W. (1996). "*Biostatistics: A Foundation for the Health Sciences*", 6th Edition, John Wiley, New York.

iv. Diggle, J. P., Liang, Kung-Yee and Zeger, S. L. (1996). "*Analysis of Longitudinal Data*", Clarendon Press, Oxford.

v. Dunn, G. and Everit, B. (1995). "*Clinical Biostatistics*", Edward Arnold, London.

vi. Rosner, B. (1994). "*Fundamentals of Biostatistics*", 4th Edition, Duxbury Press.

vii. Zolman, J.F. (1993). "*Biostatistics: Experimental Design and Statistical Inference*", Oxford University Press, New York.

viii. Lee, E.T. (1992). "*Statistical Methods for Survival Data Analysis*", 2nd Edition, John Wiley, New York.

BS Statistics (4-Years)		
DATA MINING		
STAT 442	Marks 100	Cr. Hr. 03

Course Contents:

Introduction to databases including simple and relational databases, data warehouses, Review of classification methods from multivariate analysis; classification, decision trees: classification and regression trees. Clustering methods from both statistical and data mining viewpoints; vector quantization. Unsupervised learning from Univariate and multivariate data; dimension reduction and feature selection. Supervised learning from moderate to high dimensional input spaces; introduction to artificial neural networks and extensions of regression models.

Books Recommended

i. Han, J. and Camber, M. (2000). Data Mining; "*Concepts and Techniques*". Morgan Gaufmann

ii. Benson and Smith, S.J. (1997). "*Data Warehousing, Data Mining*', and OLAP. McGraw-Hill.

iii. Mitchell, T.M. (1997). *"Machine Learning*". McGraw-Hill.

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iv.   Ripley, B.D. (1996). "*Pattern Recognition and Neural Networks*". Cambridge University Press.

v.   Breiman, L. Friedman, J.H. Olshen, R.A. and Stone, C.J. (1984). "*Classification and Regression Trees*" Wadsworth and Brooks/Cole.

BS Statistics (4-Years)		
ACTUARIAL STATISTICS-I		
STAT 443	Marks 100	Cr. Hr. 03

Course Objectives:

- To develop understanding of the mathematical concepts and techniques that are used by actuaries to model stochastic processes of both assets and liabilities.

- To learn about various types of insurance and pension schemes.

Learning Outcomes:

- Basic Mathematics involved in Actuarial Computations.

- Insurance, Types and Applications in Pakistan.

- Understanding the Life Contingencies and Actuarial Notations.

Course Contents:

Interest Rate Theory: Simple interest rate, Compound interest rate, Discount interest rate, Force of Interest, Real and Money Interest. Annuities: Description of annuities, Term annuity, Deferred annuity, Non-level annuities, Continuous annuities. Introduction to Actuarial Science, Role of Actuaries: Business, Finance, Stock Markets, Banks and other Financial Institutions. The role of Actuaries in Government Departments: SECP, State Bank, Employee Benefits Management. Insurance and Assurance, Types of Insurance: Life Insurance, Health Insurance, Motor Insurance, Businesses and Pension Fund. Islamic Mode of Insurance / Takaful. Life Insurance Contract: Define simple insurance contracts and devolve the formulae for mean and variance of the present values of the payments under these contracts, Whole life assurance, Term assurance, Pure endowment assurance, endowment assurance and critical ill-health assurance including assurances where the benefits are deferred also derive their mean and variances Define the symbols, A_x, $A_{x\sqrt{n}}$, $A_{1\,x\sqrt{n}}$, $A_{x\sqrt{n}}^1$ and their select and continuous equivalents.

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Books Recommended

i. Bowers, N.L. Gerber, H.U. Hickman, J.C. Jones, D.A. and Nesbitt, C.J. (1986). "*Actuarial Mathematics*", Society of Actuarial, Ithaca, Illinois, U.S.A. Second Edition (1997).

ii. Neill, A. (1977). "*Life Contingencies*", Heineman.

iii. Spurgeon, E.T. (1972), "*Life Contingencies*", Cambridge University Press.

BS Statistics (4-Years)		
ACTUARIAL STATISTICS-II		
STAT 444	**Marks 100**	**Cr. Hr. 03**

Course Objectives:
- Developing an understanding of the mathematical concepts and techniques that are used to model and value cash flows contingent on survival, death and other uncertain events.
- Building mathematical foundations of life insurance and superannuation models.

Learning Outcomes:
- Understanding the Life Tables, Types and Computations.
- Understanding the Theories of Mortality, Analytical Laws and Projections.
- Develop and analyze the pension and benefit strategies that are equitable and meet the needs of diverse communities.

Course Contents:

Life Tables: Describe the life table functions, express life table probabilities in term of the actuarial related functions used both in assurances and annuities. Evaluation of assurances and annuities: derive the relations between assurance and annuities and their select and continuous equivalents. Net premiums and provisions: ultimate and select mortality; net premiums and net premium provisions, random future loss, , prospective and retrospective provisions, Derive Thiele's equation, Death strain at risk, expected death strain, actual death strain, mortality benefits, Simple annuities and assurances involving two lives. Mortality: Theories of Mortality, analytical laws of mortality, techniques of projections of population mortality. Pension Theory: Structure and design of pension funds, Basic actuarial aspects of pension plans, Actuarial assumptions and actuarial cost methods, periodic gain and loss analyses, Relative merits of cost methods, sensitivity analysis.

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Books Recommended

i. Bowers, N.L. Gerber, H.U. Hickman, J.C. Jones, D.A. and Nesbitt, C.J. (1986) "*Actuarial Mathematics*", Society of Actuaries, Ithaca, Illinois, U.S.A. Second Edition (1997).

ii. Spurgeon, E.T. (1972). "*Life Contingencies*", Cambridge University Press.

iii. Neill, A. (1977). "*Life Contingencies*", Heinemann.

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BS Statistics (4-Years)		
MATHEMATICAL MODELING AND SIMULATION		
STAT 445	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- To understand the mathematical models using simulation

- To understand the simulation approaches to problem solving, on a diverse variety of disciplines.

- To check the validity of models.

Learning Outcomes:

- Recognize the connections between simulated and real data.

- Familiar with a variety of simulated examples where mathematical models helps accurately explain physical phenomena.

- Able to independently expand their mathematical or statistical expertise when needed, or for interest's sake.

Course Contents:

Monte Carlo methods: Different methods of generating random variables, generation of random numbers, acceptance and rejection techniques from various distributions. Comparison of algorithms to generate random variables. Generating random variables from failure rates. Generation from multinomial distribution / Monte Carlo integration. Gibbs sampling and other techniques. Variance reduction techniques: importance sampling for integration, control variates and antithetic variables.

Books Recommended:

    i.   Ross, S.M.(2002). "*Simulation*" (Third Edition) (Academic)

    ii.   Fishman, G.S. (1996). Monte Carlo: *"Concepts, Algorithms, and Applications*", (Springer).

    iii.   Rubinstein, R.Y. (1981). "*Simulation and the Monte Carlo Method",* (Wiley).

    iv.   Ripley, B.D. (1987) "*Stochastic Simulations*" (Wiley)

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BS Statistics (4-Years)		
CATEGORICAL DATA ANALYSIS		
STAT 446	**Marks 100**	**Cr. Hr. 03**

Course Objectives:
- To understand the basic concepts of categorical data analysis
- To recognize different types of categorical data and use appropriate methodology for categorical data
- To conduct statistical analysis using existing software and properly interpret the computer output.

Learning Outcomes:
- Implement basic categorical methods and combine them for the sampling estimation
- Obtain estimators, evaluate standard errors, construct confidence intervals and making statistical inference according to the categorical analysis techniques
- Apply the principles of lifelong learning to any new challenges arise with categorical data
- Demonstrate the knowledge to characterize, analyze and solve a wide range of problems related to the categorical data

Course Contents:

A brief history of categorical data analysis, Principles of likelihood-based inference, Sampling distributions for contingency tables, Measures of association for 2x2 tables, Testing independence in contingency tables, Exact inference for two-way tables, Inferences for three-way tables.

Introduction to generalized linear models, Logistic regression, Model building, Alternative link functions for binary outcome, Diagnostics, Receiver Operating Characteristic (ROC) Curve Analysis. Exact methods and conditional logistic regression, Methods for analyzing matched case-control data, Multinomial response models for nominal data, Multinomial response models for ordinal data.

Poisson regression model, Poisson regression for rates, Log linear models for contingency tables.

Books Recommended
i. Agresti, A. (1990), "*Categorical Data Analysis*", John Wiley and Sons.

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ii.   Bishop, Y.V.V., Fienberg, S.E. and Holland, P.W. (1975). "*Discrete Multivariate Analysis*", MA: MIT Press Cambridge.

iii.   Cox, D.R. and Snell, E.J.(1989). "*The Analysis of Binary Data*", Chapman and Hall, London.

iv.   David, W.H., Leweshow, S.L. (1989). "*Applied Logistic Regression*".

v.   Mc Gullah, P. and Nelder, J.A. (1989). "*Generalized Linear Models*", 2nd ed. Chapman and Hall, London.

vi.

BS STATISTICS (4-YEARS)		
NUMERICAL METHODS		
STAT 220	Marks 100	Cr. Hr. 03

Course Contents:

Introduction to Interpolation. Finite and Central Difference Operators. Factorial Polynomial. Finite and Divided Differences. Newton-Gregory, Newton Divided Difference and Newton-gauss formulas. Of Interpolation.

Introduction to numerical Integration and Summation. Approximation to a Definite Integral. Euler-Maclaurin Formula and its Application to summation of series and the sum of power of the whole numbers. Remainder Term in the Euler. Maclaurin Expansion. Stirling's Approximation to the factorial. Gregory's formula of Numerical Integration. Trapezoidal, Simpson's one-third and Simpson's three-eights rules.

Recommended Books:

i.   Mumtaz. K. (2002). "Numerical Methods", 2nd Edition. Engineering University Peshawar.

ii.   Scheid, F. (1983). "Numerical Analysis Schaum's Outline Series", McGraw Hill Book Company.

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iii.   Watson, W. A., Phlipson, T. and Oates, P. J. (1981). "Numerical Analysis", 2nd Edition. Edward Arnold Limited, London.

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BS Statistics (4-Years)		
BAYESIAN STATISTICS		
STAT 448	**Marks 100**	**Cr. Hr. 03**

Course Objectives:

- The aim of this course is to introduce the modern approach to Bayesian statistics,

- This course is emphasizing the computational aspects and the differences between the classical and Bayesian approaches.

- This course will help in formulating appropriate Bayesian models, including data and prior distributions.

Learning Outcomes:

- Understanding basic techniques of Bayesian statistics for decision making

- Using different simulation techniques to handle complex posterior distribution

- Knowing the application of Bayesian statistics in different models

Course Contents:

Introduction to Bayesian Inference, goals of Bayesian Inference, Conditional Probability, Conditional independence, Prior distribution and its different types, Posterior distribution, its mean, median (Bayes estimators under loss functions) and variances. Posterior Inference based on one parameter e.g. binomial, Poisson etc. Posterior inference based on normal distribution: Posterior predictive distributions, Bayesian Hypotheses Testing: Bayes factor; The highest density region; Introduction to Monte Carlo method, Discrete approximations.

Books Recommended

i.   O.Hagan A. Kendall's Advanced Theory of Statistics (Vol.2B), Bayesian Inference, Cambridge, The University Press (1994).

ii. Bernardo, J. M. & Smith, A.F.M., Bayesian Theory, John Wiley, New York (1994).

iii. Lee, P.M. Bayesian Statistics, An Introduction, Oxford University Press, New York (1991).

iv. Berger, J.O., Statistical Decision Theory and Bayesian Analysis (2nd Ed.), New York, Springer Verlag (1985).

v.   Box, G.E. P & Tiao, G. C. Bayesian Inference in Statistical Analysis, Reading Addison-Wesley (1973).

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BS Statistics (4-Years)		
STATISTICAL QUALITY CONTROL		
STAT 226		**Cr. Hr. 03**

Course Objectives:

- This course is designed to provide a conceptual and practical knowledge of techniques for quality control.
- This course is structured to monitor the process control via control charts.
- This course is designed to determine most appropriate sample size needed to accept or reject a lot of material.

Learning Outcomes:

- Design attribute and variable acceptance sampling plans for the industrial purpose.
- To construct various types of attribute and variable sampling plans using statistical software.
- Draw attribute and variable control charts to be implemented in different scenarios exist in industry.
- To construct various types of attribute and variable control charts to be implemented in different scenarios exist in industry.

Course Contents:

Concept of quality control, total control and Total Quality Management (TQM) Statistical Methods in Quality Improvement. Statistical Process Control (SPC). Statistical Quality Control (SQC). Shewhart control charts: philosophy, construction, advantages. CUSUM and moving average control charts: Average Run Length (ARL); Standard deviation run length (SDRL). X, R and S-charts. Process capability analysis: Designed experiments. Process improvements using design of experiments. Acceptance sampling for attributes and variables. Acceptance sampling plans: Single, double, and multiple sampling plans with their operatic characteristic (O.C). curves, Introduction to ISO- 9000 and ISO-14000 series.

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Books Recommended

    i.   Montgomery, D.C. (2004). "*Introduction to Statistical Quality Control*". McGraw Hill, New York.

   ii.   Miltag H. J. and Rinne H. (1993). "*Statistical Methods of Quality Assurance*", Chapman & Hall, London.

 iii.   Nelson, W. (1990). "*Accelerated Testing*". John Wiley, New York.

 iv.   Banks, J. (1989). "*Principles of Quality Control*". John Wiley, New York.

  v.   Ryan, T.P. (1989). "*Statistical Methods for Quality Improvement*". John Wiley, New York.

 vi.   Juran, J.M. and Guyana, F.K. (1988). "*Juan's Quality Control Handbook*". McGraw Hill New York.

      Feigenbaum, A.V. (1986). "*Total Quality Control*". McGraw Hill, New York.

BS (4-Years)		
INFERENTIAL STATISTICS		
STAT 217	**Marks. 100**	**Cr. Hr. 03**

Aims:

To give the basic knowledge of Statistics and prepare the students not majoring in Statistics

Objectives:

After completion of this course the student should be able to:

- Understand the use of the essential tools of basic Statistics;
- Apply the concepts and the techniques in their respective discipline and research work.

Course Contents:

Probability and Probability Distributions: *Probability:* Random experiments,' sample space and events. Counting techniques. Definitions and axioms of probability. Basic laws of probability.

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Independence of events. Bayes Theorem (proof not required) and its application. *Discrete and continuous distributions:* Binomial, Poisson Geometric and Normal Distribution. Exercises

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.

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. *Testing of Hypothesis- Single Population:* Introduction, testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, *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 *Testing of Hypothesis-Independence of Attributes:* Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes. Chi-square test of Independence, Chi square test of goodness of fit, Chi- square test of homogeneity, Introduction and application of F-distribution: Test of hypothesis for equality of two variance.

Recommended Books

i. Johnson, R and Kuby, P. (2004) "Elementary Statistics" 9th Edition Brooks/Cole, a division of Thomson Learning, Inc. USA

ii. Walpole, R.E., Myers, R.H and Myers, S.L. (1998), "Probability and Statistics for Engineers and Scientist" 6th edition, Prentice Hall, NY.

iii. Chaudhry, S.M.and Kamal, S. (1996), "Introduction to Statistical Theory" Parts I & II, 6th ed, Ilmi Kitab Khana, Lahore

iv. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000) "Probability and Statistics", 2nd ed. Schaums outlines Series. McGraw Hill. NY.

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CORE COURSE	
DATA ANALYSIS IN R	
STAT 449	Cr. Hr. 03

Course Contents:

Data: Data Types in R, Data Importing/Exporting, Data input in R, Missing data, Date Values and Basic packages.

Data Summarization: Creating a Graph, Histogram and Density Plots, Dot Plots, Bar Charts, Line Charts, Pie Chart, Boxplots and Scatterplots. Computation of Averages (Arithmetic Mean, Median, Mode) and other summary Statistics.

Basic Statistical Inference: Inferential Statistics, Performing hypothesis testing using t-test, F-test, Chi square test, non-parametric tests and inferences for Regression and Correlations.

Recommended Books:

i. Lander, J. P. (2014).*R for everyone: Advanced analytics and graphics*. Pearson Education.

ii. Teetor, P. (2011).*R cookbook: Proven recipes for data analysis, statistics, and graphics*. " O' Reilly Media, Inc.".

iii. Davies, T. M. (2016). The book of R: a first course in programming and statistics. No Starch Press.

iv. Field, A., Miles, J., & Field, Z. (2012).Discovering statistics using R. Sage publications.

v. Quick R by Data Camp https://www.statmethods.net/

DETAILS OF ALLIED COURSES FOR BS (4-YEARS) PROGRAM IN STATISTICS

Machine Learning SE-472		
Credit Hours: | 3 (3,0) | **Prerequisites:** |None		
bourse Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
CLOs will be defined by the concerned teacher when offered.		
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		

Introduction to machine learning and statistical pattern recognition. Supervised learning: Part I (Graphical models (full Bayes, Naive Bayes), Decision trees for classification & regression for both categorical & numerical data, Ensemble methods, Random forests, Boosting (Adaboost and Xgboost), Stacking; Part II (Four Components of Machine Learning Algorithm (Hypothesis, Loss Functions, Derivatives and Optimization Algorithms), Gradient Descent, Stochastic Gradient Descent, Linear Regression, Nonlinear Regression, Perceptron, Support vector machines, Kernel Methods, Logistic Regression, Softmax, Neural networks); Unsupervised learning: K-means, Density Based Clustering Methods (DBSCAN, etc.), Gaussian mixture models, EM algorithm, etc.;
\| Reinforcement learning; Tuning model complexity; Bias-Variance Tradeoff; Grid Search, Random Search; Evaluation Metrics; Reporting predictive performance.

Teaching Methodology: _____
Lectures, Written Assignments, Practical labs, Semester Project, Presentations _____
Course Assessment: _____
Midterm Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam _____
Reference Materials:

Course Name: **Artificial Intelligence**   CS-324

Credit Hours: 3 (2+1) }

Prerequisites: Discrete Structures

Incharge
Department of Statistics
University of Malakand

Assistant Registrar
(Academics) 05-Dec-2023
University of Malakand

Course Outline: Artificial Intelligence: Introduction, Al Paradigms and Hypothesis, Intelligent Agents. Difference between Cybernetic Intelligence and Artificial Intelligence, Objectives and Scope of Weak Al and Strong Al, Problem-solving: Solving Problems by Searching, Informed Search and Exploration, Constraint Satisfaction Problems, Adversarial Search. Knowledge and reasoning: Logical Agents, First-Order Logic, Inference in First-Order Logic, Knowledge Representation. Planning and Acting in the Real World. Uncertain knowledge and reasoning: Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Making Simple Decisions, Making Complex Decisions. Learning: Learning from Observations, Knowledge in Learning; Learning Methods, Reinforcement Learning. Communicating, perceiving, and acting: Communication, Probabilistic Language Processing, Perception and Robotics. Introduction to LISP/PROLOG and Expert Systems (ES) and Applications; Artificial General Intelligence, Issues in Safe Al, Introduction to Cognitive and Conscious Systems.

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Reference Materials:

1. Artificial Intelligence: Structures and Strategies for Complex Problem Solving: International Edition by George F. Luger, Latest Edition

2. Artificial Intelligence: A Modern Approach, by Stuart Jonathan Russell, Peter Norvig, John F. Canny, Latest Edition, Prentice Hall

3. Prolog Programming for Artificial Intelligence, Ivan Bratko, Latest Edition, Addison Wesley

Note:

Courses included in the General Education Category are designed by the respective departments including their course codes, credit hours and titles (reflected in the scheme of studies). All such courses approved by the Syndicate are available on the university website. For any query the office of the Registrar Academics may be approached for clarification/guidance.

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University of Malakand 05-Dec-2023