Introduction
To
Department of Statistics
Syllabus for Mphil/PhD
Session: 2019-2020, 2021-2021, 2021-2022 and 2022-2023

The Department of Statistics fosters at specializing and training in statistical methodology in its theoretical, practical/applied, and in Scientific research aspects of modern age particularly with computer intensiveness in offering Bachelor of Science (B.Sc.) Honors and Master's of Science (MS) degrees in Statistics.

The Department of Statistics is one of the four runner departments with which Jahangirnagar University began its journey in 1970 just few months before the epoch making Liberation War. Initially, it was named as the Department of Information Science, however it had changed to its present name the Department of Statistics later on. In terms of number of students, faculties and facilities available in the Department of Statistics, now, is one of the best schools of statistics in the country. It publishes a journal entitled Journal of Statistical Studies since 1982. Thus, the department moves forward with a good pace in order to encompass the state-of-art of development in statistics globally. Now-a-days the regular class size is around 70 and regular faculties are 20-30.

The faculties are well-experienced and well-known in their own filed of research in home and aboard. Almost all the faculties had higher degrees from reputed universities around the globe. Amazingly they have covered almost all areas of teaching and research interests in statistics.

The graduates of the department are well comparable with the graduates of the other departments in the university and are well established in the local job market as well as in abroad. Some of them are holding key positions in manifold areas in Government/Non-government organizations, institutions, universities, business and others. It is a matter of pride for the department.

The department had produced a number of M. Phil and Ph. D degrees who are working in local job market and in abroad satisfactorily.

The department is well-equipped with computer facilities (with two big computer labs) for the students. The department has a seminar library with a total of 2251 books and few journals which helps students and faculties of the department a lot. On an average in a working day a total of 25 students seat and study in the seminar library and a total of 40 students drawing and returning books.

In addition to its core academic program the department organizes lectures, seminars and workshops regularly throughout the year. The contributors include distinguished statisticians from around the globe. The departmental faculties are also among regular contributors.

Sports, culture and other extra curricular activities are well-organized under the leadership of Student Advisor in collaboration with the Students' Union called 'Parishankan Samity' of the department which portray national pride, prejudice and heritage. Students are also helped with different scholarships available in the department.

Department of Statistics
Jahangirnagar University

Syllabus for M. Phil/Ph.D in Statistics

Session: 2019-2020, 2021-2021, 2021-2022 and 2022-2023

The Master of Philosophy (M. Phil) program in Statistics foster at specializing and training in statistical methodology in its theoretical, practical/applied, and in scientific research aspects of modern age particularly with computer intensiveness. It meticulously helps to do such research which is very much of valued interests in order to develop knowledge in theory, methodology, application to enrich statistical methodology to help in policy planning and agenda implementation purposes.

This program shall extend over a period of two years. Each year denotes one academic year (July to June). In the first year, a student has to take two theoretical courses (a total of 2 units: 1 unit carries 100 marks) among the courses offered by the department as of his/her supervisor's approval. Pass marks in each of the courses is 50 per cent of the total marks allotted to each of the courses. Fail to do so will lead to discontinuation of the program. In the second year, a student has to write a dissertation which must be defended and be considered acceptable by the appropriate examination committee. For this purpose, three copies of the dissertation have to be submitted by a date that to be fixed by the department.

Year	Nature of Course	Unit	Marks	Credit
1	Theoretical	2	200	8
2	Dissertation Viva-voce			
Total				

Course No.	Title	Marks	Credit
Stat-601/701	Statistical Inference	100	4
Stat-602/702	Research Methodology	100	4
Stat-603/703	Econometrics and Time Series Analysis	100	4
Stat-604/704	Demography	100	4
Stat-605/705	Multivariate Analysis & Categorical Data Analysis	100	4
Stat-606/706	Design of Experiments	100	4
Stat-607/707	Epidemiology and Biostatistics	100	4
Stat-608/708	Sample surveys	100	4
Stat-609/709	Environmental Statistics	100	4
Stat-610/710	Quality Control & Industrial Statistics	100	4

Details of the course material follows:

Course Code	**STAT – 601/701**	**Credit**	**4.0**
Title	**Statistical Inference**		
Type	**Theory**	**Contract Hours**	**60 class hours**

Rationale:
Statistical inference consists in the use of statistics to draw conclusions about some unknown aspect of a population based on a random sample from that population. Some preliminary conclusions may be drawn by the use of EDA or by the computation of summary statistics as well, but formal statistical inference uses calculations based on probability theory to substantiate those conclusions. The aim of this course is to provide a strong mathematical and conceptual foundation in the methods of statistical inference, with an emphasis on practical aspects of the interpretation and communication of statistically based conclusions.

Course Objectives:

- To provide a strong mathematical and conceptual foundation in the methods of statistical inference based on frequentist approach.
- To introduce Bayesian approach for making statistical inferences.
- To discuss the Bayesian hypothesis testing problems and to induce the principle of decision theory based on Bayesian approach.
- To teach sampling techniques for drawing a sample from the posterior distribution.
- To emphasis statistical inference on practical aspects of the interpretation and communication of statistically based conclusions in real data applications.

Students Learning Outcomes

- The students will gain a deep knowledge about fundamental tools for statistical inference using frequentist approach and Bayesian approach.
- They can perform point estimation, hypothesis testing and interval estimation under a large variety of discrete and continuous probability models by using both frequentist and Bayesian approaches.
- Further, the students can evaluate the properties of these estimators and tests, for both finite sample sizes and asymptotically as the sample size tends to infinity.

Course Description
Probability Background: Probability and Measure, Family of Probability Measures, Integration, Stieltjesand Lebesgue Integrals, Borel Field (σ Field) in Extension of Probability Measure.

Estimation: Exponential Family Distributions, Convex Loss Function, Characterization of Sufficiency. Law of Equal Ignorance, Empirical Bayes Estimation Procedures, Minimax Principle, Principle of Invariance, Minimality and Admissibility in Exponential Families, Equivariance, Location Parameters, Principal of Equivariance, Location-Scale Families, Convergence in Probability and in Law, Large Sample Comparisons of Estimations, Trimmed Means, Methods of Estimation in Large Samples, Asymptotic Optimality, Asymptotic Efficiency, Asymptotic Efficiency of Bayes Estimators and Nonparametric Test Statistics.

Empirical Processes: Weak convergence and stochastic equicontinuity, stochastic equicontinuity via symmetrization and bracketing, Brownian motion and Brownian bridges, Gaussian Processes, Glivenko-Cantelli and Donsker theorems.

Theory of Hypothesis Testing: Tests Under Restricted Alternatives, Similar Region And Neyman Structure, Most Powerful Similar Region (Mpsr) Test, Uniformly Most Powerful Similar Region (Umpsr) Test, Asymptotic Efficiency of Test, Sequential Probability Ratio Test (Sprt) for three Hypotheses, Sobel and Wald Test, Lagrange Multiplier (Lm) Test, Test in Presence of Nuisance Parameters, Union-Intersection and Intersection-Union Test, Armitage Method for Composite Hypotheses, Sequential *T*, χ^2 and T^2 Test.

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Order Statistics in Statistical Inference: Types of Order Statistics, Order-Statistics and Sufficiency, Maximum-Likelihood Estimation, Linear Estimation of Location and Scale Parameter, Treatment of Outliers, the Problem of Outliers and Slippage Tests of Outliers, the Effect of Outlier Rejection on the Estimation of Parameters, Testing for Outliers from a Regression Model and in Patterned Data, Power of the Analysis of Variance Tests, Combination of Estimate, Combination of Tests, Test of Linear Hypothesis in Univariate and Multivariate Analysis when the Ratios of the Population Variance are Unknown, Application of the Method of Mixtures to Quadratcforms, Hodges-Lehmann Estimators.

Bayesian hypothesis testing: Credible interval, inference based on credible intervals, the Bayes factor, Bayesian versus frequentist hypothesis testing.

More than oneparameter: Joint versus marginal posterior inference, multivariate distributions, frequentist properties of Bayesian inference, Sampling from the posterior distribution: the method of composition, Bayesian linear regression model, Bayesian generalized linear models, more complex regression models.

Choosing the prior distribution: the sequential use of Bayes theorem, conjugate prior, Jeffrey's Prior, non informative prior distribution, informative prior distributions, prior distribution for regression models, modelling priors, other regression models.

Markov chain Monte Carlo sampling: the Gibbs sampler, the Metropolis (-Hastings) algorithm, justification of the MCMC approach, choice of the sampler, the Reversible Jump MCMC algorithm, Assessing and improving convergence of the Markov chain, Accelerating convergence, practical guidelines for assessing and accelerating convergence, data augmentation, Bayesian analysis by using WinBUGS and R.

Bayesian Tools for Statistical Modeling: hierarchical models, the Poisson-gamma hierarchical model, posterior predictive distributions, full Bayesian and empirical Bayesian approach, Gaussian hierarchical models, mixed models, the linear mixed model, the generalized linear mixed model, nonlinear mixed models, estimation of the random effects and posterior predictive distributions, choice of the level-2 variance prior, propriety of the posterior, assessing and accelerating convergence, comparison of Bayesian and frequentist hierarchical models.

Model building and assessment: Measures for model selection, the Bayes factor, information theoretic measures for model selection, model selection based on predictive loss functions, model checking, sensitivity analysis, posterior predictive checks.

Variable selection: classical variable selection vs Bayesian variable section, variable selection based on Zellner's g-prior, variable section based on Reversible Jump Markov chain Monte Carlo, spike and slab priors, stochanstic search variable selection, Gibbs variable selection, Baysian model selection, Bayesian model averaging.

Text:

1. Gorge, C. and Berger, R. L. (2003): *Statistical Inference*, 2nd edition, Thompson-Duxbury, USA.
2. Lesaffre, E.and Lawson, A. B. (2014): *Bayesian Biostatistics*, John Wiley and Sons Inc., New York

References

1. Lehman, E. L. and Cassela, G. (1998): *Theory of Point Estimation*, Springer Verlag, New York.
2. Lehman, E. L. (1997): *Testing Statistical Hypothesis*, 2nd edition, Springer Verlag, New York.
3. Rao, C. R. (1984): *Linear Statistical Inference and Its Application*, Wily Eastern, New Delhi.
4. Cox, D. R. and Hinkly, (1979): Theoretical Statisitcs, CRC Press.
5. Balakrishnan, N. and Cohen, A .C. (2014): *Order Statistics and Inference Estimation Methods*, Academic Boston,
6. Gibbons, J. D. and Chakraborti, S. (2011): *Non-Parametric Statistical Inference*, 5th Edition, McGraw-Hill,

Course Code	**STAT – 602/702**	**Credit**	**4.0**
Title	**Research Methodology**		
Type	**Theory**	**Contract Hours**	**60 class hours**

Rationale:

Progress and development in any field is linked with research and innovation. Research in every field specially in the field of education is imperative. Research methodology is taught as a supporting subject in several ways in many academic disciplines. A good researcher needs to have skills on both quantitative and qualitative research. Study of research methodology is essential for understanding and doing a valid research.

Course Objectives:

- To undertaking scientific research that aims at generating new knowledge.
- To carried out systematic approaches in any discipline of research.
- To gather sound knowledge of research methodology for understanding a valid research and able to conduct research.
- To arrive a firm decision in a coherent way.

Students Learning outcomes:

On completion of this course, students learning outcome will be:

- how to plan and conduct a survey research,
- able to determine appropriate sample size and prepare survey instruments,
- able to learn the concepts of research design,

- learn to control both sampling and non-sampling errors,
- how to monitor and evaluate development programs,
- able to write research proposal and research report,
- also able to present research findings.

Course Description

Research Design: Principal Components of Research Design, Objectives of the Study, Formulation of Hypothesis, Principal Findings of the Study; Source of Data, Comparative Analysis, Merits and Demerits of Different Sources of Data.

Sampling and Sample Size Determination, Design Effect, Type of Sampling Design Used for Bangladesh National Survey, Pilot Survey and the Purpose of Pilot Survey.

Sources of Errors in Surveys Sampling Errors and Non Sampling Errors, Rapid Methodology, Rapid Methodology Survey, its Scope Uses and Limitation; Lot Quality Sample Survey Method.

Different Parts of the Questionnaire, Guidelines to be followed for Preparing Questionnaires, Per-Coded Questionnaire. Difference between Closed Questionnaire and Open-Ended Questionnaire.

Formulating Hypothesis and Types of Hypotheses, Distinction between Research Hypothesis and Statistical Hypotheses.

Qualitative Data and its Importance, Different Methods of Qualitative Surveys Such as Focus Group and its, Importance in Health and Family Planning; Rapid Assessment Procedures, Qualitative Methodologies for Planning and Evaluation of Health Related Programs; Assessment Procedures for Nutrition and Primary Health Care, Anthropological Approaches to Improving Program Effectiveness Evaluation of Family Planning Program, Operations Research Hand its Scope and Limitations of Operation Research, Nonparametric Method in Analysis.

Test of Significance in Multivariate Analysis: Discriminate Function, MahalanobisD^2, Canonical Correlation.

Applied Regression Analysis: Logistic Regression Analysis, Cluster Analysis, Dummy Variables, Dependent and Independent Variables, Choice of Reference Category, Multicolinearityand Interpretation of the Regression Coefficients Writing a Report, what are Important Issues to be addressed while Writing Report.

Developing Research Proposal; what are the Important Components to be addressed in a Research Study; Knowledge Of Compute, Analysis Through SPSS, And Presentation By Multimedia.

Text:

1. Molhotra, N. K. (2006): Marketing Research, 4th Edition, Pearson education, Singapore.

References

1. Zikmund W. G., B. J. Carr, J. C. and Griffin, M. (2015): Business Research Method 9th edition, Harcourt College Publishers.
2. Babbie, E. (2013): The practice of Social Research 13th edition, Wads Worth, Cengage Learning
3. Copper, D. R. (1995): Business Research Method, 5th edition, Irwin/McGraw-Hill Company, New York.
4. Churchill, G. A. and Nielse, A. C., (1995): marketing Research Methodological Foundation, 6th edition, Harcourt Bruce College Publishers, New York.

Course Code	**STAT – 603/703**	**Credit**	**4.0**
Title	**Econometrics and Time Series Analysis**		
Type	**Theory**	**Contract Hours**	**60 class hours**

Rationale: The course focuses on the estimation, inference and identification of appropriateeconometric models. Besides these, here also discussed the issues and challenges of econometric models, how to interpret the results of these models, and apply Multivariate Analysis to Economic Data.This course will illustrate and equip students with different time series topics including ARCH models, Co-integration, Unit roots Analysis of Panel dataand forecasting techniques for analyzing real lifetime series data.

Course Objectives: The main objectives of this course are to:

- to present the Econometric research including specification of the model, Equation of the Model, Evaluation of the Parameter Estimates, Evaluation of the Forecasting Power of the Model, Desirable Properties of an Econometric Model, AIC, BIC and Other Criteria of Model Selection.
- to apply the multivariate analysis to economic data,
- to provide the basic knowledge of econometrics that is essential equipment for any serious economist or social scientist,
- to understand the main concepts of time Series theory and methods of analysis,
- to learn standard time series analysis topics such as modeling time series using regression analysis, univariate ARMA/ARIMA modeling, (G)ARCH modeling, Vector Autoregressive (VAR) model along with forecasting, model identification and diagnostics,
- evaluate the extent to which econometric methods can be used to determine whether a statistical association represents a causal relationship,
- use statistical software to apply allof these statistical techniques to analyze the relationship between real-world economic variables.

Course Description:

Methodology of Econometrics Research: Specification of the Model, Equation of the Model, Evaluation of the Parameter Estimates, Evaluation of the Forecasting Power of the Model, Desirable Properties of an Econometric Model, AIC, BIC and Other Criteria of Model Selection.

Application of Multivariate Analysis to Economic Data, Discriminatory Analysis, Principal Components, Canonical Correlation, Weighted Regression and Some Related Issues; Lack of Fit, Pure Error, Partial F-Test, Sequential F-Test Backward Elimination Procedure, Forward Selection Procedure, Stage-Wise Regression Procedure and Associated Tests, Models of Economic Growth: Requirement of Steady Growth, the Harrod Model, the Neo-Classical Model, Some Applications to Development Economics, DOMR's Growth Model, Suitability of the Models for Underdeveloped Countries, MahalanobisModel.

Limited and Qualitative Variables in Econometrics, Models under Rations Expectation Hypothesis, Models of Optimizing Agents, Forecastingwith a Single Equation Model, Forecasting with Multiple Equations Model.

Choice of Econometric Technique, Monte Carlo Studies, Ranking of Econometric Techniques According to the Properties of the Estimates of Structural and Reduced form Parameters.

ARCH models, Co-integration, Unit roots Analysis of Panel data.

Cointegration Analysis: Methods of Estimation of Single Equation: Engle-Granger Methods, System Methods: Triangular System, Johansen Procedure and Common Trends Representation, Identification Problem in Cointegration System, Cointegration and Granger-Causality Concept of Multicointegration and Polynomial Integration with Examples, Tests for Cointegration of Single Equation Residual Based Tests, Ecm Tests, Multiple Equation Methods: Johansen Tests.

Modeling Volatility: Economic Time Series, Arch Processes, Arch and Garch Estimates of Inflation, Garch Model of Ppi: Example, Garch Model Risk, Arch-M Model, Additional Properties of Garch Processes, Maximum Likelihood Estimation of Garch Models, Other Models of Conditional Variance, Estimating Nyse Composite Index.

Non-Linear Time-Series Models: Linear Versus Non-Linear Adjustment, Simple Extensions of Arma Model, Threshold Autoregressive Models, Extensions and Other Non-Linear Models, Testing for Non-Linearity, Estimates of Regime Switching Models, Generalized Impulse Responses and Forecasting, Unit Roots and Non-Linearity.

Text:

1. Johnston, J., and Dinardo (1997): Econometric Methods, 4th edition, McGraw-Hill.
2. Montogomery, D. C. Jennings, C. L. and Karlahci (2005): Introduction to time series analysis and forecasting, John Wily Press, New York.

References

1. Jutge, G. G., Hill, R. C., Griffins, W. E., LutKepohl, H. and Lee, T. C. (1988): Introduction to the Theory and Practical of Econometrics 2nd edition, John Wiley and sons, New York.
2. Greene, W. H. (2003): Econometric Analysis, 5th edition, Person.
3. Gujarati, D. (2003): Basic Econometrics, 4th edition, McGraw-Hill, New York.
4. Harris, R. and Robort, S. (2003): Applied time series modeling and forecasting, Replika Press, Indian.

Course Code	STAT – 604/704	Credit	4.0
Title	Demography		
Type	Theory	Contract Hours	60 class hours

Rationale:
Demography focuses on population phenomena and their relations with other population phenomena. This also reviews some of the latest developments in the large body of mathematical theory concerned with the growth processes of populations.

Course Objectives:
The objectives of this course are to:

- introduce Age-sex composition structure and Age heaping evaluation,
- construct a Lexis diagram,
- describe the relations and calculate indicators in a stationary population and stable populations,
- introduce population projection calculations and analysis,
- gather Knowledge about migration and urbanization,
- describe the distribution of a population using various demographic characteristics,
- demonstrate the different concepts of Micro demography like fecundity, fecundability and sterility.

Students Learning Outcomes:
By the end of the course students will perceive to:

- calculate a stable population, compute and analyze the basic features and measures of the associated population dynamics,
- carry out basic operations on matrices and vectors, and apply basic matrix algebra to population projection problems,
- appreciate specific issues in population projections,
- gather Knowledge about migration, urbanization and Nuptiality,
- familiar with different Mortality and Fertility models.

Course Description:
Population Research Program in Bangladesh, Population Policies and Population Control in Bangladesh, Health Policy in Bangladesh; Aging and aging Policy in Bangladesh, Use Effectiveness an Extended Use Effectiveness an Extended Use Effectiveness of Contraception, Measuring the Births Averted by Sterilization, Measuring the Impact of Family Planning Program on Fertility, Demographic Transition Theory; Momentum Effect, Tempo Effect, Population Stabilization In Bangladesh; Concept of Ideal and Desired Family Size, Measurement of Ideal and Desired Family Size, Family Formation in Bangladesh, Relation Between Family Size And Socio-Economic Conditions, Sex Preference Child and its Effect on Contraception; Effect of Infant and Under Five Mortality on the Desired Fertility, Urbanization and Internal Immigration; Effect of Rapid Urbanization on the Health of Urban Poor Model Life Tables and its Application in Developing Countries.

Parity Progression Ratios, Population Projections, Coales' Three Parameters Model and Trussell Method of Estimating the Mean Age at Marriage, Mortality Estimation by Intercensal Ratio, Brass Growth Balance Model for Measuring the Completeness of Death

Statistics, Evaluation of Birth and Death Registration for a Stable Population of Known Growth Rate, Estimating the Completeness of Death Registration from Inercensal Cohort Survival, Techniques for Correcting Age Distribution for Heaping on Multiples of Five and Graduation of Age Distribution by Sprague's Multiplier, Graduation, of Age Distribution by Brass Logit System and Method of Local Fitting Methods; Estimating Adult Mortality from Orphanhood, Widowhood and Eldest Surviving Children, Application of Relational GompertzModel in Estimation of Fertility.

Advocacy and its Importance; Gender Inequality and its Importance on Population Change; Domestic Violence and its Implications on the Health of Women; Adolescents Fertility and Implications on the Health of Adolescents; Nutrition and Factors Affecting it; Health Seeking Behavior of Women in Reproductive Ages and its Implications on Maternal and Child Health; Infant and Child Mortality Levels and Factors Affecting it; Maternal Mortality and Factors Affecting it.

Multiple Decrement Life Table and Estimation of Discontinuation of Family Planning Methods and its Implications on the Program.

Unmet Need for Contraception and its Implications in the Achievement of Demographic Goals.

Text:

1. Brass, W. (1968): *The demographic of Tropical Africa,* Princeton University Press,
2. Brass, W. (1975): *Methods of Estimating Fertility and Mortality from Defective and Limited Data*, University of North Carolina at Chapel Hill,

References

1. Keyfitz, N. (1968): Introduction to Mathematics of Demography, Population Reading Man, Addition Wesley, New York.
2. Pressat, R. (2008): The Dictionary of Demography, Blackwell, UK.
3. Pressat, R. (1974): A Work book in Demography, Methuen, London.
4. Population Council, *Journal ofStudies in Family Planning.*

Course Code	**STAT – 605/705**	**Credit**	**4.0**
Title	**Multivariate Analysis and Categorical Data Analysis**		
Type	**Theory**	**Contract Hours**	**60 class hours**

Rationale:

Multivariate analysis skills have been recognized as part of the key requisites for statistical analysts. The complexity of most phenomena in the real world requires an investigator to collect and analyze observations on many different variables instead of a single variable. The purpose of this course is to introduce various topics in multivariate analysis and to provide experience with well balancing three equally important elements: the mathematical theory; applications and interpretation to real data; and computational techniques in R/SAS.

Course Objectives:

- Develop a thorough understanding of theory and methods of multivariate data analysis.

- To implement visualization of multivariate data sets.
- To interpret the results and test the assumptions of multivariate data analysis.
- To understand academic research employing multivariate techniques.
- To tackle multivariate regression, MANOVA, data reduction and dimensionality reduction, classification, predictor and classifier instability problems in real data sets.
- Conduct basic and advanced multivariate statistics in R/SAS.

Students Learning Outcomes:

- To able to understand both the underlying mathematics and problems of applications in multivariate analysis.
- To summarize, interpret and carry out exploratory data analysis of multivariate data.
- To learn the fundamental grounding in the use of data reduction and dimensionality reduction techniques.
- To make appropriate classification and clustering in modeling the multivariate data.
- Implementation of multivariateanalysis using the R/SAS statistical software.
- Master basic techniques of reproducible research in multivariate analysis.

Course Description:

Theory of Distance and Its Application to Classification Problems: Objectives of Multivariate Analysis, Concept of Distance in Multivariate Analysis, Different Measures of Distance, Some Properties of Distance Function, Multivariate Normal Distribution, Assessing Assumptions of Multivarite Normality by Box-Cox Transformation, Detecting and Cleaning Outliers, Transformation of Multivariate Normal Observations to Near Multivariate Normal, Inference about Mean Vector, Hotteling T^2, Confidence Region, Conferring Methods of Multiple Comparison.

Analyzing Association among Variables: Measuring and Interpreting Association Especially between two Variables, Graphical Investigation of Many Associations, Correction of Correlation for Effects of Extraneous Variables, Measuring Association between two Sets of Variables, Testing Hypotheses about Sets of Associations, Test that all Population Correlations are Zero (Mutual Independence of all Variables), Test that all Population Canonical Correlations are Zero, Test that Some Population Canonical Correlations are Zero.

Two and Three-Way Contingency Tables: Log-Linear Models, Interpretation of Log-Linear Parameters, Choice of Model, Detection of Model Deviations, Log-Linear Hypotheses, Estimation, Testing Hypotheses.

Multi-Dimensional Contingency Tables: Log-Linear Models, Classification and Interpretation of Log-Linear Models, Choice of Model, Diagnostics, Model Search Strategies.

Analysis of Covariance Structure: Covariance Structure, Hypotheses about Covariance Structure, Model of Covariance Structure Analysis, Scope of Covariance Structural Analysis, Illustration of Likelihood Ratio Test, Illustration of Likelihood Ratio Test Procedures, Tests of Covariance Structure Based on Union-Intersection Principle, Illustration of Structural Analysis Based on Union-Intersection Principle, Sphericity Test, Advantages of Covariance Structure Analysis, Assumptions of Covariance Structure in Statistical Analysis, Estimation of Variance Components, Confirmatory Factor Aspect of Multivariate Analysis, Power of

Statistical Tests when Covariance Structure is Known, Tests for Broad Class of Covariance Structures, Bayesian Inference in Multivariate Regression, Multivariate Analysis of Covariance, Checking and Violation of Assumptions, Two-Way Multivariate Analysis of Variance (MANOVA), Profile Analysis, Repeated Measures with Growth Curves.

Generalized Linear Models (GLM): Exponential Family of Distributions and their Properties, Components of a Generalized Linear Model, Measuring the Goodness of Fit, Residuals, an Algorithm for Fitting Generalized Linear Models, Likelihood Inference for Glms, Link Functions, form of Posterior, Approximations, Gibbs Sampling Via Adaptive Rejection for Binary and Categorical Response Data, Latent Variable Models: Threshold Formulations, Probit Models, Discrete Choice Models, Logistic Regression and Generalizations, Data Augmentation Algorithms, Count Data: Poisson and Over-Dispersed Poisson and Log-Linear Models, Prior Distributions, Applications.

Bayesian Glms: General Setting, Examples, Priors for Glms, Markov Chain Monte Carlo Posterior Simulation Methods for Glms, Bayesian Residual Analysis and Model Choice.

Linear Mixed Models: Marginal Multivariate Model, Linear Mixed Model, Estimation and Inference for the Marginal Model, Inference for the Random Effects, Model Families in General

Likelihood-base Marginal Models: the Bahadur Model, Multivariate Probit Model, the Dale Model, Hybrid Marginal-conditional Specification, Mixed Marginal-conditional Model, Categorical Outcomes

Generalized Estimation Equation (GEE): Standard GEE Theory, Alternative GEE Methods, Prentice's GEE Method, Second-order Generalized Estimating Equation (GEE2), GEE with Odds Ratios and Alternative Logistic Regression, GEE2 Based on a Hybrid Marginal-conditional Model, Method Based on Linearization, Weighted GEE.

Generalized Linear Mixed Models (GLMM): Model Formulation, Bayesian Approach to Model Fitting, Maximum Likelihood Estimation, Empirical Bayes Estimation, Penalized Quasi-Likelihood (PQL), Marginal Quasi-Likelihood (MQL), Inference in Generalized Linear Mixed Models, Fitting GLMM with R and SAS.

Text:

1. Johnson, R. A. and Wichern, D. W. (2002): Applied Multivariate Statistical Analysis, 5th edition, Peasrson Education, Asia.
2. Agresti, A. (2002): Categorical Data Analysis, 2nd edition, John Wely, New York.
3. Molenberghs G. and Verbeke (2005): *Models for Discrete Longitudinal Data*, 2nd Ed, Springer.

References

1. Rao, C. R. (1962): *Advanced Statistical Methods in Biometric Research*, John Wiley,
2. Rao, C. R. (1984): *Linear Statistical Inference and Its Application*, 2nd edition, Wiley
3. Zhang F. K. and Ting, Y. (1990): *Generalized Multivariate Analysis*, Springer-Verlag.

4. Mardia, K. V., Kent, J. T. and Bibby, J. M. (1997): Multivariate Analysis, Academic Press, London.

Course Code	STAT – 606/706	Credit	4.0
Title	Design of Experiment		
Type	Theory	Contract Hours	60 class hours

Rationale:
This course is designed for the application of advanced Experimental design in different fields.

Course Objectives:
- To understand different experimental design both theoretical and practical.
- To use the appropriate experimental design based on study objective.
- To apply different experimental design in different fields.
- To analysis the data collected from different experiment.
- To interpret the results of the experiment and report the conclusions.

Students Learning Outcomes:
On completion of this course student will be able to:
- apply different factorial experiment in different field of application,
- choose appropriate experimental design techniques in context of the problems,
- perform formal statistical analysis of data obtain from different experimental design from a variety of discipline,
- interpret the results from the computer output of the different experiment design (Factorial, IBD, Nested and covariance analysis).

Course Description:
Review of Basic Designs, Row or Column Missing in R. B. and L. S. Designs, Basic Designs with Heterogeneous Error Variances, Analysis of Basic Designs when Usual Assumptions are Violated, Non-Orthogonal Designs, Incomplete Block Design, BIB Design with Recovery of Inter-Block Information, PBIB Design, Orthogonal Latin Squares with Construction of Latin Square Design, Weighing Design, Response Surface Design, Rotatable Design, Designs for Two-Way Elimination Of Heterogeneity, Row and Column Designs, Cross-Over Designs, Switch Over Design, Generally Balanced Design, Groups of Experiments, Repeated Measurement Designs, Stability Analysis, Factorial Experiments, Asymmetrical Factorial Experiments, Resolution Plans, Split-Split-Plot Designs, Split-Block Designs, Covariance Analysis with More than One Concomitant Variables, Bio-Assays, Nested Classification, Variance Component Analysis, Different Methods for the Estimation of Variance Components, Construction of Different Designs, Optimality of Designs.

Likelihood-base Marginal Models: Linear Mixed Model, Estimation and Inference for the Marginal Model, Inference for the Random Effects, Model Families in General, the Bahadur Model, Multivariate Probit Model, the Dale Model, Hybrid Marginal-conditional Specification, Mixed Marginal-conditional Model, Categorical Outcomes

Generalized Estimation Equation (GEE): Standard GEE Theory, Alternative GEE Methods, Prentice's GEE Method, Second-order Generalized Estimating Equation (GEE2),

GEE with Odds Ratios and Alternative Logistic Regression, GEE2 Based on a Hybrid Marginal-conditional Model, Method Based on Linearization, Weighted GEE.

Generalized Linear Mixed Models (GLMM): Model Formulation, Bayesian Approach to Model Fitting, Maximum Likelihood Estimation, Empirical Bayes Estimation, Penalized Quasi-Likelihood (PQL), Marginal Quasi-Likelihood (MQL), Inference in Generalized Linear Mixed Models, Fitting GLMM with R and SAS.

Text:

1. Montogomery, D. C. (2012): *Design and Analysis of Experiments*, 8th edition, John Wiley, New York.

References

1. Cochran, W. G. and Cox, G. M. (2000): *Experimental Designs*, 2nd edition, John Wiley, New Delhi.
2. Das, M. N. and Giri, N. C. (1997): *Design and Analysis of Experiment*s, 2nd edition, New Age International (P) Ltd., India.
3. Federer, W. T. (1967): *Experimental Design: Theory and Application*, Oxford and IBH, New Delhi.
4. Graybill, F. A. (1961): *An Introduction to Linear Statistical Models*, Vol. I, McGraw-Hill, New York.
5. John, P. W. (1971): *Statistical Design and Analysis of Experiments*, Wiley, New York.

Stat-607/707Epidemiology and Biostatistics

1 unit/4 credit (at least 50 - 60 class) 100 Marks

Course Code	**STAT – 607/707**	**Credit**	**4.0**
Title	**Epidemiology and Biostatistics**		
Type	**Theory**	**Contract Hours**	**60 class hours**

Rationale:

To learn the Bio statistical methods and to know the way of application of them to the Epidemiological studies having a clear concept.

Course Objectives:

The main objectives of this course are:

- to extractthe experimental data and make valid inferences with the application of statistical methods for the research areas of biology, genetics, public health, and medicine etc,
- prevention: protecting people; saving money by identifying the origin and causes of diseases that points out the cause of the outbreak and lead to interventions to prevent further cases of the diseases.

Students Learning Outcomes:

After the successful completion of the course, the students will be able to learn the:

- scope of Biostatistics and Epidemiologyin health-related fields including Medicine, Genetics, Public Health, Pharmacy etc.

- concepts of censoring; perceptions of different Bio-Statistical functions such as probability density function, survival function, hazard function etc. andlikelihood Functions for Censoring.
- inference process of survival distributions such as Exponential, Weibull, Extreme Value, Gamma, Lognormal etc.
- estimation of Survival Functions includingNon-parametric estimation using the Life Table Method, Product Limit Method etc; Comparison of survival distributions.
- types of epidemiological studies viz. case-control, cohort, cross sectional etc.
- disease frequency calculation such as calculation and interpretation of Incidence and Prevalence Rates, Risk ratio etc.
- measures of association, some concepts of prevention and screening tests such as tests of Sensitivity, Specificity etc.

Course Description:

Part I: Biostatistics

Basic Concept: The Proportional Hazards Model: Characteristics of the Semiparametric Model, Partial Likelihood for Data with and Without Ties, Building Multivariable Semiparametric Models, Hazard and Survival Function Estimation in Semiparametric Models, the Stratified Semiparametric Model, Diagnostics for the Cox Model: Residuals for the Semiparametric Proportional Hazards Model, Checking the Proportional Hazards Assumption, Looking for Outliers, Tracking Down Influential Observations.

Multivariate Survival Analysis: Parametric Proportional Hazards Models with Gamma Frailty: Introduction, Estimation for the Gamma Frailty Model, Maximizing the Marginal Likelihood: The Frequentist Approach, Extension of the Marginal Likelihood Approach to Interval-Censored Data, Posterior Densities: The Bayesian Approach, the Metropolis Algorithm in Practice for the Parametric Gamma Frailty Model, Theoretical Foundations of the Metropolis Algorithm.

Marginal Model for Multivariate Survival: The Fixed Effects Model, the Stratified Model, the Copula Model, the Conditional, Joint, and Population Survival Functions, the Clayton Copula, the Clayton Copula versus the Gamma Frailty Model. The Marginal Model, Consistency of Parameter Estimates from Marginal Model, Variance of Parameter Estimates Adjusted for Correlation Structure, Population Hazards from Conditional Models, Population versus Conditional Hazard from Frailty Models, Population versus Conditional Hazard Ratio from Frailty Models.

Part II: Epidemiology

Preliminary Concept: Cross Sectional, Cohort, Case-Control, Ecological Studies, Clinical Trials, Community Intervention and Cluster Randomized Trials, Longitudinal. Errors in Epidemiologic Research, Confounding Effect, Identifying Confounders, Confounding and Interaction, Controlling Confounding, Stratification, Standardization.

Brief Introduction about Ebola, Sti, Hiv/Aids, Diabetes, Mellitus, Tuberculosis, Diarrhea and Water Borne Diseases, Cardiovascular Disease, Cancer, Risk Factors and Prevention Strategy.

Modes of Transmission: The Sir Model: Introduction, the Basic Model Dynamics, the Basic Model in R, Vaccination in the Basic Model, the Basic Sir Model with Vaccination in R, the Critical Vaccination Coverage.

Modeling Infectious Diseases: Serological Data: Modeling for Hepatitis A, Model for Tuberculosis, Model Forhiv/Aids, a Mathematical Model for Hiv/Aids, a Statistical Model for the Initial Hiv/Aids Outbreak.

Estimating the Force of Infection: Age-Dependent Force of Infection, Modeling Issues, Parametric Approaches to Model the Prevalence and Force of Infection, Fractional Polynomial Models, B-Spline Model.

Texts

1. Duchateau L., and Janssen, P., (2002):*The Frailty Model,* Springer Science Plus Business Media, Llc
2. Hens, N., Shkedy Z., Aerts, M., Faes, C., Damme, P. V. and Beutels, P., (2012): *Modeling Infectious Disease Parameters Based on* Serological *and Social Contact Data*, Springer Science Plus Business Media New York.

References

1. Kenneth, J. and Rothman, S. G. (2008): *Modern Epidemiology*, 3rd Edition, Lippin Catt.
2. Lawless, J. F. (2011): *Statistical Models and Methods for Life Time Data*, 2nd Edition, Wiley Series, New York
3. Lee, E. T. (2003): *Statistical Methods for Survival Data Analysis*, 3rd Edition, Wiley Series, New York.

Course Code	**STAT- 608/708**	**Credit**	**4.0**
Title	**Environmental Statistics**		
Type	**Theory**	**Contract hour**	**60 class hours**

Rationale:

The environment is the perfect playground for statisticians. The natural world exists upon complex systems with natural variations that are full of uncertainty and randomness. Complex questions arise within all Earth's systems that need statisticians from diverse disciplines to tackle them. Statisticians can provide critical insight about the environment to help make our world a safer place.

Course Objectives:

The overall goal of this course is to provide students with a gentle introduction to the world of statistics in environment, ecology and conservation. The specific objectives are for students to:

- demonstrate the basic concepts of environment and its components,
- demonstrate broad understanding of the conceptual underpinnings of statistics in environment, ecology and conservation,
- demonstrate the environmental monitoring and sampling techniques,
- demonstrate the statistical methods of dealing with distribution pollutants.

Students Learning Outcomes:
Students completing the course will be able to:

- increase awareness about the environment and the basic concepts of the environment,
- develop knowledge on pollutants by type, source and their effects on environment,
- develop knowledge how to collect statistical data on various environmental elements,
- develop knowledge on statistical techniques to study distribution of pollutants and natural resources.hb

Course Description:

Outliers and Robustness: Outlier and Robustness, Aims and Objectives of Outlier, Importance of Outliers in Environmental Studies, Outlier-Generated Models, Multiple Outliers: Masking and Swamping, Accommodation: Outlier-Robust Methods, Multivariate Outliers, Detecting Multivariate Outliers, Tests of Discordancy, Robustness in General.

Environmental Monitoring and Sampling: Inaccessible and Sensitive Data, Encountered Data, Length-Biased or Size-Biased Sampling and Weighted Distributions, Composite Sampling, Ranked-Set Sampling.

Sampling in Wild: Quadrat Sampling, Recapture Sampling, Transect Sampling: Line Transects and Variable Circular Plots, Density Estimation Method for Line Transects, Random Sample of Transects, Systematic Selection of Transects, Detectability Functions of Transects, Adaptive Sampling.

Environmental Standards: Concept of Environmental Standards, Statistically Verifiable Ideal Standard (Svis), Guard Point Standards, Standards along Cause-Effect Chain.

Spatial Methods for Environmental Processes: Statistics for Spatial Data, Spatial Data and Spatial Models, Geostatistical Data: Spatial Data Analysis, Intrinsic Stationary, Stationary Process, Variogram, Covarigram and Correlogram, Estimation of Varigram, Comparison of Varigram and Covarogram Estimation, Exact Distribution Theory for the Variogram Estimator, Robust Estimation of the Variogram, Variogram Model Fitting.

Spatial Prediction and Kriging, Ordinary Kriging, Effect of Variogram Parameters on Kriging, Lognormal and Trans-Gausian Kriging, Cokriging, Robust Kriging, Universal Kriging, Median-Polish Kriging.

Environmental and Natural Resource Economics: Resources, Environment, and Economic Development, Measuring Growth Rates, Factors Essential to Economic Growth, Sustainable Development: Population and Sustainable Development, Agriculture and Sustainable Development, Energy and Sustainable Development, Sustainable Management for Natural Resources, Valuing the Environment: Cost-Benefit Analysis, Techniques of Valuation: Contingent Valuation, Demand-Side Methods, Supply-Side Methods.

Core Environmental and Metrological Issues: Land Use, Forestry, Soil Degradation, Water Resources, Air Pollution (Indoor and Outdoor) and its Effects on Health, Greenhouse Gases, Human Settlements, Bio Resources.

Text:

1. Barnett, V. (2004): Environmental Statistics: Methods and Applications, John Wiley and Sons, New York.

References

1. Bryan, F. J. (2000): Statistics for Environmental Science and Management, 1st edition, Chapman and Hall/CRC, Press.
2. Millard, S. P. and Neerchal, N. K. (2000): Environmental Statistics Using S-PLUS, Chapman and Hall/CRC press
3. Harris, M. J. (2002): Environment and Natural Resource Economics: A Contemporary Approach, Houghton Mifflin Company.
4. Rober, H. (1990): Spatial Data Analysis in the Social and Environmental Sciences, Cambridge University Press, Cambridge.

Course Code	**STAT- 610/710**	**Credit**	**4.0**
Title	**Quality Control and Applied Statistics**		
Type	**Theory**	**Contract hour**	**60 class hours**

Rationale:

Statistical quality control and Applied Statistics is one of the most important analytical developments available to manufacturing in this century.Statistical quality control provides close-up online views of what is happening to a process at a specific moment.

Course Objectives:

The specific objectives are for students to:

- provide the basic concepts of quality control with different methods and philosophy of SPC,
- provide broad understanding of different control charts for variables and attributes,
- demonstrate theProcess and Measurement System Capability Analysis,
- demonstratedifferentacceptance sampling methods including guidelines.

Students Learning Outcomes:

Students completing the course will be able to:

- apply different quality control tools to assess the quality of a process,

Course Descriptions:

Basic Principles of Quality Control: Meaning of Quality, Quality Improvement, Statistical Methods for Quality Control and Improvement.

Methods and Philosophy of SPC: Causes of Variation, Statistical Basis of the Control Chart: Basic Principles, Choice of Control Limits, Analysis of Patterns on Control Charts etc., Implementation and Application of SPC.

Control Charts for Variables: Control Charts: $\bar{x}, R$ and S, The Effect of Non Normality on $\bar{x}, R$ Charts, OC Function, the Average Run Length for the $\bar{x}$ Chart, the Shewhart Control Chart for Individual Measurements, Applications of These Charts.

Control Charts for Attributes: Development of Different Control Charts: for Fraction Nonconforming, for Nonconformities, the OC Function and the ASN Curve for These Charts.

Choice between Attribute and Variable Control Charts, Guidelines for Implementing Control Charts.

Process and Measurement System Capability Analysis: Process Capability Analysis Using Six-Pack, Using Histogram, a Probability Plot, Process Capability Ratios, Using Control Charts, Design of Experiments etc.

Tolerance Limits: Parametric and Nonparametric Limits.

Other Statistical Process Monitoring & Control Techniques:

The Exponentially Weighted Moving Average Control Chart, the Moving average Control Charts.

Acceptance Sampling:

Types, Lot Formation, Guidelines of Using Acceptance Sampling.

Single Sampling Plan: Designing of the Plan, the OC Curve, Rectifying Inspection etc.

Double, Multiple and Sequential Sampling Plan: Design of the Plans, the OcCurve, the ASN Curve etc.

The Dodge-Romig Sampling Plans: The AOQL Plans, LTPD Plans, Estimation of Process Average etc.

Other Acceptance Sampling Plans: Acceptance Sampling by Variables, Sequential Sampling by Variables, Chain Sampling etc.

Statistical Quality Control And Six-Sigma: 6σ Process Control and its Applications; 6σ Quality Assurance, Quality Management System; Quality Management Tools Used in 6σ, Six Steps to 6σ Control, Methods of 6σ Process: DMAIC (Duh-May-Ick), DMADV (Duh-Mad-Vec); Some Common Tools, Techniques and Unit of Measurements to Achieve 6σ: Cause and Effect Diagram also Known as a Fishbone Diagram, Cp/Cpk(Process Capability), DFSS-Design for Six Sigma, DMAIC - Define, Measure, Analyze, Improve, Control, Control Charts, DPMO - Defects Per Million Opportunities, DOE - Design of Experiments, PDCA – Plan do Check act, R &R Repeatability and Reproducibility, Tolerance Design, SPC - Statistical Process Controletc.

Text

1. Montgomery, D. C. (2008): *Introduction to Statistical Quality Control*, 6th edition, John Wiley and Sons, New York.

References

1. Banks, J. (1989): *Principles of Quality Control*, John Wiley and Sons, New York.
2. Burr, J. (2004): *Elementary Statistical Quality Control*, CRC Press.
3. Duncan, A. J. (1970): *Quality Control and Industrial Statistics*, 3rd edition, Richard D. Irwin, Homewood, Illinoy.
4. Gupta, S. C. and Kapoor, V. K. (2014), *Fundamentals of Applied Statistics*, Sultan Chand & Sons, New Delhi.
5. Grant, E. L. (1996): *Statistical Quality Control*, 7th edition, McGraw-Hill, New York.