

**Department of Statistics**  
**University of Balochistan, Quetta**



**Syllabus for BS in STATISTICS**

(Effective for Session 2018 and onwards)

## Aims and Objectives

The major aims and objectives of the curriculum of Statistics are to adapt the curriculum to meet the international standards.

1. To provide a sound footing of the subject matter of statistical theory with applications, so that the students can pursue higher degrees and research in the field of statistics.
2. To train the students in the use of statistical software and techniques of data collection and analysis so that they can compete in the job market.
3. To involve the students in research project so that they can be better trained in the field of research.
4. To develop a solid foundation for the effective operational and strategic decisions based on statistical theory and methodology in almost every discipline.

## Admission Criterion for BS in Statistics

As per University of Balochistan criterion:

The candidate seeking admission in BS Statistics Program, must meet the following eligibility criterion.

- Intermediate with Mathematics or equivalent with at least 50% marks. Or
- Diploma of Associate Engineering Examination with at least 60% marks.

## Scheme of studies for BS Statistics as per HEC criteria:

BS (Statistics) is a 134 credit hours program of studies spread over eight semesters. The domains and the number of courses and their credit hours assigned to these domains are as follows:

| Course Domain                            | Number of Courses | Number of Credit Hours |
|--|-------------------|------------------------|
| Compulsory requirement                   | 9                 | 25                     |
| General Courses                          | 7                 | 21                     |
| Discipline Specific Foundation Courses   | 9                 | 28                     |
| Major Courses including Research Project | 12                | 45                     |
| Elective Courses within the Major        | 5                 | 15                     |
| <b>Total</b>                             | <b>42</b>         | <b>134</b>             |

### Details of courses

| Compulsory Requirements                                    |           | General Courses  |           | Discipline Specific Foundation Courses                       |           | Major Courses including Research Project |           | Elective Courses within the Major                               |           |
|--|-----------|--|-----------|--|-----------|--|-----------|---|-----------|
| 9 courses  |           | 7 courses  |           | 9 courses  |           | 12 courses                               |           | 5 courses   |           |
| 25 Credit hours  |           | 21 Credit Hours  |           | 28 Credit hours  |           | 45 Credit Hours                          |           | 15 Credit Hours   |           |
| Title  | Cr. Hr.   | Title  | Cr. Hr.   | Title  | Cr. Hr.   | Title                                    | Cr. Hr.   | Title   | Cr. Hr.   |
| 1. English-I (Functional English)                          | 3         | 1. Introductory Accounting                                     | 3         | 1. Introductory Statistics                                   | 3         | 1. Regression Analysis                   | 4         | 1. Operations Research  | 3         |
| 2. English-II (Communication Skills)                       | 3         | 2. Introduction to Logic                                       | 3         | 2. Introduction to Probability and Probability Distributions | 3         | 2. Design and Analysis of Experiments-I  | 4         | 2. Introduction to Time Series Analysis                         | 3         |
| 3. English-III (Technical Writing and Presentation Skills) | 3         | 3. Introduction to Computers                                   | 3         | 3. Basic Statistical Inference                               | 3         | 3. Probability Distributions-II          | 3         | 3. Biostatistics  | 3         |
| 4. Islamic Studies/Ethics                                  | 2         | 4. Fundamentals of Economics                                   | 3         | 4. Introduction to Regression and Analysis of Variance       | 3         | 4. Sampling Techniques-II                | 4         | 4. Stochastic Processes   | 3         |
| 5. Pakistan Studies  | 2         | 5. Principles of Management                                    | 3         | 5. Applied Statistics  | 3         | 5. Econometrics                          | 4         | 5. Bayesian Inference   | 3         |
| 6. Mathematics A-I (Calculus)                              | 3         | 6. Introduction to Environmental Sciences                      | 3         | 6. Probability Distributions-I                               | 3         | 6. Design and Analysis of Experiments-II | 4         | <b>OR</b><br><b>From the list of Elective Courses on page 4</b> |           |
| 7. Mathematics A-II (Analytical Geometry)                  | 3         | 7. Measure Theory  | 3         | 7. Sampling Techniques-I                                     | 4         | 7. Statistical Inference-1               | 3         |   |           |
| 8. Mathematics A-III (Numerical Methods)                   | 3         | <b>OR</b><br><b>From the list of General Courses on page 4</b> |           | 8. Statistical Packages                                      | 3         | 8. Applied Multivariate Analysis         | 3         |   |           |
| 9. Introduction to Computer Programming                    | 3         |  |           | 9. Linear Algebra  | 3         | 9. Population Studies                    | 3         |   |           |
|  |           |  |           |  |           | 10. Statistical Inference-II             | 4         |   |           |
|  |           |  |           |  |           | 11. Nonparametric Methods                | 3         |   |           |
|  |           |  |           |  |           | 12. Research Project                     | 6         |   |           |
|  |           |  |           |  |           |  |           |   |           |
|  |           |  |           |  |           |  |           |   |           |
|  |           |  |           |  |           |  |           |   |           |
|  |           |  |           |  |           |  |           |   |           |
|  |           |  |           |  |           |  |           |   |           |
| <b>Total</b>   | <b>25</b> |  | <b>21</b> |  | <b>28</b> |  | <b>45</b> |   | <b>15</b> |

## Model Scheme of Studies for BS (4-Year) in Statistics

| Year / Semester                | Course Code | Course Title  | Credit Hours |
|--------------------------------|-------------|---|--------------|
| <b>1<sup>st</sup> YEAR</b>     |             |   |              |
| <b>1<sup>st</sup> Semester</b> | STAT-601    | Introductory Statistics                                   | 3 (3-0)      |
|                                | ISL-601     | Islamic Studies / Ethics                                  | 2 (2-0)      |
|                                | ENG-601     | English-I (Functional English)                            | 3 (3-0)      |
|                                | MATH-601    | Mathematics A-I (Calculus)                                | 3 (3-0)      |
|                                |             | General-I   | 3 (3-0)      |
|                                |             | General-II  | 3 (3-0)      |
| <b>Total</b>                   |             |   | <b>17</b>    |
| <b>2<sup>nd</sup> Semester</b> | STAT-602    | Introduction to Probability and Probability Distributions | 3 (3-0)      |
|                                | PAK-601     | Pakistan Studies  | 2 (2-0)      |
|                                | ENG-602     | English-II (Communication Skills)                         | 3 (3-0)      |
|                                | MATH-602    | Mathematics A-II (Analytical Geometry)                    | 3 (3-0)      |
|                                |             | General-III   | 3 (3-0)      |
|                                |             | General-IV  | 3 (3-0)      |
| <b>Total</b>                   |             |   | <b>17</b>    |
| <b>2<sup>nd</sup> YEAR</b>     |             |   |              |
| <b>3<sup>rd</sup> Semester</b> | STAT-603    | Basic Statistical Inference                               | 3 (3-0)      |
|                                | ENG-603     | English-III (Technical Writing and Presentation Skills)   | 3 (3-0)      |
|                                | COMP-602    | Introduction to Computer Programming                      | 3 (2-1)      |
|                                |             | General-V   | 3 (3-0)      |
|                                |             |   | General-VI   |
| <b>Total</b>                   |             |   | <b>15</b>    |
| <b>4<sup>th</sup> Semester</b> | STAT-605    | Applied Statistics  | 3 (2-1)      |
|                                | STAT-604    | Introduction to Regression and Analysis of Variance       | 3 (3-0)      |
|                                | MATH-603    | Mathematics A-III (Numerical Methods)                     | 3 (3-0)      |
|                                | STAT-620    | Linear Algebra  | 3 (3-0)      |
|                                |             | General-VII   | 3 (3-0)      |
| <b>Total</b>                   |             |   | <b>15</b>    |
| <b>3<sup>rd</sup> YEAR</b>     |             |   |              |
| <b>5<sup>th</sup> Semester</b> | STAT-607    | Probability Distributions-I                               | 3 (3-0)      |
|                                | STAT-608    | Sampling Techniques-I                                     | 4 (3-1)      |
|                                | STAT-610    | Design and Analysis of Experiments-I                      | 4 (3-1)      |
|                                | STAT-609    | Regression Analysis                                       | 4 (3-1)      |
|                                | STAT-606    | Statistical Packages                                      | 3 (2-1)      |
| <b>Total</b>                   |             |   | <b>18</b>    |
| <b>6<sup>th</sup> Semester</b> | STAT-612    | Probability Distributions-II                              | 3 (3-0)      |
|                                | STAT-613    | Sampling Techniques-II                                    | 4 (3-1)      |
|                                | STAT-615    | Design and Analysis of Experiments-II                     | 4 (3-1)      |
|                                | STAT-614    | Econometrics  | 4 (3-1)      |
|                                |             | Elective-I  | 3 (3-0)      |
| <b>Total</b>                   |             |   | <b>18</b>    |

| 4 <sup>th</sup> YEAR     |          |                               |            |
|--------------------------|----------|-------------------------------|------------|
| 7 <sup>th</sup> Semester | STAT-617 | Statistical Inference-I       | 3 (3-0)    |
|                          | STAT-618 | Applied Multivariate Analysis | 3 (2-1)    |
|                          | STAT-611 | Nonparametric Methods         | 3 (3-0)    |
|                          |          | Elective II                   | 3 (3-0)    |
|                          |          | Elective-III                  | 3 (3-0)    |
| <b>Total</b>             |          |                               | <b>15</b>  |
| 8 <sup>th</sup> Semester | STAT-619 | Statistical Inference-II      | 4 (3-1)    |
|                          | STAT-616 | Population Studies            | 3 (3-0)    |
|                          | STAT-621 | Research Project              | 6          |
|                          |          | Elective-IV                   | 3 (3-0)    |
|                          |          | Elective-IV                   | 3 (3-0)    |
| <b>Total</b>             |          |                               | <b>19</b>  |
| <b>TOTAL</b>             |          |                               | <b>134</b> |

**Note:** 4 credit hours courses must include Lab. /Practical.

### List of General Courses

Seven courses are to be selected from the following list of courses, according to available facilities and faculty of the university.

1. Introductory Accounting
2. Introduction to Logic
3. Introduction to Computers
4. Fundamentals of Economics
5. Principles of Management
6. Introduction to Environmental Sciences
7. Chemistry
8. Physics
9. Introduction to Psychology
10. Introduction to Sociology
11. Measure Theory
12. Advanced Calculus
13. Introduction to International Relations
14. Fundamentals of Geography

or any other subject depending upon the expertise available.

### List of Elective Courses

Nine courses are to be selected from the following list of courses, according to available facilities and faculty of the university.

1. Operations Research
2. Introduction to Time Series Analysis
3. Stochastic Processes

4. Reliability Theory
  5. Decision Theory
  6. Population Models
  7. Robust Methods
  8. Survival Analysis
  9. Official Statistics
  10. Biostatistics
  11. Data Mining
  12. Actuarial Statistics-I
  13. Actuarial Statistics-II
  14. Mathematical Modeling and Simulation
  15. Categorical Data Analysis
  16. Research Methodology
  17. Bayesian Inference
  18. Statistical Quality Control
  19. Fundamentals of Mathematical Statistics
  20. Introductory Spatial Statistics
  21. Advanced Operations Research
  22. Applied Statistical Learning
- or any other subject depending upon the expertise available.

### **Course Contents for BS Statistics**

#### **Discipline Specific Foundation and Major Courses**

##### **STAT- 601: Introductory Statistics**

**3 (3-0)**

**Objectives:** This course will begin with a brief overview of the discipline of statistics and will then quickly focus on descriptive statistics, introducing graphical methods of describing data. By the end of this course, student gain a sound understanding about what statistics represent, how to use statistics to organize and display data, and how to draw valid inferences based on data by using appropriate statistical tools.

**Course Contents:** The nature and scope of the Statistics, Variables and their types, Data and its sources, Scales of measurements, Tabulation and classification of data, Graphs and Charts: Stem-and leaf diagram, Box and Whisker plots and their interpretation. Measures of Central Tendency, Quantiles, Measures of Dispersion: Their properties, usage, limitations and comparison. Moments, Measures of Skewness and Kurtosis and Distribution shapes. Rates and ratios, Standardized scores.

Index numbers: construction and uses of index numbers, un-weighted index numbers (simple aggregative index, average of relative price index numbers), weighted index numbers (Laspeyres, Paasche and Fisher's ideal index numbers), Consumer price index (CPI) and Sensitive Price Indicators

**Recommended Books:**

1. Clarke, G.M. and Cooke, D. (2004). *A Basic Course in Statistics*, 5<sup>th</sup> ed. John Wiley, London.
2. Chaudhry, S.M. and Kamal, S. (2008). *Introduction to Statistical Theory*, Parts I & II, 8<sup>th</sup> ed. Ilmi Kitab Khana, Lahore, Pakistan.
3. Mann, P. S. (2010). *Introductory Statistics*. Wiley.
4. Mclave, J.T., Benson, P.G. and Snitch, T. (2005). *Statistics for Business & Economics*, 9<sup>th</sup> ed. Prentice Hall, New Jersey.
5. Stephens, L. J. (2006). *Schaum's Outline of Theory and Problems of Beginning Statistics*, 2<sup>nd</sup> ed. McGraw-Hill, New York.
6. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000). *Probability and Statistics*, 2<sup>nd</sup> ed. Schaums Outlines Series. McGraw Hill. New York.
7. Sullivan, M. (2011). *Fundamentals of Statistics*, 3<sup>rd</sup> ed. Prentice Hall, Boston.
8. Walpole, R.E., Myers, R.H. and Myers, S.L. (1998). *Probability and Statistics for Engineers and Scientist*, 6<sup>th</sup> ed. Prentice Hall, New York.
9. Weiss, N.A. (1997). *Introductory Statistics*, 4<sup>th</sup> ed. Addison-Wesley Pub. Company, Inc.

**STAT- 602: Introduction to Probability and Probability Distributions 3 (3-0)**

**Objectives:** Probability theory is the branch of mathematics that deals with modeling uncertainty. It is important because of its direct application in areas such as genetics, finance and telecommunications. This course provides an introduction to probability theory, random variables and Markov processes.

**Course Contents:** Probability Concepts, Addition and Multiplication rules, bivariate frequency tables, joint and marginal probabilities, Conditional probability and independence, Bayes' rule. Random Variables, Discrete Probability Distribution, Mean and Variance of a discrete random variable, Bernoulli trials, Properties, applications and fitting of Binomial, Poisson, Hypergeometric, Negative Binomial and Geometric distributions  
Continuous Random Variable, probability density function and its properties, Normal Distribution and its properties, Standard Normal Curve

**Recommended Books:**

1. Cacoullos, T. (2009). *Exercises in Probability*. Springer-Verlag, New York.
2. Chaudhry, S.M. and Kamal, S. (2008). *Introduction to Statistical Theory*, Parts I & II, 8<sup>th</sup> ed. Ilmi Kitab Khana, Lahore, Pakistan.
3. Mann, P.S. (2010). *Introductory Statistics*. Wiley, New York.
4. Clark, G.M. and Cooke, D. (1998). *A Basic Course in Statistics*, 4<sup>th</sup> ed. Arnold, London.
5. Mclave, J.T., Benson, P.G. and Snitch, T. (2005), *Statistics for Business & Economics*, 9<sup>th</sup> ed. Prentice Hall, New Jersey.
6. Santos, D. (2011). *Probability: An Introduction*. Jones and Bartlett Learning,
7. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000). *Probability and Statistics*, 2<sup>nd</sup> ed. Schaums Outlines Series. McGraw Hill. NY.
8. Walpole, R.E., Myers, R.H and Myers, S.L. (2007). *Probability and Statistics for Engineers and Scientist*, 7<sup>th</sup> ed. Prentice Hall, NY.
9. Weiss, N.A. (1997). *Introductory Statistics*, 4<sup>th</sup> ed. Addison-Wesley Pub. Company, Inc.

**STAT- 603: Basic Statistical Inference****3 (3-0)**

**Objectives:** This course studies the fundamentals of Statistical Inference and teaches how to draw the right conclusions and interpretations about a model that has generated the data set. In this course student will learn which are the most efficient statistical inference procedures used in practice and will understand in what sense these procedures are considered to be efficient.

**Course Contents:** Sampling and sampling distribution of sample mean, proportion, difference between means and difference between proportions; Point and interval estimate properties of good point estimator; Testing of hypothesis for population mean, difference between population means and population proportion and difference between two population proportions, difference between means for paired data; Single population variance, ratio of two variances. Introduction of Non-parametric methods: The sign test, Wilcoxon's signed rank test, Mann-Whitney U test, Median test, Run test, Kolmogorov-Smirnov test, Kruskal-Wallis test, Median test for k-samples, Friedman's test.

**Recommended Books:**

1. Chaudhry, S.M. and Kamal, S. (2008). *Introduction to Statistical Theory*, Part I, II, 8<sup>th</sup> ed. Ilmi Kitab Khana, Lahore, Pakistan.
2. Clark, G.M. and Cooke, D. (1998). *A Basic Course in Statistics*, 4<sup>th</sup> ed. Arnold, London.
3. McIave, J.T., Benson P.G. and Snitch, T. (2005). *Statistics for Business & Economics*, 9<sup>th</sup> ed. Prentice Hall New Jersey.
4. Spiegel, M.R., Schiller, J.L. and Sirinivasan, R.L. (2000). *Probability and Statistics*, 2<sup>nd</sup> ed. Schaums Outlines Series. McGraw-Hill. NY.
5. Walpole, R.E., Myers, R.H. and Myers, S.L. (2007). *Probability and Statistics for Engineers and Scientist*, 7<sup>th</sup> ed. Prentice Hall, NY.
6. Weiss, N.A. (1997). *Introductory Statistics*, 4<sup>th</sup> ed. Addison-Wesley Pub. Company, Inc.

**STAT- 604: Introduction to Regression and Analysis of Variance****3 (3-0)**

**Objectives:** The objective of this course is to provide foundations on regression and analysis of variance of experimental data obtained from laboratory and/or industrial processes. It is desired that at the end of the course, the student will be equipped with the basic knowledge and art of statistical data analysis combined with systematic approaches to regression and analysis of variance.

**Course Contents:** Relationship between variables. Simple linear regression. Estimation of parameters by method of least squares and corresponding variance estimates, Testing and confidence intervals for least squares estimators. mean prediction and individual prediction. Multiple linear regression with two regressors, coefficient of multiple determination. Partial and multiple correlation up to three variables. Inference of simple, partial and multiple correlation coefficients. Analysis of variance for one-way classification and two-way classification. Decomposition of total sum of squares. Multiple comparison tests; least significant difference and Duncans' multiple range test, Tukey's test.

**Recommended Books:**

1. Chaudhry, S.M., and Kamal, S. (2008). *Introduction to Statistical Theory*, Part I, II, 8<sup>th</sup> ed, Ilmi Kitab Khana, Lahore, Pakistan.



2. Clark, G. M. and Kempston, R. E. (1997). *Introduction to the Design & Analysis of Experiment*. Arnold London.
3. Walpole, P.E., Myers R.H., Myers S.L. (2007). *Probability and Statistics for Engineers and Scientists*, 7<sup>th</sup> ed. Prentice Hall.
4. Weiss, N.A, (1997). *Introductory Statistics*, 4<sup>th</sup> ed. Addison-Wesley Pub. Company, Inc.

### **STAT- 605: Applied Statistics**

**3 (2-1)**

**Objectives:** This course is designed to train the students in theoretical as well as applied statistics. The statistical analysis is a very essential part of research and students need to grasp the concepts, theoretical rational of use of certain statistical analysis and also to learn to carry out these analyses.

**Course Contents:** Sampling: Introduction to sampling, sample versus population, advantages of sampling, statistic and parameter. Probability sampling techniques: Simple Random sampling, Stratified random sampling, Systematic random sampling, Cluster Sampling. Non-probability sampling techniques: Quota sampling, purposive sampling, Snowball sampling. Census and survey problem, framing of questionnaire, Sampling and Non-Sampling Errors. Time Series Analysis: Components of time series and their decomposition.

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.)

#### **Recommended Books:**

1. Chaudhry, S.M. and Kamal, S. (2008). *Introduction to Statistical Theory*, Part I, II, 8<sup>th</sup> ed. Ilmi Kitab Khana, Lahore, Pakistan.
2. Clark, G.M. and Cooke, D. (1998). *A Basic Course in Statistics*, 4<sup>th</sup> ed. Arnold, London.
3. Cochran, W.G. (1977). *Sampling Techniques*, 3<sup>rd</sup> ed. John Wiley and Sons, New York.
4. Mclave, J.T. Benson, P.G. and Snitch, T. (2005). *Statistics for Business & Economics*, 9<sup>th</sup> ed. Prentice Hall, New Jersey.
5. Pollard, A.H. Yousuf, F. and Pollard G.M. (1982). *Demographic Techniques*. Pergamon Press, Sydney.
6. Walpole, P.E. Myers, R.H., Myers S.L. (1998). *Probability and Statistics for Engineers and Scientists*. Prentice Hall.

### **STAT- 606: Statistical Packages**

**3 (2-1)**

**Objectives:** This course is designed to train students to use statistical software, perform appropriate statistical analyses based on the research questions, research design, and appropriateness or tenability of statistical assumptions.

**Course Contents:** Introduction to Minitab, data manipulation in Minitab, graphical representation in Minitab, Qualitative and Quantitative data presentation and analyzing data in Minitab, Programming in Minitab

Introduction of SPSS, data manipulation in SPSS, simple arithmetic in SPSS, SPSS function related to probability distributions, SPSS modules, simple graphing in SPSS. Analysis using SPSS syntax programming

Introduction to R, statistical analysis and programming with R.

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

**Recommended Books:**

1. Colin D. Gray and Paul R. Kinnear. (2012). *IBM SPSS statistics 19 made simple*. Psychology Press, New York.
2. Kerr A. W., Hall, H. K., and Kozub, S. A. (2002). *Doing Statistics with SPSS*. Sage Publications.
3. de Sá, M. and Joaquim, P. (2003). *Applied Statistics using SPSS, STATISTICA and MATLAB*. Springer, NY.
4. Ryan, Barbara F. Joiner, Brian L. and Cryer, Jonathan D. (2005). *MINITAB Handbook*, 5<sup>th</sup> ed. Duxbury Press, California.
5. Crawley, M.J. (2007). *The R Book*. John Wiley & Sons Ltd, Chichester.

**STAT- 607: Probability Distributions- I**

**3 (3-0)**

**Objectives:** Probability theory is the branch of mathematics that deals with modelling uncertainty. It is important because of its direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modelling. This course provides an elementary introduction to probability and probability distribution with applications.

**Course Contents:** Distribution function, Probability mass function and probability density function. Location, scale, and shape parameters. Joint and conditional distributions for two and more random variables, Marginal and conditional distributions, stochastic independence, Baye's theorem, Mathematical expectation and its properties Conditional expectation, variance and moments, Probability generating function, Moment generating and characteristic functions and their properties. Factorial Moments, Cummulants. Relation between moments and cummulants. Probability distributions: Bernoulli, Binomial, Hypergeometric, Poisson, Negative binomial, Geometric, discrete uniform, Multinomial distribution. Normal approximation to binomial & Poisson distribution, Normal distribution with moments and cummulants

**Recommended Books**

1. Fridett, B. and Gray, L. (1997). *A Modern Approach to Probability Theory*. Birkhallser, Boston.
2. Freund, J. E. (1997). *Mathematical Statistics*, 6<sup>th</sup> ed. Prentice Hall, New Jersey.
3. Hirai, A.S. (2002). *A Course in Mathematical Statistics*, Ilmi Kutab Khana, Lahore.
4. Hogg, R.M. and Craig, A.T. (1995). *Introduction to Mathematical Statistics*. Prentice Hall, Engle wood Cliffs, New Jersey.
5. Mood, A.M, Graybill, F.A. and Boes, D.C. (1997). *Introduction to the Theory of Statistics*. McGraw Hill, New York.
6. Norman L. Johnson , Samuel Kotz , N. Balakrishnan (1994). *Continuous Univariate Distributions*, Vol. 1 (Wiley Series in Probability and Statistics). Wiley-Interscience: New York.

7. Ross, S.M. (2009). *First Course in Probability*, 8<sup>th</sup> ed. Pearson.
8. Stirzaker, D. (1999). *Probability and Random Variables*. Cambridge University Press, Cambridge.
9. Stuart, A. and Ord, J.K. (1998). *Kendall's Advanced Theory of Statistics*, Vol. I. Charles Griffin, London.

#### **STAT- 608: Sampling Techniques-I**

**4 (3-1)**

**Objectives:** This course will introduce students to a wide range of statistical sampling techniques that are used to make inferences about a population. Students will learn when to use and how to implement sampling designs especially the Simple Random Sampling and the Stratified Random Sampling. They will also understand why the sampling design used to collect data determines how we choose to graph the data, estimate certain parameters, and quantify the uncertainty in these estimates with a margin of error.

**Course Contents:** 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, Ratio and regression estimates in simple and stratified random sampling

#### **Recommended Books:**

1. Bethelam, J. (2009). *Applied Survey Methods: A Statistical Perspective*. Willey.
2. Chambers, R. L., and Skimmer, C. J. (2003). *Analysis of Survey Data*. Wiley.
3. Chaudhary, A. and Stemger, H. (2005). *Survey sampling theory and methods*. Chapman & Hall.
4. Cochran, W.G. (1977). *Sampling Techniques*, 3<sup>rd</sup> ed. John Wiley and Sons, New York.
5. Kish, L. (1992). *Survey Sampling*. John Wiley, New York.
6. Rao, P.S.R.S. (2000). *Sampling Methodologies with Applications*. Chapman & Hall
7. Raj, D. and Chandhok, P. (1998). *Sample Survey Theory*. Narosa Publishing House, New Delhi.
8. Singh, R. and Singh N. (1996). *Elements of Survey Sampling*. Kulwar Academic Publisher, Dodrecht.
9. Sukhatme, P.V, Sukhatme, B., Sukhatme, S., and Asok, A. (1985) *Sampling Theory of Survey with Application*. Iowa State University Press

#### **STAT- 609: Regression Analysis**

**4 (3-1)**

**Objectives:** This course is offered to develop a thorough understanding of regression analysis, master basic techniques of reproducible research, conduct basic and advanced regression analyses.

**Course Contents:** Linear regression and its assumptions, Least squares estimators, Maximum Likelihood Estimator, tests of significance for regression model and regression parameters. Confidence intervals for regression parameters, Test of linearity of regression, Use of

extraneous information in linear regression model. Residual analysis, Detection and study of outliers and influential observations, Polynomial regression, orthogonal polynomial, orthogonal regression analysis, Specification of models.

**Recommended Books:**

1. Baltagi, B. H. (1999). *Econometrics*, 2<sup>nd</sup> ed. Springer-Varlag.
2. Johnston, J. and Di. Nardo, J. (1997). *Econometric Method*, 4<sup>th</sup> ed. McGraw-Hill, New York.
3. Gujarati, D.N. (2003). *Basic Econometrics*, 4<sup>th</sup> ed. McGraw Hill, New York.
4. Maddala, G.S. (1977). *Econometrics*. McGraw Hill. New York.
5. Yan, X. and Zu, X. G. (2009). *Linear Regression Analysis: Theory & Computing*. World Scientific Publications.
6. Wonnacott, T.H. and Wonnacott R.J. (1998). *Econometrics*. John Wiley, New York.
7. Greene, W.H. (2017). *Econometric Analysis*, 8<sup>th</sup> ed. Pearson.

**STAT- 610: Design and Analysis of Experiments-I**

**4 (3-1)**

**Objectives:** The course introduces the learner about the basic designs that included the Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD) and Latin Square Design. The course also touches some advance techniques like cross-over design and incomplete block design and covariance analysis. The course is designed to give the knowledge to learners to select the appropriate technique of design and analysis of experiment for real life problems especially in the field of agriculture, engineering, and biology.

**Course Contents:** Principles of design of experiments, aspects of experimental design, Analysis of variance and its assumptions, Cochran theorem, Fixed, random and mixed effect models, Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD), Latin square (LS) design, sample size estimation, Graeco-Latin square. Handling missing observations in all designs, Relative efficiency of designs, Estimation of mean squares and their expectations, Multiple Comparisons tests, Contrast analysis, Contrasts. Effect of violation of assumptions. Transformations. Incomplete block designs: BIBD - Lattice designs, PBIBD with recovery of intra-block information.

**Recommended Books:**

1. Montgomery, D. C. (2009). *Design and Analysis of Experiments*. 7<sup>th</sup> ed. John Wiley, New Jersey.
2. Boniface, D.R. (1995). *Experiment Design & Statistical Methods*. Chapman & Hall.
3. Cochran, W.G. and Cox, G.M. (1992). *Experimental Design*. John Wiley, New York.
4. Clarke, G.M., and Kempton, R.E. (1997). *Introduction to the Design & Analysis of Experiments*. Edward Arnold.
5. Das, M.N. and Geri, N.C, (1986). *Design and Analysis of Experiments*. John Wiley, New York.
6. Harold, R. L (1992). *Analysis of Variance in Experimental Design*. Springer-Verlag.
7. Hicks, C.R. (1982). *Fundamental Concepts in Design and Analysis of Experiments*. Saunders
8. Hunter, B. and Hunter, W. G. (2005). *Statistics for Experimenters: Design, Innovation and Discovery*. Wiley.

**STAT- 611: Nonparametric Methods****3(3-0)**

**Objectives:** The course gives an introduction to nonparametric statistics, starting with a repetition of the difference between the mean and the median and the influence of having data with a skewed distribution. The main idea of this course is to get students acquainted with the fundamentals, basic properties and use of the most important recent nonparametric techniques. Another aim is to familiarise students with research questions in this domain.

**Course Contents:** Rationale of non-parametric methods, Chi-Square Procedures: Chi-Square Goodness of fit Test, Chi-Square test of independence, Location estimates for single sample: The sign test, modified sign test, Wilcoxon signed rank test, confidence interval based on these tests. Runs test for randomness. Anderson-Darling test.

Distribution tests and rank transformation, Kolmogorov's test, Lilliefors's test and Shapiro-Wilks test for normality. Tests and estimation for two independent samples; the median test, Wilcoxon Mann – Whitney test. The Siegel – Tukey test, the squared rank test for variance, Smirnov test, Tests for paired samples, Kruskal – Wallis test, Friedman test, multiple comparison with the Friedman test, Cochran's test for binary responses Spearman's rank correlation coefficient, Kendall's rank correlation coefficient. Theil's regression method

**Recommended Books:**

1. Conover, W.J. (1999). *Practical Nonparametric Statistics*, 3<sup>rd</sup> ed. John Wiley and Sons, New York
2. Gibbons, J.D. and Chakraborti, S. (1992). *Nonparametric Statistical Inference*. Marcel Dekker, New York.
3. Lehman, E.L. (1973). *Nonparametric Statistical Methods, based on Ranks*. Holden-Day San Francisco
4. Maritz, J.S. (1995). *Distribution-Free Statistical Methods*. Chapman & Hall London
5. Sprint, P. (2007). *Applied Nonparametric Statistical Methods*, 4<sup>th</sup> ed. Chapman & Hall London.

**STAT- 612: Probability Distributions – II****3 (3-0)**

**Objectives:** This course provides an introduction to continuous variables and their probability distributions. Characteristics of continuous probability distributions and their properties. The course aims to introduce students to order statistics and their uses.

**Course Contents:** Uniform, Beta, Lognormal, Exponential, Gamma, Laplace, Rayleigh, Weibull with moments and cummulants; Distributions of functions of random variables: Chi-square, t and F distributions, their derivations and properties. Central limit and Chebyshev's theorems and other inequalities, Weak and Strong Laws of large numbers and their applications, Order statistics, Distributions of rth and sth order statistics, Bivariate Normal distribution.

**Recommended Books:**

1. Hogg, R.V., McKean, J.W., and Craig, A.T. (2005). *Introduction to Mathematical Statistics*, 6<sup>th</sup> ed. Prentice Hall.
2. Ross, S.M. (2002). *Introduction to Probability Models*, 8<sup>th</sup> ed. Academic Press.
3. Ross, S.M. (2005). *A First Course in Probability*, 7<sup>th</sup> ed. Prentice Hall.

4. Dekking, F. M., Kraaikamp, C., and Lopuhaae, H. P., and Meester, L. E. (2005). *A Modern Introduction to Probability and Statistics*. Springer.
5. Fridett, B. & Gray, L. (1997). *A Modern Approach to Probability Theory*. Birkhallser, Boston.
6. Freund, J. E. (1997). *Mathematical Statistics*. Prentice Hall, New Jersey.
7. Haq, M. (1984). *Foundation of Probability and Statistics*. Tahir sons, Urdu Bazar, Karachi.
8. Hirai, A.S. (1998). *A Course in Mathematical Statistics*. Ilmi Kutab Khana, Lahore.

### **STAT- 613: Sampling Techniques-II**

**3 (3-0)**

**Objectives:** This is an advance level course on sampling. The course covers the advance topics like systematics sampling, single stage and multistage cluster sampling, double sampling and also the comparison of methods. In the field of research, the role of sampling is very important. In this course, the sources of errors in survey is also discussed that increase the accuracy of sampling process.

**Course Contents:** Systematic sampling, Cluster Sampling. Efficiency of systematic sampling compared with simple random sampling, stratified random sampling and cluster sampling. Sub sampling, PPS-Sampling, Double Sampling, Multistage and Multiphase sampling, Thomson Hurwitz estimator, Comparison of different sample designs; non-response, their sources and bias, Randomized response.

#### **Recommended Books:**

1. Bethelam, J. (2009). *Applied Survey Methods: A Statistical Perspective*. Wiley.
2. Chambers, R. L., and Skimmer, C. J. (2003). *Analysis of Survey Data*. Wiley.
3. Chaudhary, A., and Stemger, H. (2005). *Survey sampling theory and methods*. Chapman & Hall.
4. Cochran, W.G. (1977). *Sampling Techniques*. 3<sup>rd</sup> ed. John Wiley and Sons, New York.
5. Raj, D. (1971). *Design of Sample Survey*. McGraw-Hill, New York.
6. Raj, D. and Chandhok, P. (1998). *Sample Survey Theory*. Narosa Publishing House, New Delhi.

### **STAT- 614: Econometrics**

**4 (3-1)**

**Objectives:** The objective of this course is to introduce students to the main concepts and tools used in econometrics. In particular, we will learn when and how to apply multivariate regression analysis. Students will learn to additional tools to handle time series and panel data and interpret regression outputs.

**Course Contents:** Introduction to econometrics, Problems of autocorrelation, multicollinearity, heteroscedasticity and their solution; 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.

**Recommended Books:**

1. Baltagi, B. H. (1999). *Econometrics*, 2<sup>nd</sup> ed. Springer-Verlag.
2. Draper, N.R. and Smith, H. (2004). *Applied Regression Analysis*. John Wiley, New York.
3. Gujarati, D. (2004). *Basic Econometrics*. John Wiley, New York.
4. Guttman, I. (1980). *Linear Models: An Introduction*. John Wiley, New York.
5. Johnston, J. and Di. Nardo, J. (1997). *Econometric Methods*, 4<sup>th</sup> ed. McGraw Hill, New York.
6. Koutsoyiannis, A. (1980). *Theory of Econometrics*. Macmillan.
7. Montgomery, D.C., and Peck E.A. (1992). *Introduction to Linear Regression Analysis*, 2<sup>nd</sup> ed. John Wiley and sons Inc. New York.
8. Greene, W.H. (2017). *Econometric Analysis*, 8<sup>th</sup> ed. Pearson.

**STAT- 615: Design and Analysis of Experiments-II****4 (3-1)**

**Objectives:** The course aims to equip students with the ability to critically review basic concepts and models of advanced experimental design and to analyze the results of a designed experiments in order to conduct the appropriate statistical analysis of the data.

**Course Contents:** Cross-over design. Analysis of covariance in CRD and RCBD. Introduction to Factorial Experiments: simple, main and interaction effects, hidden replication,  $2^k$ ,  $3^k$  series and mixed level factorial experiments and their analyses. Confounding in factorial experiments, Complete and partial confounding, single replication of factorial experiments, Fractional factorial experiments, Confounding in Fractional replications. Split-plot, split-split plot, strip plot and nested designs. Missing observations in Split plot design. Response surface designs. Fitting of response surface models and estimation of optimum response.

**Recommended Books:**

1. Montgomery, D.C. (2009). *Design and Analysis of Experiments*, 7<sup>th</sup> ed. John Wiley, New Jersey.
2. Boniface, D.R. (1995). *Experiment Design & Statistical Methods*. Chapman & Hall.
3. Cochran, W.G. and Cox, G.M. (1992). *Experimental Design*. John Wiley, New York.
4. Clarke, G.M. and Kempton, R.E. (1997). *Introduction to the Design & Analysis of Experiments*. Edward Arnold.
5. Das, M.N. and Geri, N.C. (1986). *Design and Analysis of Experiments*. John Wiley, New York.
6. Harold, R.L. (1992). *Analysis of Variance in Experimental Design*. Springer-Verlag.
7. Hicks, C.R. (1982). *Fundamental Concepts in Design and Analysis of Experiments*. Saunders
8. Hunter, B. and Hunter, W. G. (2005). *Statistics for Experimenters: Design, Innovation and Discovery*. Wiley.

**STAT- 616: Population Studies****3 (3-0)**

**Objectives:** This course will provide the collecting and interpreting demographic data. Introduce methods and techniques to analyze demographic data: life table, population projections, advanced survey analysis, qualitative research methods, population projection and population stationary.

**Course Contents:** Sources of Demographic Data: Components of population growth. Composition of population and vital events.

Testing the accuracy of the demographic data: Types and sources of errors. General testing procedures. Testing the accuracy of age sex data. Checking the accuracy of single year age distribution. Checking the accuracy of grouped-age data.

Basic demographic measures: Fertility and mortality measures. Mortality rates. Total and general fertility rates. Standardized death and birth rates.

Life Tables: Construction of complete and abridged life tables. Different types of life tables. Graph of  $I_x$ ,  $q_x$  and  $d_x$ . Description and uses of life table columns. Stationary population models. Model life tables. Population estimates and projections. Inter-censal estimates. Population projection through various methods.

### **Recommended Books**

1. Bogue, D.J. Arriagu, E.E. and Anderson, D.L. (1993). *Readings in Population Research Methodology*, Vol. I-VIII, United Nations Fund; Social Development Centre, Chicago.
2. Hinde, A. (1998). *Demographic Method*. Arnold New York.
3. Impagliazzo, J. (1993). *Deterministic Aspects of Mathematical Demography*. Springer Verlag New York.
4. Weinstein, J. and Pillai, V.K. (2001). *Demography: The Science of Population*. Allyn & Bacon.
5. Keyfitz, N. (1983). *Applied Mathematical Demography*. Springer Verlag N.Y.
6. Pollard, A.H., Yousaf, F. and Pollard, G.M. (1982). *Demographic Techniques*. Pergamon Press, Sydney.
7. Pakistan Demographic Survey (2007). Govt. of Pakistan.

### **STAT- 617: Statistical Inference-I**

**3 (3-0)**

**Objectives:** The course aim to teach students to understand the types of questions that the statistical method address, to apply statistical methods to other examples and situations, to interpret the results and use data to make evidence based decisions that are technically sound.

**Course Contents:** Estimation of Parameters, Properties of Estimators: unbiasedness, consistency, sufficiency, efficiency, Invariance, completeness. Cramer-Rao inequality, Rao-Blackwell and Lehmann - Scheffe Theorems, Methods of Estimation: Moments, Maximum likelihood, least-squares, minimum Chi- square and Bayes' method.

### **Recommended Books:**

1. Bickel, P.J. and Docksum, K.A. (2005), *Mathematical Statistics*, Vol I, 2<sup>nd</sup> ed. Prentice Hall, N.J.
2. Hogg, R.V., McKean, J.W. and Craig, A.T. (2005). *Introduction to Mathematical Statistics*. 6<sup>th</sup> ed. Prentice Hall.
3. Hogg, R.V., and Tanis, E.A. (2009). *Probability and Statistical Inference*. 8<sup>th</sup> ed. Pearson.
4. Lindgren, B.W. (1998). *Statistical Theory*. Chapman and Hall, New York.
5. Mood, A.M., Graybill, F.A. and Boss, D.C. (1997). *Introduction to the Theory of Statistics*. McGraw Hill, New York.
6. Rao, C.R., (2009). *Linear Statistical Inference and its Applications*. John Wiley, New York.
7. Rohatgi, V. K. (1984). *Statistical Inference*. Courier Dover Publications.



8. Stuart, A. and Ord, J.K. (2009). *Kendall's' Advanced Theory of Statistics*, Vol. II. Charles Griffin, London.

**STAT- 618: Applied Multivariate Analysis**

**3 (3-0)**

**Objectives:** This course is designed to provide students with a working knowledge of the basic concepts underlying the most important multivariate techniques, with an overview of actual applications in various fields, and with experience in actually using such techniques on a problem of their own choosing. The course will address both the underlying mathematics and problems of applications.

**Course Contents:** Introduction to Multivariate data analysis, Basics of matrix and vector algebra, Geometry of vectors and sample, Expectation of sample mean, covariance matrix, linear combination of variables, Generalized variance. Descriptive statistics. Quadratic form, eigen analysis, spectral decomposition. Bivariate Normal distribution, Multivariate Normal Distribution: Multivariate Normal density and its properties, Sampling distribution of sample mean vector and covariance matrix including their large sample behavior. MANOVA, Assessing normality, transformation to make non-normal data to normal, Outliers, Hotelling's  $T^2$  and likelihood ratio tests, Inferences about mean vector(s), Confidence regions and simultaneous comparisons of component means, Multivariate Linear Regression. Canonical correlation.

Exploratory Principal components analysis, Factor Analysis, Discrimination and Classification, Cluster Analysis

**Recommended Books:**

1. Anderson, T.W. (2003). *An Introduction to Multivariate Statistical Analysis*. John Wiley, New York.
2. Chatfield, C. and Collins, A.J. (1980). *Introduction to Multivariate Analysis*. Chapman and Hall, London.
3. Hair, J.F., Anderson R.E., Jatham, R.L. and Black W.C., (1998). *Multivariate Data Analysis*, 5<sup>th</sup> ed. Pearson Education, Asia edition.
4. Johnson, R.A. and Wichern, D.W. (1992). *Applied Multivariate Statistical Analysis*, 6<sup>th</sup> ed. Prentice Hall. London.
5. Hair, J.F.J., Black, W.C., Babin, B.J. and Anderson, R.E. (2009). *Multivariate Data Analysis*, 7<sup>th</sup> ed. Pearson education Asia Edition.
6. Manly, B.F.J. (1994). *Multivariate Statistical Methods, A Primer*, 2<sup>nd</sup> ed. Chapman and Hall, London.
7. Raykov, T. and Marcoulides, G. A. (2008). *Introduction to Applied Multivariate Analysis*. Tylor & Francis.

**STAT- 619: Statistical Inference-II**

**3 (3-0)**

**Objectives:** The object for this course, is that the student should learn and master the basic techniques and results, for statistical inference both in the frequentistic and Bayesian framework.

**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. 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.

**Recommended Books:**

1. Bickel, P.J., and Docksum, K.A. (2005), *Mathematical Statistics*, Vol I, 2<sup>nd</sup> ed. Prentice Hall, N.J.
2. Hogg, R.V., McKean, J.W., and Craig, A.T. (2005). *Introduction to Mathematical Statistics*, 6<sup>th</sup> ed. Prentice Hall.
3. Hogg, R.V., and Tanis, E.A. (2009). *Probability and Statistical Inference*, 8<sup>th</sup> ed. Pearson.
4. Lindgren, B.W. (1998). *Statistical Theory*. Chapman and Hall, New York.
5. Mood, A.M., Graybill, F.A. and Boss, D.C. (1997). *Introduction to the Theory of Statistics*. McGraw Hill, New York.
6. Rao, C.R., (2009). *Linear Statistical Inference and its Applications*. John Wiley, New York.
7. Rohatgi, V. K. (1984). *Statistical Inference*. Courier Dover Publications.
8. Stuart, A. and Ord, J.K. (2009). *Kendall's' Advanced Theory of Statistics*. Vol. II. Charles Griffin, London.

**STAT- 620:                      Linear Algebra**

**3 (3-0)**

**Objectives:** The main objective of this course is to help students learn in rigorous manner, the tools and methods essential for studying the solution spaces of problems in mathematics, engineering, the natural sciences, and social sciences and develop mathematical skills needed to apply these to the problems arising within their field of study; and to various real-world problems.

**Course Outline:** System of Linear Equations: Representation in matrix form. Matrices. Operations on matrices. Echelon and reduced echelon form. Inverse of a matrix (by elementary row operations). Solution of linear system. Gauss-Jordan method. Gaussian elimination. Determinants: Computing of determinants. Definition of higher order determinants. Properties. Expansion of determinants. Vector Spaces: Definition and examples, subspaces. Linear combination and spanning set. Linearly Independent sets. Finitely generated vector spaces. Bases and dimension of a vector space. Operations on subspaces, Intersections, sums and direct sums of subspaces. Quotient Spaces. Linear mappings: Definition and examples. Rank and nullity. Eigen-values and eigenvectors. Singular value decomposition.

**Recommended Books:**

1. Curtis, C.W. (2004). *Linear Algebra*. Springer.
2. Apostol, T. (1997). *Multi Variable Calculus and Linear Algebra*, 2<sup>nd</sup> ed. John Wiley and sons.

3. Anton, H and Rorres, C. (2010). *Elementary Linear Algebra: Applications*, 10<sup>th</sup> ed. John Wiley and Sons.
4. Friedberg, S. and Insel, A. (2003). *Linear Algebra*, 4<sup>th</sup> ed. Pearson Education Canada.
5. Grossman, S.I. *Elementary Linear Algebra*, 5<sup>th</sup> ed. Cengage Learning.

**STAT- 621: RESEARCH PROJECT**

**6**

**Note:** A research project will be assigned and completed by each student. At the end of the project, it will be mandatory for each student to submit his/her project/research report for evaluation.

## **Elective Courses for BS Statistics**

### **STAT- 622: Research Methodology**

**3 (3-0)**

**Course Contents:** Definition of Research, Types of Research: Quantitative and Qualitative research. Plagiarism and ethics of research. Selection of Problem, Search of References, Formation of Hypothesis and Procedure for its Testing, Research Design, Planning of Experiments and surveys to Test Hypothesis Objectivity, Principles of Experimental Design, Steps in Experimentation, Designing Questionnaire, Collection of Data, Data Analysis, Functional/causal 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.

#### **Recommended Books:**

1. William D. Crano and Marilyn B. Brewer (2001). *Principles and Methods of Social Research*. Lawrence Erlbaum.
2. Leonard Bickman, Debra Rog (1997). *Handbook of Applied Social Research Methods*. Sage Publications, Inc.
3. Linda Kalof and Amy Dan (2008). *Essentials of Social Research*. Open University Press.
4. Roger Sapsford and Victor Jupp Babbie (2006). *Data Collection and Analysis*. 2<sup>nd</sup> ed. Sage Publications Ltd.

### **STAT-623: Operations Research**

**3 (3-0)**

**Course Contents:** History and definition of Operation Research, Types of OR models, 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, Transportation Problem, Assignment problem. Network Analysis, PERT/CPM techniques, Queuing Models.

#### **Recommended Books:**

1. Bazarra, N.M., Jarvis J.J. and Sherali, H.D. (1990). *Linear Programming and Network Flows*, 2<sup>nd</sup> ed. John Wiley & Sons, NY.
2. Bronson, R. (1983). *Operations Research*. Schaums' Outline Series. McGraw-Hill.
3. Gupta, P.K. & Hira, D.S. (2008). *Operations Research*, 7<sup>th</sup> ed. S. Chand & Co., New Delhi.
4. Hillier, F.S. and Lieberman G. J. (2005). *Introduction to Operations Research*, 8<sup>th</sup> ed. Holden Day.
5. Ravindran, A., Philips, D.J and Silberg, J.J. (2007). *Operations Research: Principles and Practice*, 2<sup>nd</sup> ed. John Wiley.
6. Taha, H.A. (2002). *Operations Research*. Macmillan. London

### **STAT- 624: Population Models**

**3 (3-0)**

**Course Contents:** Stationary population models, Population estimates and projections, Intercensal estimates, Population projections through various methods. Theory of demographic transition, Stable and stationary population models, their applications and uses, Malthusian and post Malthusian theories of growth, Consequences of world population growth & population explosion; State of Population in Pakistan, Development of demographic profile in Pakistan, Recent demographic parameters. Current and future demographic activities in Pakistan

**Recommended Books**

1. Bogue, D.J. Arriagu, E.E., Anderson, D.L. (1993). *Readings in Population Research Methodology*, Vol. I-VIII, United Nations Fund; Social Development Centre, Chicago.
2. Hinde, A., (1998). *Demographic Method*. Arnold New York.
3. Impagliazo, J. (1993). *Deterministic Aspects of Mathematical Demography*. Springer Verlag New York.
4. Jay Weinstein, Vijayan, K. Pillai, (2001). *Demography: The Science of Population*. Allyn & Bacon.
5. Keyfitz, N. (1983). *Applied Mathematical Demography*. Springer-Verlag N.Y.
6. Pollard, A.H., Yousaf, F & Pollard, G.M. (1982). *Demographic Techniques*. Pergamon Press, Sydney.
7. Pakistan Demographic Survey (2007). Govt. of Pakistan.

**STAT- 625: Stochastic Processes**

**3 (3-0)**

**Course Contents:** Introduction, Generating Functions, Laplace Transforms, Difference Equations, Differential-Difference Equations, Introduction to Stochastic Processes. Types of stochastic process, stationary process. 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, Random process, Weiner process, Markov Processes with Discrete and continuous State Space (Continuous Time Markov Chains). Introduction to Brownian motion.

**Recommended Books**

1. Cox, D.R. and Miller H.D. (1984). *The Theory of Stochastic Processes*. Chapman and Hall, London.
2. Grimmet G. and Stirzaker D. (2001). *Probability and Random Processes*. Oxford University Press.
3. Hole, P.G., Port, S. and Stone, C.L. (1984). *An Introduction to Stochastic Process*. John Wiley, New York.
4. Karlin, S.A. and Taylor H.M. (1984). *A first course in Stochastic Process*. Academic Press London.
5. Medhi, J. (1982). *Stochastic Processes*. Wiley Eastern Ltd.
6. Ross, S. M. (2006). *Stochastic Process*. John Wiley, New York.
7. Srinivasin, S.K. and Mehta, K.M. (1988). *Stochastic Processes*. Tata McGraw-Hill.

**STAT- 626: Reliability Theory**

**3 (3-0)**

**Course Contents:** Basic concepts of reliability, Structural reliability, Life time 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 simulations, 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

**Recommended Books:**

1. Achintya Halder, Sankaran Mahadevan (2000). *Reliability Assessment Using Stochastic Finite Element Analysis*.
2. Gertsbakh, I.B. (1989). *Statistical Reliability Theory*. Marcel Decker. New York.
3. Gertsbakh, I. (2009). *Reliability Theory: with Applications to Preventive Maintenance*. Springer, New Dehli.
4. Lawless, J.F. *Statistical Model and Methods for Lifetime Data*, 2<sup>nd</sup> ed. John Wiley & Sons.
5. Mann, N.R., Scheefer, R.E. and Singapoor walla, N.D. (1974). *Methods for Statistical Analysis of Reliability*, John Wiley & Sons.

**STAT- 627: Introduction to Time Series Analysis**

**3 (3-0)**

**Course Contents:** Time series analysis: concepts, Stochastic Process, Stationary Time-Series, Exponential smoothing techniques, auto-correlation and auto-covariance, estimation of auto-correlation function (ACF) and Partial autocorrelation function (PACF) and standard errors, 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

**Recommended Books:**

1. Chatfield, C. (2000). *Time Series Forecasting*. Chapman and Hall, London.
2. Chatfield, C. (1996). *The Analysis of Time Series: An Introduction*. Chapman and Hall, London.
3. Box, G.E.P. and Jenkins, G.M., and Reinsel G. C. (2008). *Time Series Analysis: Forecasting and Control*. John Wiley & Sons.
4. Brock well P.J. and Davis R.A. (1991). *Time Series Theory and Methods*. Springer Verlag New York.
5. Chatfield C. (2003). *The Analysis of Time Series: An Introduction*. Taylor & Francis, NY, USA.
6. Cox, D. R., Hinckley D.V. and Nielsen O.E.B. (1996). *Time Series Models - In Econometrics, Finances and Other Fields*. Chapman & Hall, London.
7. Jonathan D. C. and Kung-Sik C. (2008). *Time Series Analysis with Applications in R*. Springer, USA.
8. Hamilton J. D. (1994). *Time Series Analysis*. Princeton University Press, UK.
9. Peter J. B and Richard A. D (2002). *Introduction to Time Series and Forecasting*. Second Edition, Springer, USA.

**STAT- 628: Decision Theory****3 (3-0)**

**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, Prior distributions and conjugate priors, Bayes' decision procedure. Admissibility of Bayes' and minimax procedures. Game theory

**Recommended Books:**

1. Berger, J.O. (1985). *Statistical Decision Theory & Bayesian Analysis*. Springer-Verlag.
2. Lindgren, B.W. (1971). *Elements of Decision Theory*. MacMillan New York.
3. Blackwell, D., and Girshick, M.A. (1966). *Theory of Games and Statistical Decision*. John Wiley & Sons, New York.

**STAT- 629: Robust Methods****3 (3-0)**

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

**Recommended Books:**

1. Rousseeuw, P.J., and Leroy, A.M. (1987). *Robust Regression and Outlier Detection*. John Wiley, New York.
2. Hampel, T.R., Roehetti, E.M., Rousseeuw, P.J., and Stahel, W.A. (1986). *Robust Statistics, The Approach based on Influence Functions*. John Wiley, New York.
3. Huber, P.J. (1981). *Robust Statistics*. John Wiley, New York.
4. Wilcox, R. (2005). *Introduction to Robust Estimation and Hypothesis Testing*, 2<sup>nd</sup> ed. Elsevier Academic Press. London.
5. Olive D. J. (2007): Applied Robust Statistics, Southern Illinois University Department of Mathematics.

**STAT- 630: Official Statistics****3 (3-0)**

**Course Contents:** Official Statistics, Statistical system and international standards, set up of national and provincial statistical organization in Pakistan, its role in development of Statistics, working and publications.

Sources of official Statistics, National Database Registration Authority (NADRA) and its role, Economic Statistics producers, International 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, Prices and price mechanisms. Deflation and Inflation of series, Industrial quantum index, National sample surveys and censuses conducted in Pakistan, and international data/surveys.

**Suggested Reports:**

1. Hansen M.H. (1980). *Progress and Problems in Survey Methods and Theory. Illustrated by the work of U.S. Bureau of the Census, U.S. Department of Commerce*; A Monograph.
2. NIPA (1962). *Administrative uses of Statistics*. NIPA Res. Sr.No.2 Karachi.
3. Statistical Institute for Asia & Pacific SIAP (1984). *Training of Trainers in Statistical Operations and Procedures*. Part-I, II UNDP, Tokyo.
4. Statistics Division (1979). *Retrospect, Perspective and Prospect*, Islamabad.
5. Statistics Division. *Activity Report (1988-89)*. Government of Pakistan, Islamabad.
6. Various Publications of PBS, State Bank of Pakistan, Ministry of Finance, etc.
7. Zarkovich S.S. (1966). *Quality of Statistical Data, Food and Agricultural Organization*. The U.N. Rome.
8. Statistics Reorganization Act 2011

**STAT- 631: Survival Analysis****3 (3-0)**

**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; Goals of survival analysis, application of the survival data analysis by comparison of various treatments and survival patterns. Describing the probability distribution of the survival and hazard function. Basic layout of the survival data 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 semiparametric models. Evaluation assumptions of Cox's proportional hazards model. Introduction to estimation of Stratified Cox's procedures for single and multiple variable adequacy Assessment of the Proportional Hazards Model

**Recommended books:**

1. Aalen, O. O, Borgan, O. and Gjessing (2012). *Survival and Event history analysis*. Springer series, New York
2. Machin, D., Cheung, Y. B. & Parmar, M. K. (2006). *Survival Analysis: A practical approach*, 2<sup>nd</sup> ed. John Wiley & Sons, Ltd. England, U.K.
3. Klein, J. P., & Moeschberger, M. L. (2003). *Survival Analysis: Techniques for Censored and Truncated data*. 2<sup>nd</sup> ed., Springer series, New York.
4. Lee, E. T., & Wang, J. W (2013). *Statistical Methods for Survival Data Analysis*, 4<sup>th</sup> ed. John Wiley & Sons, New Jersey.



## STAT- 632: Biostatistics

**Course Contents:** Definition of Biostatistics, type of variables and observations in biological, health and medical sciences, Uniqueness in terms of behaviour of variables their domain, and units; Categorical, numerical and censored data. Populations, Target populations and sampled Population: Role of sampling in biostatistics, Size of samples of various types of studies, Proportions, rates and ratios; incidence, prevalence and odds. Distributional behaviour 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

### Recommended Books:

1. Altman, G. (1991). *Practical Statistics for Medical Research*. Chapman & Hall, London.
2. Ahmad, M., Ahmad, A., and Hanif, M. (2004). *Manual of Statistics for Medical Sciences*. ISOSS Publications Lahore.
3. Daniel, W.W. (2010). *Biostatistics: A Foundation for the Health Sciences*, 6<sup>th</sup> ed. John Wiley, New York.
4. Hanif M., Munir A. and Aftab M. A. (2006). *Biostatistics for Health Students with Manual on Software Applications*. ISOSS Publication.
5. Rosner, B. (2006). *Fundamentals of Biostatistics*. Duxbury Press.
6. Shoukri, M. M. & Pause, C. A. (1999). *Statistical Methods for Health Sciences*, 2<sup>nd</sup> ed. CRC Press, Florida.
7. Zar, J. (2000). *Biostatistical Analysis*, 5<sup>th</sup> ed. John Wiley and Sons.
8. Zolman, J.F. (1993). *Biostatistics: Experimental Design and Statistical Inference*. Oxford University Press, New York.

## STAT- 633: Data Mining

3 (3-0)

**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.

### Recommended Books

1. Benson and Smith, S.J. (1997). *Data Warehousing, Data Mining, and OLAP*. McGraw-Hill.
2. Bramer M (2007): *Principles of Data Mining*. Springer-Verlag London Limited UK.
3. Breiman, L. Friedman, J.H. Olshen, R.A. and Stone, C.J. (1984). *Classification and Regression Trees*. Wadsworth and Brooks/Cole.
4. Han, J., Kamber, J. Pei, J., and Burlington, M. A. (2012). *Data mining: concepts and techniques*. Haryana, India.
5. Mitchell, T.M. (1997). *Machine Learning*. McGraw-Hill.
6. Rao C. R., Wegman E. J. & Solka J. L (2005): *Handbook of Statistics, Vol. 24: Data mining and data visualization*. Elsevier B.V., North Holland.

7. Ripley, B.D. (1996). *Pattern Recognition and Neural Networks*. Cambridge University Press.
8. Suh, S. C. (2012). *Practical applications of data mining*. Suh. Publisher
9. Tan P., Steinbach M. & Kumar V. (2006): *Introduction to Data Mining*. Addison Wesley, New York.

### STAT- 634: Actuarial Statistics – I

3 (3-0)

**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  $A_x, A_{x:\overline{n}}, A_{x:\overline{n}}^1, A_{x:\overline{n}}^{\overline{1}}$  and their select and continuous equivalents.

#### Recommended books:

1. Booth, P.M. et al. (1999). *Modern Actuarial Theory and Practice*. Chapman & Hall.
2. Bowers, N.L. Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). *Actuarial Mathematics*. Society of Actuaries, 2nd Edition.
3. Broverman, S.A. (2015). *Mathematics of Investment and Credit*, 6<sup>th</sup> ed. ACTEX Publications.
4. Daniel, J.W. and Vaaler, L.J.F. (2007). *Mathematical Interest Theory*. Pearson, Prentice Hall.
5. Dickson, D.C.M. Hardy, M.R. and Waters, H.R. (2013). *Actuarial Mathematics for Life Contingent Risks*, 2nd Edition.

### STAT- 635: Actuarial Statistics – II

3 (3-0)

**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.

**Recommended books:**

1. Allen, et al. (2013). *Retirement Plans: 401(k)s, IRAs, and Other Deferred Compensation Approaches*. 11<sup>th</sup> ed. McGraw Hill.
2. Benjamin, B. and Pollard, J.H. (2015). *The Analysis of Mortality and other Actuarial Statistics*. 3<sup>rd</sup> ed. Society of Actuaries.
3. Booth, P.M. et al. (1999). *Modern Actuarial Theory and Practice*. Chapman & Hall.
4. McGill, et al. (2010). *Fundamentals of Private Pensions*, 9<sup>th</sup> ed. Oxford University Press.
5. Yamamoto, D.H. (2015). *Fundamentals of Retiree Group Benefits*. 2<sup>nd</sup> ed. ACTEX.

**STAT- 636: Mathematical Modeling and Simulation****3 (3-0)**

**Course Contents:** Monte Carlo methods: Different methods of generating random numbers, generation of random variables, 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 resampling techniques, Variance reduction techniques: importance sampling for integration, control variates and antithetic variables.

**Recommended Books:**

1. Bernard, P., Autor Zeigler, Praehofer, H., Kim, T.G. (2000). *Theory of Modeling and Simulation*.
2. Daniel P. M, Maynard T. (2006). *Mathematical Modeling and Computer Simulation*. Thomson Brooks/Cole.
3. Fishman, G.S. (1996). *Monte Carlo: Concepts, Algorithms, and Applications*. Springer.
4. Ripley, B.D. (1987). *Stochastic Simulations*. Wiley.
5. Ross, S.M. (2002). *Simulation*, 3<sup>rd</sup> ed. Academic Press.
6. Rubinstein, R.Y. (1981). *Simulation and the Monte Carlo Method*. Wiley.
7. Velten, K. (2009). *Mathematical Modeling and Simulation*. Wiley VCH, Germany.

**STAT- 637: Categorical Data Analysis****3 (3-0)**

**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, 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

**Recommended Books:**

1. Agresti, A. (2012). *Categorical Data Analysis*, 3<sup>rd</sup> ed. Wiley.

2. Agresti, A. (2007). *An Introduction to Categorical Data Analysis*, 2<sup>nd</sup> ed. John Wiley & Sons.
3. Chap, T. L. (1998). *Applied Categorical Data Analysis*. Wiley.
4. Hosmer, D. W., Lemeshow, S. (2004). *Applied Logistic Regression*. John Wiley & Sons.
5. Powers, D. A., and Yu, Xie (2008). *Statistical Methods for Categorical data analysis*, 2<sup>nd</sup> ed. Emerald Group publishing.
6. Simonoff, J. S. (2003). *Analyzing Categorical Data*. Springer

**STAT- 638: Bayesian Inference**

**3 (3-0)**

**Course Contents:** Conditional Probability, Prior information, Prior distributions, Methods of elicitation of prior distributions, Posterior distributions: The posterior means, medians (Bayes estimators under loss functions) and variances of univariate and bivariate posterior distributions, Non-informative priors: Methods of elicitation of non-informative priors, Bayesian Hypotheses Testing: Bayes factor; The highest density region; Posterior probability of the hypothesis.

**Recommended Books:**

1. Hoff, P.D. (2009). *A First Course in Bayesian Statistical Methods*. Springer, New York.
2. Lee, P.M. (2004). *Bayesian Statistics: An Introduction*, 3<sup>rd</sup> ed. Arnold Publishers.
3. Congdon, P. (2006). *Bayesian Statistical Modelling*, 2<sup>nd</sup> ed. John Wiley & Sons, Chichester.
4. Bolstad, W.M. (2004). *Introduction to Bayesian Statistics*. John Wiley & Sons, New Jersey.
5. Jeff, G. (2002). *Bayesian Methods: A Social and Behavioral Science Approach*. Chapman and Hall.

**STAT- 639: Statistical Quality Control**

**3 (3-0)**

**Course Contents:** Concept of quality control and Quality assurance, 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); Fast Initial Response (FIR). ARL and FIR for control charts, attribute and variable control charts. Process capability analysis: Process improvements using design of experiments. Acceptance sampling for attributes and variables, Acceptance sampling plans: Single, double, and multiple sampling plans with their O.C. curves, Military Standard 501 Sampling Plans. Introduction to ISO- 9000 and ISO-14000 series

**Recommended Books:**

1. Banks, J. (1989). *Principles of Quality Control*. John Wiley, New York.
2. Feigenbaum, A.V. (1986). *Total Quality Control*. McGraw-Hill, New York.
3. Juran, J.M. and Guyana, F.K. (1988). *Juan's Quality Control Handbook*. McGraw Hill New York.
4. Miltag H. J. and Rinne H. (1993). *Statistical Methods of Quality Assurance*, Chapman & Hall, London.

5. Montgomery, D.C. (2013). *Introduction to Statistical Quality Control*. McGraw Hill, New York.
6. Nelson, W. (1990). *Accelerated Testing*. John Wiley, New York.
7. Ryan, T.P. (1989). *Statistical Methods for Quality Improvement*. John Wiley, New York.

### **STAT-640: Fundamentals of Mathematical Statistics**

**3 (3-0)**

**Objectives:** The aim of the course is to focus on techniques of integration and applications of integrals. The course also aims at introducing the students to infinite series, parametric curves and polar coordinates.

**Course Contents:** Introduction: Probability and random variables. Mathematical expectations. Moment generating function: Properties, limitations, theorems, uniqueness theorem.

Cumulants: Additive property, effect of change and scale. Definitions, scope and Characteristic function: Properties, theorems, necessary and sufficient conditions.

Special discrete and continuous distributions: MGF, cumulants and characteristic functions of Binomial, Poisson, Geometric, Uniform, Exponential, Normal, Gamma distributions. Recurrence relation.

Bivariate Normal Distribution: MGF, Marginal distributions, Conditional distributions.

Convergence in Probability: Weak law of large numbers, Bernoulli's law of large numbers.

Probability generating functions and convolutions.

Central Limit Theorem: Linderberg-Levy theorem, Applications of CLT. Liapounoff's CLT.

Variate Transformations: Square root, Sine inverse, Logarithmic and Fisher's Z-transformation.

#### **Recommended Books:**

1. Bickel, P.J. and Doksum, K.A. (2005), *Mathematical Statistics*. Vol I, 2nd ed. Prentice Hall, N.J.
2. Hogg, R.V., McKean, J.W. and Craig, A.T. (2005). *Introduction to Mathematical Statistics*. 6th ed. Prentice Hall.
3. Hogg, R.V., and Tanis, E.A. (2009). *Probability and Statistical Inference*. 8th ed. Pearson.
4. Lindgren, B.W. (1998). *Statistical Theory*. Chapman and Hall, New York.
5. Mood, A.M., Graybill, F.A. and Boss, D.C. (1997). *Introduction to the Theory of Statistics*. McGraw Hill, New York.

### **STAT-641: Introductory Spatial Statistics**

**3 (3-0)**

**Objectives:** The aim of the course is to highlight the significance and introduce the fundamentals of the Discipline of International Relations to the students.

**Course Contents:** Introduction: Review of non-spatial statistics, overview of different types of spatial data.

Geostatistics: Variograms and covariance functions, fitting variogram functions, kriging, spatial regression and smoothing methods.

Areal data: neighborhoods, testing for spatial association, global and local tests for association, CAR and SAR models.

Point process data: Types of spatial patterns, CSR and tests.

**Recommended Books:**

1. Bivand, R.S., Pebesma, E.J., and Gómez-Rubio, V. (2008). *Applied Spatial Data Analysis with R*. Springer.
2. Schabenberger, O., and Gotway, C.A. (2005). *Statistical Methods for Spatial Data Analysis*. Chapman & Hall.
3. Waller, L., Gotway, C. A. (2004). *Applied Spatial Statistics for Public Health Data*. Wiley.

**STAT-642: Advanced Operations Research****3 (3–0)**

**Objectives:** The aim of the course is to introduce advanced topics of operations research to solve nonlinear programming, queuing and decision theory and to apply these techniques constructively to make effective business decisions.

**Course Contents:** Nonlinear Programming. Constrained and unconstrained problems. Inventory control models, ABC analysis and selective inventory management. Queuing Models. Pure birth and death models. Generalized Poisson queuing model. Dynamic programming. Principal of optimality. General goal programming model formulation and its objective function. Solution of linear and linear integer goal programming. Decision theory. Decision making under certainty, uncertainty and risk. Game theory. Optimal solution of Two-Person Zero-Sum games and mixed strategy games.

**Recommended Books:**

1. Hillier B.S., and Liberman, G.J. (2021). *Introduction to Operations Research*. 11th Ed. McGraw Hill.
2. Taha, H.A. (2007). *Operations Research: An Introduction*. 8th Ed. MacMillan Publishing Co. Inc. New York.

**STAT-643: Applied Statistical Learning****3 (3–0)**

**Objectives:** The aim of the course is to introduce advanced topics of operations research to solve nonlinear programming problems and applications of queuing and decision theory.

**Course Contents:** Introduction to statistical learning: Basics of machine learning, types of machine learning, supervised, unsupervised and reinforcement learning, regression and classification problems.

Managing and understanding data: Vectors, factors, lists, data frames, matrices and arrays, exploring the structure of data, exploring numeric and categorical variables, exploring relationship between variables.

Classification using Nearest Neighbors: the K-NN algorithm, measuring similarity and distances, choosing an appropriate K, preparing data for K-NN. Application of K-NN to a real data set.

Classification using Decision Trees: divide and conquer rule, the C5.0 decision tree algorithm, choosing the best split, pruning the decision tree. Application of decision tree to a real data set.

Regression methods: Linear regression, OLS, multiple linear regression, correlations.

Neural Networks and Support Vector Machines: Neurons, activation functions, network topology, SVM, Application of NN and SVM to real data sets.  
Evaluating and improving model performance. Ensembles, bagging, boosting and random forests.

**Recommended Books:**

1. Lantz, B. (2015). *Machine Learning with R*. 2nd Ed. PACKT publishing.
2. James, G., Witten, D., Hastie, T., and Tibshirani, R. (2013). *An introduction to Statistical Learning: With Applications in R*. Springer.
3. Hastie, T., Tibshirani, R., Friedman, J. (2009). *The Elements of Statistical Learning*. Springer.

## Compulsory Courses for BS Statistics

**ENG-601: English-I (Functional English) 3 (3-0)**

**Objectives:** Enhance language skills and develop critical thinking.

**Course Outline: Basics of Grammar:** Parts of speech and use of articles Sentence structure, active and passive voice Practice in unified sentence Analysis of phrase, clause and sentence structure Transitive and intransitive verbs Punctuation and spelling. **Comprehension:** Answers to questions on a given text, **Discussion:** General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students). **Listening:** To be improved by showing documentaries/films carefully selected by subject teachers.

**Translation skills, Paragraph writing,** Topics to be chosen at the discretion of the teacher

**Recommended books:**

1. Thomson, A. J., & Martinet, A.V., (1997). *Practical English Grammar, Exercises 1*, 3<sup>rd</sup> ed. Oxford University Press, Oxford, ISBN 0194313492
2. Thomson, A. J., & Martinet, A.V. (1997). *Practical English Grammar, Exercises 2*, 3<sup>rd</sup> ed. Oxford University Press, ISBN 0194313506
3. Boutin, M. C., Brinand, S. & Grellet, F., (1993). *Writing. Intermediate, Oxford supplementary Skills, Fourth Impression*, ISBN 0 19 435405 7 Pages 20-27 and 35-41.
4. Tomlinson, B. & Ellis, R. (1992). *Upper Intermediate, Oxford Supplementary Skills. Third Impression*. ISBN 019453402 2.

**ISL-601: Islamic Studies 2 (2-0)**

**Objectives:** This course is aimed to provide Basic information about Islamic Studies, to enhance understanding of the students regarding Islamic Civilization, to improve Students skill to perform prayers and other worships, to enhance the skill of the students for understanding of issues related, to faith and religious life.

**Course Outline: Introduction to Quranic Studies,** Basic Concepts of Quran, History of Quran, Uloom-ul –Quran, **Study of Selected Text of Holly Quran,** Verses of Surah Al-Baqra Related to Faith(Verse No-284-286), Verses of Surah Al-Hujrat Related to Adab Al-Nabi

(Verse No-118), Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11), Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77), Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154), Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.), Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment, Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14), **Seerat of Holy Prophet (S.A.W)**, Life of Muhammad Bin Abdullah ( Before Prophet Hood), Life of Holy Prophet (S.A.W) in Makkah, Important Lessons Derived from the life of Holy Prophet in Makkah, **Seerat of Holy Prophet (S.A.W)**, Life of Holy Prophet (S.A.W) in Madina, Important Events of Life Holy Prophet in Madina, Important Lessons Derived from the life of Holy Prophet in Madina, **Introduction to Sunnah: Basic Concepts of Hadith, History of Hadith, Kinds of Hadith, Uloom –ul-Hadith, Sunnah& Hadith, Legal Position of Sunnah, Selected Study from Text of Hadith, Introduction to Islamic Law & Jurisprudence**, Basic Concepts of Islamic Law & Jurisprudence, History & Importance of Islamic Law & Jurisprudence, Sources of Islamic Law & Jurisprudence, Nature of Differences in Islamic Law, Islam and Sectarianism, **Islamic Culture & Civilization**, Basic Concepts of Islamic Culture & Civilization, Historical Development of Islamic Culture & Civilization, Characteristics of Islamic Culture & Civilization, Islamic Culture & Civilization and Contemporary Issues, **Islam & Science**, Basic Concepts of Islam & Science, Contributions of Muslims in the Development of Science, Quran & Science, **Islamic Economic System**, Basic Concepts of Islamic Economic System, Means of Distribution of wealth in Islamic Economics, Islamic Concept of Riba, Islamic Ways of Trade & Commerce, **Political System of Islam**, Basic Concepts of Islamic Political System, Islamic Concept of Sovereignty, Basic Institutions of Govt. in Islam, **Islamic History**, Period of KhlaftE-Rashida, Period of Ummayyads, Period of Abbasids, **Social System of Islam**, Basic Concepts of Social System of Islam, Elements Of Family, Ethical Values Of Islam.

#### **Recommended Books:**

1. Bhatia, H.S. (1989). *Studies in Islamic Law, Religion and Society*. Deep & Deep Publications New Delhi
2. Hassan, H.H. *An Introduction to the Study of Islamic Law*. Leaf Publication Islamabad, Pakistan.
3. Hasan, A. (1993). *Principles of Islamic Jurisprudence*. Islamic Research Institute, International Islamic University, Islamabad.
4. Muhammad, H. *Emergence of Islam*. IRI, Islamabad
5. Muhammad, H. *Muslim Conduct of State*.
6. Muhammad, H. *Introduction to Islam Mulana Muhammad Yousaf Islahi*.
7. Waliullah, M. (1982). *Muslim Jurisprudence and the Quranic Law of Crimes*. Islamic Book Service
8. Zia-ul-Haq, M. (2001). *Introduction to Al Sharia Al Islamia*. Allama Iqbal Open University, Islamabad.

#### **COMP-601: Introduction to Computers**

**3 (3-0)**

**Objectives:** To develop understanding of basics of computer components, their operations, algorithm development techniques and basic programming.

**Course Contents:** Introduction to computer components and operating systems, Number systems, Problems solving techniques, flow chart and algorithm development, Computer programming fundamentals.



Introduction to numbers systems, CPU, memory, input/output devices, data organization, file storage, programs and software, system and application software, operating systems, communication technology, Compiler, DBMS, Computer networks and internet, WWW, web mail applications, Computer graphics, AI, Viruses and Anti-Viruses.

Programming languages, compilation and interpretation, problem specification, algorithms, flow chart, pseudo code, basic programming techniques, data types and declaration, header file and linkage, variables and constants, arrays, input/output, termination, remark, control structures, Branching, conditional structures, repetition and loops, basic library functions,

**Recommended books:**

1. Brookshear, G. and Brylow, D. (2015). *Computer science: An Overview*, 12<sup>th</sup> ed. Pearson.
2. Dale, N. and Lewis, J. (2015). *Computer Science Illuminated*, 6<sup>th</sup> ed. John Lewis.

**COMP-602: Introduction to Computer Programming**

**3 (2-1)**

**Objectives:** To learn the fundamental programming concepts and methodologies which are essential to building good C/C++ programs. To practice the fundamental programming methodologies in the C/C++ programming language. To code, document, test, and implement a well-structured, robust computer program using the C/C++ programming language. To write reusable modules (collections of functions).

**Course Contents:** Computers and problem solving: software development methodology

- Structure of a C++ program
- C++ building blocks: defining variables, data types, arithmetic, assignment, increment, decrement operators and operations, elementary input/output
- Debugging in C++
- Introduction to C++ functions: function structure, functions that return a single value, performing calculations in functions, using simple library functions
- Pretest and posttest loops: for loop, while loop, do while loop, nesting loops
- Decisions: logical expressions and operators, if statements, switch statement, nested if statements
- Functions with arguments: input arguments, output arguments, function scope
- Using functions to build larger programs: Preprocessor, header files, prototyping
- Representation and conversion of data types
- Array and String processing
- Introduction to pointers: address operator, indirection operator, defining pointer variables, manipulating pointer variables

**Recommended books:**

1. Deitel, P.J. and Deitel, H. (2016). *C++ How to Program*, 9<sup>th</sup> ed. Pearson.
2. Stroustrup, B. (2013). *The C++ Programming Language*, 4<sup>th</sup> ed. Pearson Education.

**Objectives:** Enable the students to meet their real life communication needs.

**Course Contents: Paragraph writing:** Practice in writing a good, unified and coherent paragraph, **Essay writing**, Introduction, **CV and job application**, Translation skills Urdu to English, **Study skills**, Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension, **Academic skills**, Letter/memo writing, minutes of meetings, use of library and internet. **Presentation skills**, Personality development (emphasis on content, style and pronunciation).

**Recommended Books:**

1. Thomson, A. J. & Martinet, A. V. (1986). *Practical English Grammar, Exercises 2*, 3<sup>rd</sup> ed. Oxford University Press, ISBN 0 19 431350 6.
2. Boutin, M. C., Brinand, S. & Grellet, F. (1993). *Writing. Intermediate, Oxford, Supplementary Skills, Fourth Impression*. ISBN 019 435405 7 Pages 45-53 (note taking).
3. Nolasco, R. (1992). *Writing. Upper-Intermediate, Oxford Supplementary Skills. Fourth Impression*. ISBN 0 19435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
4. Tomlinson, B. and Ellis R. (1991). *Oxford Supplementary Skills. Third Impression*, ISBN 0 19 453403 0.

**Objectives:** Develop vision of historical perspective, government, politics, Contemporary Pakistan, ideological background of Pakistan. Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

**Course contents: Historical Perspective**, Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah. Factors leading to Muslim separatism, People and Land, Indus Civilization, Muslim advent, Location and geo-physical features. **Government and Politics in Pakistan**, Political and constitutional phases: 1947-58, 1958-71, 1971-77, 1977-88, 1988-99, 1999 onward. **Contemporary Pakistan**, Economic institutions and issues, Society and social structure, Ethnicity, Foreign policy of Pakistan and challenges, Futuristic outlook of Pakistan.

**Recommended Books:**

1. Afzal, M. R. (1998). *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research.
2. Amin, T. *Ethno -National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
3. Burki, S. J. (1980). *State & Society in Pakistan*. the Macmillan Press Ltd
4. Burke, S. M & Ziring, L. (1993). *Pakistan's Foreign policy: An Historical analysis*. Karachi: Oxford University Press.
5. Haq, N. (1993). *Making of Pakistan: The Military Perspective*. Islamabad:
6. Mehmood, S. (1994). *Pakistan Political Roots & Development*. Lahore.
7. Waseem, M. (1987). *Pakistan under Martial Law*. Lahore: Vanguard.

**ENG-603: English -III (Technical Writing and Presentation Skills)****3 (3-0)**

**Objectives:** Enhance language skills and develop critical thinking

**Course Contents:** **Essay writing**, Descriptive, narrative, discursive, argumentative, **Academic writing**, How to write a proposal for research paper/term paper, How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency), **Technical Report writing, Progress report writing**

**Recommended Books:**

1. White, R. (1992). *Writing: Advanced*. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3
2. Langan, J. (2004). *College Writing Skills*. McGraw-Hill Higher Education.
3. Kruszner, L.G. and Mandell, S.R. (2017). *Patterns of College Writing: A Rhetorical Reader and Guide*, 14<sup>th</sup> ed. ARS, NY.

**MATH-601: Mathematics A-I (Calculus)****3 (3-0)**

**Objectives:** To prepare the students, not majoring in mathematics, with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

**Course Contents:**

*Preliminaries:* Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.

*Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

*Derivatives and their Applications:* Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.

*Integration and Definite Integrals:* Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

**Recommended Books:**

1. Anton, H., Bevens I., and Davis S. (2005). *Calculus: A New Horizon*, 8<sup>th</sup> ed. John Wiley, New York
2. Stewart, J. (1995). *Calculus*, 3<sup>rd</sup> ed. Brooks/Cole. (suggested text)
3. Swokowski E.W. (1983). *Calculus and Analytic Geometry*. PWS-Kent Company, Boston
4. Thomas, G.B., Finney A.R. (2005). *Calculus*, 11<sup>th</sup> ed. Addison-Wesley, Reading, Ma, USA

**MATH-602: Mathematics A-II (Analytical Geometry)****3 (3-0)**

**Objectives:** To prepare the students, not majoring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

**Course Contents:** *Geometry in Two Dimensions:* Cartesian-coordinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

*Circle:* Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.

*Conic Sections:* Parabola, ellipse, hyperbola, the general-second-degree equation

**Recommended Books:**

1. Abraham, S. (1969). *Analytic Geometry*. Scott, Freshman and Company.
2. Kaufmann J.E. (1987). *College Algebra and Trigonometry*. PWS-Kent Company, Boston
3. Swokowski E.W. (1986). *Fundamentals of Algebra and Trigonometry*, 6<sup>th</sup> ed. PWS-Kent Company, Boston

**MATH-603: Mathematics A-III (Numerical Methods)**

**3 (3-0)**

**Objectives:** To apply numerical methods to obtain approximate solutions to mathematical problems. To derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solutions of differential equations.

**Course Contents:** Techniques for simple optimisation, interpolation from the known to the unknown, linear algebra underlying systems of equations, ordinary differential equations to simulate systems, and stochastic simulation under random influences. The mathematical and computational foundations of the numerical approximation and solution of scientific problems; simple optimisation; vectorisation; clustering; polynomial and spline interpolation; pattern recognition; integration and differentiation; solution of large scale systems of linear and nonlinear equations; modelling and solution with sparse equations; explicit schemes to solve ordinary differential equations; random numbers; stochastic system simulation.

**Recommended Books:**

1. Kreyszig, E. (2006). *Advanced Engineering Mathematics*, 9th ed. Wiley.
2. Greenbaum, A. and Chartier, T.P. (2012). *Numerical methods*. Princeton University Press.
3. Cheney, W. and Kincaid, D. (2004). *Numerical Mathematics and Computing*. Thomson.
4. O'Leary, D.P. (2008). *Scientific computing with case studies*. SIAM.
5. Etter, D.M. (1993). *Engineering problem solving with Matlab*, Prentice-Hall.

## General Courses for BS Statistics

### ECO-601: Fundamentals of Economics

3 (3-0)

**Objectives:** To gain an understanding of core economic principles and how they apply to a wide range of real-world issues.

**Course Contents:** Basic Economic concepts: Nature and functions of every economic system. Nature and scope of economic analysis. Economic terms. The major segments of economic theory. Micro-economics and macro-economics. Micro-economic (Price Theory): The price of market mechanism. The influence of the price system on resource allocation, consumption patterns and income distribution. Determination of price by supply and demand. The assumption of perfect competition. The theory of demand and utility. Elasticity of demand and its measurement. The theory of cost and supply. Equilibrium of the firm Equilibrium of demand and supply in the short-run and long-term periods. Pricing of the productive factors. Wages, profits, interest and rent. Macro-economic (income and Employment Theory): Measurement of national income. Concept of GNP, and NNP. Circular flow of national income. Three approaches to national income measurement, income at factor cost, income at market price and expenditure approach. Determination of the national income and employment. Equilibrium level of national income, saving, consumption and investment schedules and their inter-section. Say's law of markets and its refutation by "Keynes" general theory of employment-aggregate demand, aggregate supply, effective demand. Consumption function: The propensity of consume. The multiplier and its calculation. Logical identity of saving and investment. Investment as determinant of effective demand: Determinants of investment. The marginal efficiency of capital. The accelerator and its interaction with the multipliers. The rate of interest and investment. Economics, Statistics and Mathematics: **Economic Planning in Pakistan:** Economic Development through Planning: The concept of measurement of economic development. The imperfections of market economy. The need and objectives of economic Planning. Special features of Pakistan's economy: Primary production in population pressure, capital deficiency, Low income. Development Planning in Pakistan:

#### Recommended Books:

1. Samuelson, P.A. (1961). *Economics*. McGraw-Hill Compant, New York.
2. Stonier, A.H. and Huage, D.C: A Text- Book of Economic Theory (Longmans, London, 1964).
3. Adrus, J.R. and Mohammad, A.F: Trade, Finance and Development in Pakistan, (Karachi 1966).
4. Meenal, S.A: Money and Banking in Pakistan (Karachi, 1966).
5. Qureshi, Al (ed.): The Third Five Year Plans and other Papers (Rawalpindi, 1966).
6. Mahbub-ul-Haq: The Strategy of Economic Planning\_\_ A Case Study of Pakistan. (Karachi, Oxford University Press,1963).
7. Govt. of Pakistan: First, Second and Third Five-Year Plans of Pakistan Report of the Food and Agriculture Commission (Karachi, 1960).
8. Pakistan Economic Survey for the years 1963-64, 1964-65 and 1965-66.
9. Pakistan Budgets for the years 1964-65, 1965-66 and 1966-67.

**CHEM-601: Chemistry****3 (3-0)**

**Objectives:** This subject enables the students to get knowledge pertaining basic of Chemistry.  
**Course Contents: Introduction:** Atom, Relative atomic mass, Isotopes, Isobars and Isotones, Determination of relative atomic mass (mass spectrophotometer), Empirical formula, Molecular formula, concept of Mole, Avogadro's number, Stoichiometry, Law of conservation of mass and Law of definite proportion, Limiting reactant, the concept of Yield (theoretical, actual and percentage yield), Numerical related to the above topics. **Solutions:** Concepts of solutions, Concentration units of the solution, Types of solution, ideal and non-ideal solution, Raoult's Law, Vapour pressures of solution, Solubility and solubility curve, Colligative properties of solution, Energetics of solution, Hydration and Hydrolysis. Numerical related to the above topics. **Seperation techniques:** Introduction to qualitative and quantitative analysis. Filtration (gravity and suction filtration), Distillation, Sublimation, Crystallization, Solvent Extraction (Distribution/Partition Law), Chromatography (introduction, classification and paper chromatography).

**Recommended Books:**

1. Chemistry 4<sup>th</sup> edition by John A. Olmsted and Gregory M. William.2004.
2. Chemistry: Student study guide by John A, Olmsted.2005
3. Chemistry: Matter and it's changes, by James E. Brady.2007
4. World of Chemistry by Steven S. Zumdahl.2002

**SOC-601 Introduction of Sociology****3 (3-0)**

**Objectives:** To enable students to cope effectively with the socio-cultural and interpersonal processes of a constantly changing complex society.

**Course Contents: Introduction:** Field of Sociology, Sociology as a science sociology and other social sciences. **Basic Concepts:** Interaction Social, Norms and sanctions. Status and roles. Values and beliefs. Institutions. Social Structure. Groups. Social organization, Society. **Culture:** Elements culture. Cultural processes. **Socialization and Personality Development:** Biological foundations of personality. Cultural background of personality. **Processes and Social Change:** Co-operation, competition, and conflict. Social change: determinants, deterrents and consequences of change.

**Recommended Books:**

1. Chaudhry Mohammad Iqbal, and Mushtaq Ahmad Khan: *Sociology: An Introduction*, Lahore, Noorsons, 1966.
2. Young, Kimbal, and Raymond W.Mack: *Sociology and Social Life*, New York: American Book Company, 1959.

**ENV-601: Introduction to Environmental Sciences****3 (3-0)**

**Objectives:** To give students an understanding of how science and the scientific method work to address environmental problems. The student will become familiar with the Earth's major systems (ecosystems and biogeochemical cycles), how they function and how they are affected by human activity (population growth, air, water and soil pollution, ozone depletion, global

warming, solid waste disposal). Students will learn about the interaction of human society (urban sprawl, energy use/generation, resource consumption and economics) with the Earth's systems.

**Course Contents:** Definition, Definition, scope and importance, Need for public awareness. Environmental issues; the current environmental challenges, Renewable and non-renewable resources, **Natural Resources:** Natural resources and associated problems. **Forest resources:** Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people. **Water resources:** Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources. **Food resources:** World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, Fertilizer-pesticide problems, water logging, salinity, Energy resources: Growing energy needs, renewable and Non-renewable energy sources, use of alternate energy sources,

Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable life styles.

**Ecosystems:** Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids.

**Environmental Pollution:** Causes, effects and control measures of :

(a) Air pollution (b) Water pollution(c) Soil pollution(d) Marine pollution(e) Noise pollution (f ) Thermal pollution (g) Nuclear hazards.

**Solid waste management:** Causes, effects and control measures of urban and industrial wastes. . Role of an individual in prevention of pollution.

. Pollution case studies.

. Disaster management: floods, earthquake, cyclone and landslides.

Social Issues and Environmental Management

### **Recommended Books:**

1. The Environment and Emerging Development Issues Saburo Okita World Institute For Development Economics Research of The United Nations University,2013
2. Environmental Science: Earth as a Living Planet, Botkin, D.B & Keller, E.A. 9th Ed. John Wiley & Sons, 2013.
3. Environmental Science: systems and solutions, McKinney, M.L., Schoch, R.M. & Yonavjak, L. 5th Ed. Jones & Bartlett Publishers, 2013
4. Environmental Science: Toward a Sustainable Future, Wright, R.T. & Nebel, B.J. 10th Ed. Pearson Educational, 2007.
5. Environmental Science: working with the Earth.11th Ed. Miller, G., Tyler. Cengage Learning, 2005.
6. Perspectives In Environmental Studies nubha Kaushik And C.P. Kaushik New Age International (P) Limited, Publishers New Delhi .2007

**MATH-604: Introduction of Logic****3 (3-0)**

**Objectives:** The course aims to introduce the student to the idea of formalising arguments, both semantically and syntactically, and to the fundamental connection between these approaches.

**Course Contents:** Arguments, formal and informal logic; Sentential logic and what it means; translations from English; Evaluating logical arguments: validity, soundness, and semantics; Tests for Validity, First in class test; Adding to our logical language: Predicate logic; Semantics for predicate logic and the evaluation of arguments; Introduction to logical proofs ('deductions') Sentential Deduction, Second in class test Predicate Deduction; Applications.

**Recommended Books:**

1. Enderton, H.B. (2001). *A Mathematical Introduction to Logic*, 2<sup>nd</sup> ed. Academic Press.
2. Mendelson, E. (1997). *Introduction to Mathematical Logic*. Wadsworth and Brooks.
3. Chiswell, I. and Hodges, W. (2007). *Mathematical Logic*. Oxford University Press.

**MATH-605: Measure Theory****3 (3-0)**

**Objectives:** The aim of the course is to introduce the basic ideas and techniques of measure theory and Lebesgue integration.

**Course Contents:** Lebesgue extension of a measure; Algebras and  $\sigma$ -algebras of sets; Measure spaces; Properties of the Lebesgue measure; Lebesgue extension of a measure defined on a ring of sets;  $\sigma$ -additive and  $\sigma$ -semi-additive measures; Extension a measure from a semi-ring of sets to the corresponding ring of sets; Measurable functions; Convergence almost everywhere; Measurable functions and uniform convergence; the Egorov theorem; Definition and properties of measurable functions; Lebesgue integral; The definition and the properties of the Lebesgue integral; The Lebesgue, the Levi and the Fatou convergence theorems for the Lebesgue integral; Comparison of the Lebesgue integral and of the Riemann integral. Absolute continuity and  $\sigma$ -additivity of the Lebesgue integral; the Chebyshev inequality; Lebesgue integral for simple functions.

**Recommended Books:**

1. Bogachev, V.L. (2006). *Measure Theory*. Springer-Verlag, Berlin.
2. Capinski, M. (2005). *Measure, Integral and Probability*, 2<sup>nd</sup> ed. Springer-Verlag, London.
3. Tao, T. (2011). *An Introduction to Measure Theory*. AMS, Rhode Island, USA.

**ACCT-601: Introductory Accounting****3 (3-0)**

**Objectives:** This course provides the student with an introductory level understanding of the fundamentals of bookkeeping and accounting.

**Course Contents:** Financial statements and business decisions, The statement of financial position and income statement, the adjustment process, reporting and interpreting cash flows, communicating and interpreting accounting information, Sales revenue, receivables and cash,



cost of goods sold and inventory, Property, plant, equipment and intangibles, Current and noncurrent liabilities, Owner's equity, analyzing financial statements.

**Recommended Books:**

1. Piper, M. (2013). *Accounting made simple: Accounting explained in 100 pages or less*. Simple Subjects, LLC.
2. Shim, J.K. and Siegel, J.G. (2010). *Accounting Handbook*. 5<sup>th</sup> ed. Barron's Educational Series.
3. McLaney, E. and Atrill, P. (2012). *Accounting and Finance and Introduction*. 6<sup>th</sup> ed. Pearson Education Limited.

**COMP-602: Introduction to Computer Programming**

**3 (2-1)**

**Objectives:** This course is designed to teach students the C++ programming language and introductory and intermediate programming concepts with examples and applications using the C++ language.

**Course Contents:** Introduction to computer programming using C++. Fundamentals of structured design with development, testing, implementation, and documentation. Includes language syntax, data and file structures, input/output devices, and files. Program structure, blocks, storage types, console and file I/O, functions, arrays, strings, pointers, call-by-reference, call-by-value, and dynamic memory allocation.

**Recommended books:**

1. Dewhurst, S.C. (2005). *C++ (Computer Programming Language)*. Addison-Wesley, Upper Saddle River, N. J.
2. Lippman, S.B., Lajoie, J. and Moo, B. (2015). *C++ Primer*. Addison-Wesley, Upper Saddle River, N.J.
3. Stroustrup, B. (2014). *Programming: Principles and Practices Using C++*, 2<sup>nd</sup> ed. Addison-Wesley, Upper Saddle River, N.J.

**MGMT-601: Principles of Management**

**3 (3-0)**

**Objectives:** The objective of this course is to familiarize you with the knowledge, roles, responsibilities, and skills required of modern managers.

**Course Contents:** Introduction to management process and learning. Ethics and social responsibility, Managers as decision makers, Planning techniques, Control and control systems, Strategy and strategic management, Organization structure and design, Human resource management and leadership, Individual behavior, motivation, Teams and Team Work, Communication, Diversity and Global Cultures, Globalization and International Business, Entrepreneurship and small business.

**Recommended books:**

1. Schermerhorn, J.R. (2014). *Exploring Management*. 4<sup>th</sup> ed. John Wiley & Sons, Inc., Hoboken, NJ;
2. Griffin, R.W. (2017). *Management*. 12<sup>th</sup> ed. Cengage Learning, Boston.
3. King, D. and Lawley, S. (2013). *Organizational Behaviour*. Oxford University Press.

**PHY-601: Physics****3 (3-0)**

**Objectives:** The main objective of this course is to present an opportunity for the student to build a knowledge base of useful concepts - concepts which will help he/she feel at home in our present, technologically oriented society.

**Course Contents:** Introduction to Physics: Review of Mathematics, Metric System, Measurement. Kinematics: Graphical and Mathematical analysis of motion, constant velocity, accelerated motion. Vector quantity: Definition, addition, resolution. Dynamics: First, second and third law of motion. Motion in two dimension: Projectile and circular motion. Simple harmonic motion. Universal gravitation. Momentum and its conservation. Work and Power. Energy and its conservation. Waves and waves behavior, Sound and musical acoustics. Geometric and physical optics. Current and Electricity.

**Recommended books:**

1. Wolfson, R. (2016). *Essential University Physics: Volume 1*. 3<sup>rd</sup> ed. Pearson Education Inc.
2. Giancoli, D.C. (2013). *Physics: Principles with Applications*. 7<sup>th</sup> ed. Pearson Inc.
3. Halliday, D., Resnick, R. and Walker, J. (2010). *Fundamentals of Physics*. 9th ed. John Wiley & Sons.

**MATH-606: Advanced Calculus****3 (3-0)**

**Course Contents:** Techniques of integration: Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions. Integration by parts, substitution and partial fractions. Approximate integration. Improper integrals. Gamma functions. Applications of integrals: Area between curves, average value. Volumes. Arc length. Area of a surface of revolution. Applications to Economics, Physics, Engineering and Biology. Infinite series: Sequences and series. Convergence and absolute convergence. Tests for convergence: divergence test, integral test, p- series test, comparison test, limit comparison test, alternating series test, ratio test, root test. Power series. Convergence of power series. Representation of functions as power series. Differentiation and integration of power series. Taylor and McLaurin series. Approximations by Taylor polynomials.

**Recommended Books:**

1. Thomas, G.B. and Finney, R.L. (2005). *Thomas' Calculus*. 11th Edition. Addison Wesley Publishing Company.
2. Anton, H., Bevens, I. and Davis, S. *Calculus*. 8th Edition, John Wiley & Sons, Inc.
3. Hughes-Hallett, Gleason, McCallum, et al. (2002). *Calculus Single and Multivariable*. 3rd Edition. John Wiley & Sons, Inc.

**IR-601: Introduction to International Relations****3 (3-0)**

**Course Contents:** Meaning, Definition, Nature, and Scope of International Relations. Evolution and Development of International Relations. Significance of International Relations. Concept of Nation State. International System and Sub-Systems. National Interest, Foreign

Policy and Diplomacy. Power and Balance of Power. Regionalism and Globalization. State and Non-state Actors. Human Rights in International Relations. Religion, Ethics, Morality and Justice in International Relations. The Role of Economics in International Relations. The Concept of War and Peace in International Relations. Latest/emerging concepts and trends.

**Recommended Books:**

1. Mingst, K.A. and McKibben, H.E. and Arreguín-Toft, I.M. (2016). *Essentials of International Relations*. Oxford Publishers.
2. Devetak, R. and George, J. (2017). *An Introduction to International Relations*. Cambridge University Press.
3. Columbus, T. (1992). *Introduction to International Relations: Power and Justice*. Prentice Hall.
4. Goldstine, J. (2003). *International Relation*. Pearson Education.

**GEO-601: Fundamentals of Geography**

**3 (3-0)**

**Course Contents:** Introduction: Definitions, scope and branches of Geography, Roots of the discipline and basic geographic concepts, Themes and traditions of Geography, Tools of Geography.

The Universe: Galaxies and solar system

The Earth as a planet: Celestial positions, its shape and size, Rotation, revolution and related phenomena.

Spheres of the earth: Lithosphere, Atmosphere, Hydrosphere, Biosphere.

Man-environment interaction: Population, Major Economic activities, Settlements, Pollution.

**Recommended Books:**

1. Arbogast, A. F. (2007). *Discovering Physical Geography*. John Wiley and Sons, London.
2. Christopherson, R. W. (2009) *Geo systems: An introduction to Physical Geography*. Pearson Prentice Hall, New Jersey.
3. Guinness, J. P. and Nagle, G. (2011) *Geography*. Hodder Education, London.
4. King, C. (1980). *Physical Geography*. Basil Blackwell, Oxford.

Dr. Farhat Iqbal  
Associate Professor  
Department of Statistics  
University of Balochistan, Quetta.