

**UNIVERSITY OF THE PUNJAB**

**NOTIFICATION**

It is hereby notified that the Vice-Chancellor has, in exercise of the powers vested in him under Section 15(3) of the University of the Punjab Act, 1973 and in anticipation of the approval of the Syndicate, approved the recommendations of the Principal, College of Statistical and actuarial Sciences duly forwarded by the Dean, Faculty of Sciences regarding approval of BS 5<sup>th</sup> to 8<sup>th</sup> Semester Syllabus (in replacement of M.Sc. Statistics) in the Subject of Statistics for affiliated College with effect from the Academic Session, 2021.

The Syllabus of BS 5<sup>th</sup> to 8<sup>th</sup> Semester in Statistics is attached herewith vide Annexure-A.

**Admin. Block,  
Quaid-i-Azam Campus,  
Lahore.**


No.D/ 72 /Acad.

**Sd/-  
Muhammad Rauf Nawaz  
Registrar**

**Dated: 06-01-/2022.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Pro-Chancellor  
Minister of Education, Govt. of the Punjab, Lahore.
2. Members of the Syndicate
3. Dean, Faculty of Science.
4. Principal, College of Statistical and Actuarial Sciences
5. Principals, affiliated Colleges.
6. Controller of Examinations
7. Director, Quality Enhancement Cell
8. Director, IT (For uploading on website)
9. Deputy Registrar (Affiliation)
10. Deputy Registrar (General)
11. Secretary to the Vice-Chancellor
12. P.S. to Pro Vice-Chancellor
13. P.S. to the Registrar
14. Admin. Officer Syndicate (with file)
15. Assistant Syllabus

  
Assistant Registrar (Academic)  
for Registrar

**BS Statistics (5th Semester) for affiliated Colleges**  
**Course Titles, Credit Hours and Codes Semester-V to VIII**

Course Title	Credit Hours	New Code
<b>SEMESTER-V</b>		
Parametric and Non-Parametric tests (Theory)	3	STAT-301
Parametric and Non-Parametric tests (Practical)	1	STAT-302
Design and Analysis of Experiments (Theory)	3	STAT-303
Design and Analysis of Experiments (Practical)	1	STAT-304
Sampling Techniques (Theory)	3	STAT-305
Sampling Techniques (Practical)	1	STAT-306
Probability Theory (Theory)	3	STAT-307
Probability Theory (Practical)	1	STAT-308
Statistical Computer Packages	2	STAT-309
<b>Semester's Total Credits</b>	<b>18</b>	
<b>SEMESTER-VI</b>		
Advanced Experimental Design (Theory)	3	STAT-310
Advanced Experimental Design (Practical)	1	STAT-311
Advanced Sampling Techniques (Theory)	3	STAT-312
Advanced Sampling Techniques (Practical)	1	STAT-313
Multivariate Techniques (Theory)	3	STAT-314
Multivariate Techniques (Practical)	1	STAT-315
Probability Distributions (Theory)	3	STAT-316
Probability Distributions (Practical)	1	STAT-317
Fortran Computer Language	2	STAT-318
<b>Semester's Total Credits</b>	<b>18</b>	
<b>SEMESTER-VII</b>		
Statistical Inference-I (Theory)	3	STAT-401
Statistical Inference-I (Practical)	1	STAT-402
Basic Econometrics (Theory)	3	STAT-403
Basic Econometrics (Practical)	1	STAT-404
C++ Computer Programming Language	3	STAT-405
Research Methodology	2	STAT-406
Time Series Analysis-I (Specialization)	3	STAT-411
Operation Research (Specialization)	3	STAT-412
<b>Semester's Total Credits</b>	<b>19</b>	
<b>SEMESTER-VIII</b>		
Statistical Inference-II (Theory)	3	STAT-407
Statistical Inference-II (Practical)	1	STAT-408
Applied Econometrics (Theory)	3	STAT-409
Applied Econometrics (Practical)	1	STAT-410
Time Series Analysis-II (Specialization)	3	STAT-413
Multivariate Analysis (Specialization)	3	STAT-414
Total Quality Management (Specialization)	3	STAT-415
<b>Semester's Total Credits</b>	<b>17</b>	

**College of Statistical and Actuarial Sciences**

University of the Punjab, Q.A. Campus, Lahore

Tel: +92-42-35962612-4 ~ E-mail: info.stat@pu.edu.pk

**BS Statistics (5<sup>th</sup> Semester) for affiliated colleges  
(Semester-V to VIII)**

**Course Outlines & Books Recommended**

**Semester-V**

Module Code:	STAT-301 STAT-302
Module Title:	<ul style="list-style-type: none"><li>• Parametric and Nonparametric Tests (Theory) – 3 Credit Hours</li><li>• Practical – 1 Credit Hour</li></ul>
Name of Scheme:	BS Statistics

**Course Outline**

1. Tests of hypothesis: parametric methods, Type I and Type II error, pointer of the test, Z-test, t-test, F-test.
2. Analysis of categorized data. Goodness of fit tests. Homogeneity of variance. Bartlett test and Cochran test. Contingency tables. Test of independence in contingency tables. Fisher's exact test for 2x2 contingency tables, Test for Homogenty.
3. Non-parametric methods. Chebyshev's inequality. 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.
4. Sequential test. Test for proportion. Operating characteristic (OC) function. Average sample number (ASN) function. Test for standard deviation.

**Books Recommended**

1. Dixon, W.J., and Massey, F.J. "Introduction to Statistical Analysis" McGraw-Hill Company, New York, Fourth Edition, 1979.
2. Steel, R.G.D. and Torrie, J.H. "Introduction to Statistical Analysis" McGraw-Hill Book Company, New York, Second Edition, 1980.

**Reference Books**

1. Larson, H.J. "Introduction to Probability Theory and Statistical Inference" John Wiley and Sons, New York, Third Edition, 1982.
2. Wilcox, Rand R. "Fundamentals of modern Statistical methods", Springer N.Y. 2001.
3. Vaidyanathan, M. "Latest Statistical Methods", S. Chand and Company, New Delhi, 2001.
4. Aggarwal, Y.P. "Statistical Methods" Sterling publisher, New Delhi, 1998.

Module Code:	STAT-303 STAT-304
Module Title:	<ul style="list-style-type: none"> <li>• Design and Analysis of Experiments (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

1. Concept of experiment. Planning of experiment. Design of experiment and its terminology. Principles of experimental designs. Analysis of Variance (ANOVA). Inference about means after ANOVA. Multiple comparison tests: LSD test, Duncan's test, Tukey's test, Orthogonal contrast test, Scheffe's Test, Transformations.
2. Layout and analysis of Completely Randomized, Randomized Complete Block, Latin Square and Graeco-Latin Square designs. Estimation of missing observations. Relative efficiency of these designs. Fixed, Random and Mixed effect models. Expected mean squares deviations. Partitioning of treatment and error SS. Orthogonal Polynomials.
3. Covariance analysis for Completely Randomized, Randomized Complete Block and Latin Square designs; single and double covariates.

### Books Recommended

1. Cochran, W.C. and Cox, G.M. "Experimental Design" John Wiley and Sons, New York, Second Edition, 1957.
2. Montgomery, D.C. "The Design and Analysis of Experiments". John Wiley and Sons, New York, Fourth Edition, 1997.
3. John, J.A. and Quenoville, M.H. "Experiments and Analysis of Experiments", Charles Griffin & Co. London, Second Edition, 1977.

### Reference Books

1. Kempthorne, O. & Hinkelmann, K. "Design and Analysis of Experiments, Vol.1", John Wiley and Sons, New York, 1994.
2. Barker, T.B. "Quality by Exp. Design", Second Edition, 1994, Marcel Dekker, Inc. New York.
3. Boniface, D.R., "Experiment Design and Statistical Methods for Behavioural and Social Research", Chapman & Hall, London, First Edition, 1995.
4. Ostle, B. and Mensing, R.W. "Statistics in Research" The Iowa State University Press, New York, Second Edition, 1971.
5. Winer, B.J. "Statistical principles in Experimental Design", McGraw-Hill Book Company, New York, Second Edition, 1971.
6. Federer, W.T. "Experimental Design". Macmillan Company, New York, 1955.
7. Graybill, F.A. "An Introduction to Linear Statistical Models Vol.1", McGraw Hill Book Company, New York, 1961.
8. Heath, D. "An Introduction to Experimental Design and Statistics for Biology", UCI Press, London, Second Edition, 1996.
9. Clewer, Alan, G. "Practical Statistics and Experimental Design for Plant and Crop Science", Wiley, N.Y., 2001.
10. Quinn Gerry, P. "Exp. Design and Data Analysis for Biologists", Camb. Press, Cambridge, 2002.
11. Jeff Wu, C.F. "Experimental: Planning Analysis", Wiley N.Y., 2002.
12. Kuehl, R.O., "Design of Experiments: Statistical principles of research design and analysis" Duxbury, Boston, 2000.

Module Code:	STAT-305 STAT-306
Module Title:	<ul style="list-style-type: none"> <li>• Sampling Techniques (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

1. Sampling and non-sampling errors and their sources. Non-response and their sources. Bias and sources of bias. Probability and Non-probability samples.
2. Simple random sampling. Estimation of mean, total, proportion and variance. Confidence limits, Determination of sample size. Inverse Sampling.
3. Stratified random sampling. Estimation of mean, total, proportion and variance. Arbitrary, proportional and optimum allocations and their comparisons. Determination of sample size. Effect of deviation from optimum allocation. Controlled and two way selection. Gain in precision in stratified sampling as compared with simple random sampling. Construction of strata.
4. Systematic sampling. Estimation of mean, total and variance. Systematic sampling under stratification. Comparison of systematic, stratified and random sampling for population with linear trend. Population in random order. Periodic variations.

### Books Recommended

1. Cochran, W.G. "Sampling Techniques" John Wiley and Sons, New York, Third Edition, 1977.
2. Raj, D., "Sampling Theory" Mc-Graw-Hill Book Company, New York, 1971.
3. Singh, D. Chaudhry F.S. "Theory and Analysis of Sample Survey Designs", Wiley Eastern Limited, New Dehli, India, 1986.

### Reference Books

1. Fuller, Wayne A. "Sampling Statistics" John Wiley and Sons, New Jersey, 2009.
2. Brewer, K. "Combined Survey Sampling Inference" Oxford University Press, New York, 2002.
3. Raj, D. "Design of Sample Survey" Mc-Graw-Hill Book Company, New York, 1971.
4. Kish, L. "Survey Sampling" John Wiley and Sons, New York, 1965.
5. Som, R.K. "A Manual of Sampling Techniques" Heinemaan Educational Books Limited, London, 1973.
6. Sukhatme, P.V. and Sukhatme, B.V., Sukhatme, S. and Asok, C. "Sampling Theory of Surveys with Applications" Iowa State University Press, Ames, IOWA. Third Edition, 1984.

Module Code:	STAT-307 STAT-308
Module Title:	<ul style="list-style-type: none"> <li>• Probability Theory (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

Probability. Kinds of probability. Conditional probability and independence. Total probability and Bayes theorem. Random variables. Distribution function, probability function and probability density function. Moments, factorial moments and cumulants. Probability generating function. Moments generating function. Cumulant generating function. Chebyshev inequality, Univariate distributions: Discrete uniform, binomial, hyper-geometric, multinomial, Poisson, geometric, negative binomial distributions.

### Books Recommended

1. Hogg. R.V. and Craig, A.T., "Introduction to Mathematical Statistics" Prentice-Hall International, Inc. Engle Wood Cliffs, N.T., Fifth Edition, 1995.
2. Mood, A.M., Graybill, F.A. and Bloes, D.C. "Introduction to the Theory of Statistics" McGraw-Hill Book Company, New York, Third Edition, 1974.

### Reference Books

1. J. Susan Milton and Jesse C. Arnold, "Introduction to probability and statistics", McGraw Hill, 2003.
2. Sheldon, M. Ross, "Introduction to probability modes", Academic press, 2003.
3. Dudewicz, E.J. and Misra, S.N. "Modern Mathematical Statistics" John Wiley and Sons, New York, 1988.
4. Hogg. R.V. and Tanis, E.A. "Probability and Statistical Inference" McMillan Publishing Company, New York, Forth Edition, 1993.
5. Stuart, A. and Ord, J.K. "Kendall's Advanced Theory of Statistics Vol.-I" Edward Arnold, London, Sixth Edition, 1994.

Module Code:	STAT-309
Module Title:	<ul style="list-style-type: none"> <li>Statistical Computer Packages 2 Credit Hours (Paper: Theory &amp; Practical equal marks)</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

Introduction to Computer and Windows, Introduction to SPSS, Starting SPSS, How to exit from SPSS, Different windows in SPSS, Data Entry in SPSS: Defining a variable, Entering data, Saving data file, Defining Value Labels, Computing frequencies, Computing the new variables, Selection of cases, Defining Date Variable, Defining weights variable, Recoding and categorizing the existing variables, Categorizing the variables, Ranking the cases, Defining the missing values, Replacing the missing values, Creating a time series, Exploring the variable.

Finding descriptive statistics, Editing Output., Cross tabulation and measures of association, Entering a Cross-tabulated data, Graphs for variables and cross-tabulated variables, Merging and Splitting files, Bar Chart, Pie Chart, Histogram, and Histogram.

Box plot, P-P plot, Q-Q plot, One sample t-test, Independent Samples t-test, Paired samples t-test, Parametric statistical inference (one sample, Two sample, More than two sample).

Scatter Diagram, Correlation, Partial Correlation, and Regression Analysis: Simple and Multiple regressions, Non-Parametric Tests, Test of inference about proportions (one & several), Computing probability distribution and distribution functions.

### Recommended Books:

1. Discovering Statistics by using SPSS. 3<sup>rd</sup> ed. Any Field.
2. Ho, Robert (2006), Handbook of Univariate and Multivariate Data Analysis and Interpretation with SPSS, Chapman and Hall/CRC.
3. Kirkpatrick, L.A. and Feeney, B.C. (2001), A Simple Guide to SPSS for Windows, Wadsworth: Thompson Learning.
4. George, D. and Mallery, P. (1999), SPSS for Windows: Step by Step, Allyn and Bacon.
5. Brace, N., Kemp, R. and Snelgar, R. (2003), SPSS for Psychologists: 2nd Edition, Palgrave and Macmillan.
6. Statistics for researchers.

## Semester-VI

Module Code:	STAT-310 STAT-311
Module Title:	<ul style="list-style-type: none"><li>• Advanced Experimental Design (Theory) – 3 Credit Hours</li><li>• Practical – 1 Credit Hour</li></ul>
Name of Scheme:	BS Statistics

### **Course Outline**

1. Factorial experiments and its advantages.  $p \times q$  Factorial in Randomized Complete Block designs. 2nd series Factorial experiments. Linear and quadratic components of main effects and interactions. 3rd series Factorial experiments.
2. Confounding, its types and its advantages. Complete and partial confounding in 2nd series.
3. Fractional replication. Quasi-Latin squares.
4. Split-plot designs and Split-split plot designs.
5. Balanced incomplete and Partially Balanced incomplete block designs. Comparison of Incomplete Block design with Randomized Complete Block design. Youden Squares.

### **Books Recommended**

1. Cochran, W.C. and Cox, G.M. "Experimental Design", John Wiley and Sons, New York, Second Edition, 1957.
2. Montgomery, D.C. "The Design and Analysis of Experiments", John Wiley and Sons, New York, Fourth Edition, 1997.
3. John, J.A. and Quenoville, M.H. "Experiments Design and Analysis", Second Edition, Charles Griffin & Co. London, 1977.

### **Reference Books**

1. Kempthorne, O. & Hin Kelmann, K. "Design and Analysis of Experiments, Vol.1", John Wiley and Sons, New York, 1994.
2. Barker, T.B. "Quality by Exp. Design", Marcel Dekker, Inc. New York, Second Edition, 1994.
3. Boniface, D.R., "Experiment Design and Statistical Methods for Behavioural and Social Research", Chapman & Hall, London. First Edition, 1995.
4. Ostle, B. and Mensing, R.W. "Statistics in Research", The Iowa State University Press, Third Edition, 1975.
5. Winer, B.J. "Statistical Principles in Experimental Design". McGraw-Hill Book Company, New York, Second Edition, 1971.
6. Federer, W.T. "Experimental Design", Macmillan Company, New York, 1955.
7. Graybill, F.A. "An Introduction to Linear Statistical Models, Vol.1" McGraw Hill Book Company, New York, 1961.
8. Heath, D. "An Introduction to Experimental Design and Statistics for Biology", UCI Press, London, second edition, 1996.
9. Clewer, AlanG, "Practical Statistics and Experimental Design for Plant and Crop Science", Wiley N.Y., 2001.
10. Quinn Gerry P, "Exp. Design and Data Analysis for Biologists" Camb. Press, Cambridge, 2002.
11. JeffWu, C.F. "Experimental: Planning Analysis", Wiley, New York, 2002.
12. Kuehl, R.O. "Design of experiments: Statistical principles of research design and analysis" Duxbury, Boston, 2000.



Module Code:	STAT-312 STAT-313
Module Title:	<ul style="list-style-type: none"> <li>• Advanced Sampling Techniques (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

1. Ratio and Regression estimation. Estimation of total, mean square error and bias using design based approach and model based approach in estimate in simple random sampling. Unbiased ratio-type estimators. Ratio estimation in stratified sampling. Estimation of mean and variance in linear regression estimates. Best linear unbiased estimator (BLUE). Bias of the linear regression estimates. Regression estimation in stratified sampling. The Linear regression estimator under the general linear model.
2. Cluster sampling. Estimation of mean, total and variance for single-stage cluster sampling. Cost function. Variance function, cluster sampling for proportions, Sampling with unequal probability with replacement.
3. Two-stage sampling. Estimation of mean, total, proportion and variance. Both stages with equal probability. Two-stage sampling with units of unequal sizes, First stage PPS (with replacement) and second stage with equal probability. Both stages with probability proportional to size and with replacement. Sampling methods when a single primary unit is selected for the sample. Basic concept of double sampling.

### Books Recommended

1. Cochran, W.G. "Sampling Techniques" John Wiley & Sons, New York, Third Edition, 1977.
2. Raj, D., "Sampling Theory" Mc-Graw-Hill Book Company, New York, 1971.
3. Singh, D. Chaudhry F.S. "Theory and Analysis of Sample Survey Designs", Wiley Eastern Limited, New Dehli, India, 1986.

### Reference Books

1. Fuller, Wayne A. "Sampling Statistics" John Wiley and Sons, New Jersey, 2009.
2. Brewer, K. "Combined Survey Sampling Inference" Oxford University Press, New York, 2002.
3. Raj, D. "Design of Sample Survey" Mc-Graw-Hill Book Company, New York, 1971.
4. Kish, L. "Survey Sampling" John Wiley and Sons, New York, 1965.
5. Som, R.K. "A Manual of Sampling Techniques" Heinemaan Educational Books Limited, London, 1973.
6. Sukhatme, P.V. and Sukhatme, B.V., Sukhatme, S. and Asok, C. "Sampling Theory of Surveys with Applications" Iowa State University Press, Ames, IOWA. Third Edition, 1984.

Module Code:	STAT-314 STAT-315
Module Title:	<ul style="list-style-type: none"> <li>• Multivariate Techniques (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

Review of matrix algebra, Notions of multivariate distributions. The multivariate normal distribution and its properties. Linear compound and linear combinations. Estimation of the mean vector and the covariance matrix. The Wishart distribution and its properties. The joint distribution of the sample mean vector and the sample covariance matrix.

### Books Recommended

1. Johnson, R.A., & Wichern, D.W. (2008). Applied multivariate statistical analysis, Pearson Education: Singapore.
2. Anderson, T.W. (2003). An introduction to multivariate statistical analysis (3<sup>rd</sup> ed.). John Wiley & Sons: New York.
3. Chatfield, C. & Collins, A.J. (1980). Introduction to multivariate analysis. Chapman and Hall: London.
4. Morrison, D.F. (1990). Multivariate statistical methods (3<sup>rd</sup> ed.). McGraw Hill Publishing Co.: New York.

### Reference Books

1. Kandall, M.G., & Stuart, A. (1983). The advanced theory of statistics (4<sup>th</sup> ed.). Charles Griffin and Company: London.
2. Rao, C.R. (1973). Linear statistical inference and its applications (2<sup>nd</sup> ed.). John Wiley and Sons: New York.

Module Code:	STAT-316 STAT-317
Module Title:	<ul style="list-style-type: none"> <li>• Probability Distributions (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

Continuous distributions: continuous uniform, normal, exponential, gamma, beta, lognormal, Weibull, Pareto and Cauchy distributions and their properties.

Bivariate distributions. Marginal distribution. Conditional distribution and independence. Conditional expectation and conditional variance. Bivariate normal distribution and its properties.

Transformation of random variables. Sum, product and quotient of random variables. Moment generating function techniques. Derivations of chi-square, t and F distributions and their properties. Order statistics, Distribution of the rth order statistics. Distribution of sample range, sample median and sample mid-range.

### Books Recommended

1. Hogg. R.V. and Craig, A.T., "Introduction to Mathematical Statistics" Prentice-Hall International, Inc. Engle Wood Cliffs, N.T., Fifth Edition, 1995.
2. Mood, A.M., Graybill, F.A. and Bloes, D.C. "Introduction to the Theory of Statistics" McGraw-Hill Book Company, New York, Third Edition, 1974.

### Reference Books

1. J. Susan Milton and Jesse C. Arnold, "Introduction to probability and statistics", McGraw Hill, 2003.
2. Sheldon, M. Ross, "Introduction to probability modes", Academic press, 2003.
3. Dudewicz, E.J. and Misra, S.N. "Modern Mathematical Statistics" John Wiley and Sons, New York, 1988.
4. Hogg. R.V. and Tanis, E.A. "Probability and Statistical Inference" McMillan Publishing Company, New York, Forth Edition, 1993.
5. Stuart, A. and Ord, J.K. "Kendall's Advanced Theory of Statistics Vol.-I" Edward Arnold, London, Sixth Edition, 1994.

Module Code:	STAT-318
Module Title:	<ul style="list-style-type: none"> <li>FORTRAN Computer Language -- 2 Credit Hours (Paper: Theory &amp; Practical equal marks)</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

Introduction to the Computers: History, Main Computers, Various Input and Output devices and Tips for the computer maintenance.

Introduction to Operating Systems, Introduction to DOS: DATE, TIME, COPY, XCOPY, FORMAT, DEL, RENAME etc. Commands.

FORTRAN, FORTRAN fundamentals, Constants, Variables and Arithmetic. Input, Output and Format Statements. Decision making in FORTRAN language. Branching and looping Arrays, Functions, sub-programs and sub-routines filing.

### Books Recommended

1. Lipschutz, M.M. Lipschuts S. "Theory and Problems of Data Processing". Schaum's outline series. McGraw Hill Book Company, New York.
2. Lipschutz., AS. And Poc., A. "Theory and Problems of Programming with FORTRAN". Schaum's out line series, McGraw Hill Book Company, New York.
3. Salaria R.S. "Programming in Microsoft FORTRAN 77", BPB Publications, New Delhi, India, 1994.

### Reference Books

1. Fouri, W.M. Gaughran, S.L and Fouri, M. "IBM FORTRAN 77: Elements of Programming Style" 1986, Hayden Book Company.
2. Zwoss, V. "Introduction to Computer Science" 1981, Braves and Noble Books, New York.

## Semester-VII

Module Code:	STAT-401 STAT-402
Module Title:	<ul style="list-style-type: none"><li>• Statistical Inference-I (Theory) – 3 Credit Hours</li><li>• Practical – 1 Credit Hour</li></ul>
Name of Scheme:	BS Statistics

### **Course Outline**

Point estimation, problem of estimation. Properties of a good estimator: Unbiasedness, Consistency, Efficiency and Sufficiency. Mean-squared error. Consistency and Best asymptotically normal estimator. Minimal sufficient statistics. Joint sufficiency. Exponential family. Sufficiency and Completeness. Cramer-Rao inequality. Minimum Variance Bound estimators. Rao-Blackwell and Lehmann-Sheffe theorems. Uniformly Minimum Variance Unbiased estimators. Joint completeness. Location invariant and scale-invariant estimators. Pitman estimators for location and scale.

Bayes estimators. Prior and Posterior distributions. Posterior Bayes estimators. Loss function and Risk function. Bayes estimator, Minimax Methods of estimation.

### **Books Recommended**

1. Hogg, R.V. and Craig, A.T. "Introduction to Mathematical Statistics", Prentice-Hall International, Inc. Engle Wod Cliff, N.J., Sixth Edition, 2004.
2. Hogg, R.V. and Tanis E.A., "Probability and Statistical Inference" Macmillan Publishing Company, New York, Seventh Edition, 2009.
3. Mood, A.M. Graybill, F.A. and Boes, D.C., "Introduction to the Theory of Statistics", McGraw-Hill Book Company, New York, Third Edition, 1974.
4. Levy, P.S. and Lemeshow, S, "Sampling of Populations: Methods and Applications", John Wiley, New York, Third Edition, 1999.
5. Lehman, E.L. "Theory of Point Estimation", John Wiley, New York, 1983.
6. Rao, C.R., "Linear Statistical Inference and its Applications", John Wiley, New York, 1973.
7. Hoel, P.G. "Introductions to Mathematical Statistics" Fifth Edition, John Wiley, 1984.

### **Reference Books**

1. Lindgrind, B.W. "Statistical Theory" Macmillan Publishing Company, New York, Third Edition, 1976.
2. Stuart, A. and Ord, J.K. "Kendalls Advanced Theory of Statistics, Vol-2, Edward Arnold, London, Fifth Edition, 1991.
3. Spanos. A "Probability theory and Statistical Inference" Cambridge University Press, 1999.
4. Welsh, A.H. "Aspects of Statistical Inference" John Wiley, 1996.
5. Freund, J.E. "Mathematical Statistics" Sixth Edition, 1999.
6. Kale, B.K. "a first course on parametric inference" Narosa, India, 1999.
7. Hagan, A. "Kendall's Advanced theory of Statistics Vol.2B; Baysian inference" Arnold, U.K. 1994.

Module Code:	STAT-403 STAT-404
Module Title:	<ul style="list-style-type: none"> <li>• Basic Econometrics (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

#### 1. **Econometrics**

Its nature, methodology and functions.

#### 2. **Simple Linear regression**

Ordinary least squares method; assumptions and estimation. Maximum likelihood method; assumptions and estimation, Properties of OLS and ML estimators. Partition of total sum of squares. Sampling distribution of sum of squares, Testing of hypotheses confidence intervals for the parameters and Linear combinations of parameter. Comparison of simple linear regressions, Chow test.

#### 3. **General Linear regression**

Ordinary least squares method; assumptions and estimation. Maximum likelihood method; assumptions and estimation properties of OLS and ML estimators. Partition of total sum of squares. Sampling distribution of sum of squares, Testing of hypotheses for the single, all some any parameters, Linear combinations of parameters. Comparison of general linear regressions, Chow test. Gauss Markov's theorem.

#### 4. **Other topics**

Stepwise regression, Ridge regression, GLR partitioned form: Estimator & testing of hypothesis, Use of extraneous information in linear regression.

### Books Recommended

1. Gujrati, D. "Basic Econometrics", McGraw Hill Book Company, Third Edition, 1995.
2. Johnston, J. "Econometric Methods", McGraw-Hill Book Company, Third Edition, 1985.
3. Koutsoyiannis, A. "Theory of Econometrics", Macmillan Press Ltd., Hong Kong, 1979.
4. Maddala, G.S. "Introduction to Econometrics", John Wiley, India, Third Edition, 2005.
5. Ramanathan, R. "Introductory Econometrics with Applications", South-Western Thomson Learning, USA, Fifth Edition, 2002.

### Reference Books

1. Dutta, M. "Econometric Methods", "South-Western Publishing Company, England, 1975.
2. Goldberger, A.S. "Econometric Theory", John Wiley and Sons, New York, 1964.
3. Wonnacott, T.H. and Wonnacott, R.J. "Econometrics", John Wiley and Sons, New York, 1979.
4. Draper, N.R. and Smith, I.I. "Applied Regression Analysis", John Wiley & Sons, New York, 1998.

Module Code:	STAT-405
Module Title:	<ul style="list-style-type: none"> <li>• C++ Computer Programming Language – 3 Credit Hours (Paper: Theory &amp; Practical equal marks)</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

Introduction to C-Language, Basic Data types, Input, Output and Format. Decision making in C-Language, Branching and Looping. Arrays, Strings, Pointers, Structure and Union. Functions and Concepts of Filing. Introduction to Macros, building of projects and libraries.

### Books Recommended

1. Herold H. and Unger W. "C Complete Manual", Second revised edition, 1992, Galgotia Publications Pvt., New Delhi, India.
2. Kernighan B.W. Ritchie D.M. "The C++ Programming Language", Second Edition, Prentice Hall of India Pvt. Lt., New Delhi, India.
3. Tizzard, K. "C for Professional Programmers", Second Edition, 1992, Ellis Horwood, London
4. Hancock L. Krieger M. "C The Primer" Second Edition 1985, McGraw Hill Book Company,
5. Schildt H. "C++ Made Easy", 1990, McGraw Hill Book Co.
6. Kochan S.G. "Programming in C" Revised Edition, 1990, Hayden Books, USA.

Module Code:	STAT-406
Module Title:	• Research Methodology – 2 Credit Hours
Name of Scheme:	BS Statistics

### Course Outline

1. Introduction: Definition of Research, Types and Methods of Conducting Research, Census and Survey, Sampling frame, Types of errors in surveys (coverage, non-response, measurement, errors etc.) and methods of control of such errors, Steps for successful surveys.
2. Types of Surveys: Qualitative and Quantitative survey, Assessments survey, Marketing survey, Evaluation of a survey.
3. Methods for conducting a Survey: Mail surveys, telephone surveys, face to face surveys, and drop off surveys.
4. Sample size: Various methods of sample selection, sample size and its practical difficulties.
5. Constructing a questionnaire for different types of surveys.
6. Scaling Techniques.
7. The analysis of Data.
8. Style and Format of report writing.
9. Preparing the report.

### Books Recommended

1. Salant, P. and Dillaman, D.A. "How to conduct your own survey", John Wiley and Sons, Inc. 1994.
2. Goode, W. J. and Hatt, P. K. "Methods in Social Research", McGraw-Hill Book Company, Inc.
3. Gupta, S. "Research Methodology and Statistical Techniques", Deep & Deep Publication, New Delhi, 1997.
4. Dalemus T. "Elements of Survey Sampling" SAREC, Stockholm, 1985.

### Reference Books

1. Grosh, Margaret, "Designing Household Survey Questionnaires for Developing Countries", World Bank, New Age Int. 1999.
2. Kish, Leslie, "Survey sampling", Wiley 1995.
3. Barnett Vic, "Sample Survey", Arnold London, 2002.
4. Gupta S. "Research Methodology and Statistical techniques" Deep & Deep Pub. New Delhi 2003.



Module Code:	STAT- 411
Module Title:	Time Series Analysis-I (Theory) – 3 Credit Hours
Name of Scheme:	BS Statistics (Specialization)

## Course Outline

1. Introduction to time series, time series analysis, Objectives of time series analysis, Components of time series, time series plots, time series and stochastic processes, special features of time series data, means, variance, auto-covariance, auto-correlation and partial auto-correlation for sample time series data.
2. Simple Descriptive Techniques: Stationary time series, transformations, Analyzing the secular trend, Filtering, Differencing, Analyzing Seasonal Variations, Analyzing Cyclical Variations, Analyzing Irregular Variations, Auto-correlation (correlogram) and other tests of randomness.
3. Probability Models for Time Series: Stochastic processes and stationary processes, useful stochastic processes, purely random process, random walk, moving average process, Stationarity and Invertibility of moving average models, auto-regressive process, Stationarity and invertibility of auto-regressive models, Duality between moving average and auto-regressive models, Principle of parsimony, Recursion rule for ACVF and ACF of auto-regressive process, Yule-Walker equations for auto-regressive process, Mixed ARMA models, moving average and auto-regressive representations of mixed ARMA models, Models for Non-stationary Time series, Box-Jenkins Integrated ARIMA models, Stationarity through differencing, other transformations. General linear processes and continuous processes.

## Books Recommended

1. Chatfield, C. (2003). *The analysis of time series: An introduction* (6<sup>th</sup> ed.). Chapman & Hall: London.
2. Wei, W. (1990). *Time series analysis: Univariate and multivariate methods*. Addison-Wesley publishing company, Inc.
3. Box, G.E.P., Jenkins, G.M. & Reinsel, G.C. (2004). *Time series analysis: Forecasting and control* (3<sup>rd</sup>ed.). Holden-dayk: San Francisco.
4. Brockwell, P.J., & Davis, R.A. (2002). *Introduction to time series and forecasting*. (2<sup>nd</sup>ed.). Springer: New York.

## Reference Books

1. Gottman, J.M. (1981). *Time series analysis*, University Press: Cambridge.
2. Gyer, J.D. (1990). *Time series analysis*. Duxbury Press: Boston.
3. Montgomery, D.C. (1990). *Forecasting and time series analysis* (2<sup>nd</sup> ed.). McGraw Hill Book Company: New York.
4. Anderson, T.W. (1994). *Statistical analysis of time series*. Wiley: New York.
5. Janacek & Gareth. (2001). *Practical time series*. Arnold Co.: UK.
6. Akaike, H. & Kitagawa, G. (1999). *The practice of time series analysis*. Springer: New York.
7. Hamilton, & James, D. (1994). *Time series analysis*. Princeton University Press: New Jersey.
8. Chatfield, C. (2000). *Time series forecasting*. Chapman & Hill/CRC: New York.

Module Code:	STAT-412
Module Title:	Operation Research (Theory) – 3 Credit Hours
Name of Scheme:	BS Statistics (Specialization)

### **Course Outlines**

Definition and nature of Operations Research (OR). Phases of an OR study. Modeling, constraints, objective and criterion. Problem formulation. Decision Variables, Objective function, Constraints Model building approach to problem solving. Types of models available for OR. Deterministic models, Stochastic Models. Examples of Models. Example of OR applications.

Introduction to linear programming. Graphical solution technique. Simplex Method, Application of Simplex Network.

### **Recommended Books**

1. Taha, H.A. "Operations Research. An Introduction". Macmillan Publishing Company, New York, Fifth Edition, 1994.

## Semester-VIII

Module Code:	STAT-407 STAT-408
Module Title:	<ul style="list-style-type: none"><li>• Statistical Inference-II (Theory) – 3 Credit Hours</li><li>• Practical – 1 Credit Hour</li></ul>
Name of Scheme:	BS Statistics

### **Course Outline**

Method of moments. Maximum likelihood method and its properties. Method of least squares and its properties. Ordered least squares estimation of location and scale parameters. Minimum chi-square method.

Interval estimation. Confidence interval and its interpretation. One-sided confidence intervals. Methods of finding confidence intervals. Pivotal quantity method. Confidence intervals for the mean and variance. Confidence region for the mean and variance. Large-sample confidence intervals. Bayesian interval estimates. Shortest sets of confidence intervals.

Tests of Hypotheses. Simple and composite hypotheses. Power function. Size and power of a test. Randomized and Non-randomized tests. Most powerful tests. Neyman-Pearson lemma. Loss function and Risk function. Bayes test. Generalized likelihood-ratio tests. Uniformly most powerful tests, unbiased test. Monotone likelihood ratio tests of hypotheses. Sequential probability ratio test. Approximate sequential probability ratio test. Average sample number.

### **Books Recommended**

1. Hogg, R.V., & Craig, A.T. (1995). *Introduction to mathematical statistics* (5<sup>th</sup> ed.). MacMillan: New York.
2. Mood, A.M., Graybill, F.A., & Boes, D.C. (1974). *Introduction to the theory of statistics* (3<sup>rd</sup> ed.). McGraw-Hill: New York.
3. Levy, P.S., & Lemeshow, S. (2008). *Sampling of populations: Methods and applications* (4<sup>th</sup> ed.). John Wiley: New York.
4. Lehmann, E.L., & Casella, G. (1998). *Theory of point estimation* (2<sup>nd</sup> ed.). Springer: New York.
5. Rao, C.R. (2001). *Linear statistical inference and its applications* (2<sup>nd</sup> ed.). John Wiley: New York.
6. Hoel, P.G. (1984). *Introduction to mathematical statistics* (5<sup>th</sup> ed.). John Wiley: New York.

### **Reference Books**

1. Hogg, R.V., & Tanis, E.A. (2005). *Probability and statistical inference* (7<sup>th</sup> ed.). Prentice Hall: New Jersey.
2. Lindgren, B.W. (1993). *Statistical theory* (4<sup>th</sup> ed.). Chapman and Hall: New York.
3. Kendall, M., Stuart, A., & Ord, J.K. (1991). *Kendall's advanced theory of statistics, Vol. 2: Classical Inference and relationship* (5<sup>th</sup> ed.). Oxford University Press: New York.
4. Spanos, A. (1999). *Probability theory and statistical inference*. Cambridge University Press: UK.
5. Welsh, A.H. (1996). *Aspects of statistical inference* (1<sup>st</sup> ed.). John Wiley: New York.
6. Miller, I., & Miller, M. (1998). *John E. Freund's mathematical statistics* (6<sup>th</sup> ed.). Prentice Hall: New Jersey.
7. Kale, B.K. (2005). *A first course on parametric inference* (2<sup>nd</sup> ed.). Narosa: New Dehli.

Module Code:	STAT-409 STAT-410
Module Title:	<ul style="list-style-type: none"> <li>• Applied Econometrics (Theory) – 3 Credit Hours</li> <li>• Practical – 1 Credit Hour</li> </ul>
Name of Scheme:	BS Statistics

### Course Outline

1. Non-spherical disturbances, Consequences of using OLS estimators, ML method assumption and estimation, Generalized least squares; assumption, estimation, properties of GLS estimators. Aitken theorem, Stochastic regressors.
2. Multicollinearity: types, reasons, consequences, remedial measures, Farrar and Glauler test.
3. Heteroskedasticity: Reasons, tests, remedial measures.
4. Autocorrelation: Reasons, tests, remedial measures, consequences.
5. Specification Errors: Over and under specified models and their consequences. Error in variables.
6. Other variables: Instrumental variables, Lagged variables, Dummy variables.
7. Systems of simultaneous linear equations: Reduced form equations, Simultaneous equations Bias. Identification (order and rank conditions), Methods of estimation for identified equations.
8. Income and Wealth distribution: Techniques for income distribution analysis (Lovernz curve, Gini coefficients, Pareto curve).

### Books Recommended

1. Gujrati, D. "Basic Econometrics", McGraw Hill Book Company, Third Edition, 1995.
2. Johnston, J. "Econometric Methods", McGraw-Hill Book Company, Third Edition, 1985.
3. Koutsoyiannis, A. "Theory of Econometrics", Macmillan Press Ltd., Hong Kong, 1979.
4. Maddala, G.S. "Introduction to Econometrics", John Wiley, India, Third Edition, 2005.
5. Ramanathan, R. "Introductory Econometrics with Applications", South-Western Thomson Learning, USA, Fifth Edition, 2002.

### Reference Books

1. Dutta, M. "Econometric Methods, "South-Western Publishing Company, England, 1975.
2. Goldberger, A.S. "Econometric Theory", John Wiley and Sons, New York, 1964.
3. Wonnacott, T.H. and Wonnacott, R.J. "Econometrics", John Wiley and Sons, New York, 1979.
4. Draper, N.R. and Smith, I.I. "Applied Regression Analysis", John Wiley & Sons, New York, 1998.

Module Code:	STAT-413
Module Title:	Time Series Analysis-II (Theory) – 3 Credit Hours
Name of Scheme:	BS Statistics (Specialization)

### Course Outline

1. Model Building, various stages of model building, Identification of model from sample time series, steps for model identification, estimating the auto-covariance, auto-correlation function and partial auto-correlation function, pattern of theoretical ACF and PACF as a tool of model identification.
2. Estimating the parameters of an auto-regressive model, estimating the parameters of moving average, Back casting, dual estimation, mixed ARMA model and integrated model. The Box-Jenkins seasonal model. Model diagnostics; Residual analysis, over fitting and parameter redundancy, portmanteau tests. Model selection criteria, AIC, BIC.
3. Forecasting: Univariate procedures, Minimum mean square estimate of forecast, forecast weights, mean, variance and forecast limits for forecast, forecast error, minimum mean square forecast error, structure of minimum mean square forecast error. Multivariate procedures, comparison of forecasting procedures. Prediction theory.

### Books Recommended

1. Chatfield, C. (2003). *The analysis of time series: An introduction* (6<sup>th</sup> ed.). Chapman & Hall: London.
2. Wei, W. (1990). *Time series analysis: Univariate and multivariate methods*. Addison-Wesley publishing company, Inc.
3. Box, G.E.P., Jenkins, G.M. & Reinsel, G.C. (2004). *Time series analysis: Forecasting and control* (3<sup>rd</sup>ed.). Holden-dayk: San Francisco.
4. Brockwell, P.J., & Davis, R.A. (2002). *Introduction to time series and forecasting*. (2<sup>nd</sup>ed.). Springer: New York.

### Reference Books

1. Gottman, J.M. (1981). *Time series analysis*, University Press: Cambridge.
2. Gyer, J.D. (1990). *Time series analysis*. Duxbury Press: Boston.
3. Montgomery, D.C. (1990). *Forecasting and time series analysis* (2<sup>nd</sup> ed.). McGraw Hill Book Company: New York.
4. Anderson, T.W. (1994). *Statistical analysis of time series*. Wiley: New York.
5. Janacek & Gareth. (2001). *Practical time series*. Arnold Co.: UK.
6. Akaike, H. & Kitagawa, G. (1999). *The practice of time series analysis* .Springer: New York.
7. Hamilton, & James, D. (1994). *Time series analysis*. Princeton University Press: New Jersey.
8. Chatfield, C. (2000). *Time series forecasting* .Chapman & Hill/CRC: New York.

Module Code:	STAT-414
Module Title:	Multivariate Analysis (Theory) – 3 Credit Hours
Name of Scheme:	BS Statistics (Specialization)

### Course Outline

The Hotelling's  $T^2$  distribution. The linear discriminant function, Mahalanobis distances. Tests of hypotheses and confidence intervals for mean vectors: One sample and two-sample procedures. Multivariate statistical procedures: Discriminant analysis, Principal component analysis, Factor analysis, and Canonical correlation analysis.

### Books Recommended

1. Johnson, R.A., & Wichern, D.W. (2008). *Applied multivariate statistical analysis*. Pearson Education: Singapore.
2. Anderson, T.W. (2003). *An introduction to multivariate statistical analysis* (3<sup>rd</sup> ed.). John Wiley & Sons: New York.
3. Rencher, A.C. (2002). *Methods of multivariate analysis* (2<sup>nd</sup> ed). John Wiley & Sons: New York.
4. Tabachnick, B.G., & Fidell, L.S. (2006). *Using multivariate statistics* (5<sup>th</sup> ed.). Allyn & Bacon: Boston.
5. Bhuyan, K.C. (2008). *Multivariate analysis and its applications*. New Central Book Agency: Kolkata.
6. Chatfield, C., & Collins, A.J. (1980). *Introduction to multivariate analysis*. Chapman and Hall: London.

### Reference Books

1. Morrison, D.F. (1990). *Multivariate statistical methods* (3<sup>rd</sup> ed.). McGraw Hill Publishing Co.: New York.
2. Kandall, M.G., & Stuart, A. (1983). *The advanced theory of statistics* (4<sup>th</sup> ed.). Charles Griffin and Company: London.
3. Rao, C.R. (1973). *Linear statistical inference and its applications* (2<sup>nd</sup> ed.). John Wiley and Sons: New York.

Module Code:	STAT-415
Module Title:	Total Quality Management (TQM) (Theory) – 3 Credit Hours
Name of Scheme:	BS Statistics (Specialization)

### Course Outlines

The basics of Management. Defining Quality. Different views of Quality. Dimensions of Quality. Quality Management. Principles of Quality Management. Eras of Quality Management, their foci and major developments. Introduction to Total Quality Management, Basic concepts, Purpose, benefits and framework of TQM, Implementation of TQM. Barriers to TQM implementation, Guru's of TQM, their Philosophies and Pioneering Works. Customer satisfaction. Internal and External Customer, Customer perception of quality. Employee involvement, Quality Control Circles & Teams.

Continuous Process Improvement: The PDSA Cycle, Kaizen, Six Sigma, Japanese 5-S practice. DRIVE framework. Costs of Quality. Quality Function Deployment. Benchmarking: Reasons to Benchmark, Types of Benchmarking, Benchmarking process, Benefits of Benchmarking, Obstacles to successful Benchmarking. New and old tools of Quality Management.

Statistical Process Control: Statistical Control Charts, Statistical basis of the Control Chart, Steps in the development of control charts, Types of control charts, Process Capability. Acceptance Sampling: Lot by lot Acceptance Sampling for attributes. Types of Sampling Plans. Single Sampling Plans: Construction of OC-curve, Rectifying Inspection. Double and Multiple Sampling Plans.

Quality Management Systems: ISO 9000 Series of Standards: Requirements, Implementation & Benefits. Environmental Management System: ISO 14000 series of Standards: Requirements, Implementation and Benefits.

### Books Recommended

1. Besterfield, D.H., Michna, C.B., Besterfield, G.H. & Sacre, M.B. (2003). *Total Quality Management* (3<sup>rd</sup> ed.). Pearson Education.
2. James, P. (1996). *Total quality management*. Prentice Hall.
3. Montgomery, D.C. (2009). *Statistical Quality Control* (6<sup>th</sup> ed.). John Wiley & Sons, New York.

### Reference Books

1. Evans, J.R. & Lindsay, W.M. (2005). *The Management and Control of Quality* (6<sup>th</sup> ed.). Thomson South-Western.
2. Oakland, J.S. (2003). *Total Quality Management* (3<sup>rd</sup> ed.). Butterworth-Heinemann.
3. Grant, E.L. & Leaven-worth, R.S. (1996). *Statistical Quality Control Handbook* (7<sup>th</sup> ed.). McGraw-Hill Book Company, New York.