COURSE CAPSULES

First Semester

ST 5101. Calculus and Matrix Algebra (2)
Preliminaries: Number system, Concept of sets, Intervals, Inequalities, Relations and functions, Types of functions. Trigonometry: Basic trigonometric identifies, Trigonometric functions and inverse functions, Additive formulas. Differentiation: Concept of limit, Concept of derivatives, Techniques of differentiation, Differentiation of algebraic, logarithmic, exponential and trigonometric functions, Determination of maxima and minima, partial derivatives, Total differential. Integration: Basic rules of integration, Definite integral, Application of integral calculus. Matrix algebra: Different forms of matrices, Matrix operations, Determinants, Conditions for non singularity, Matrix inverse, Solution of set of linear equations, Cramer's rule, Quadratic forms, Jacobian and Hessian determinants, Eigen vectors and Eigen values.

ST 5102. Basic Statistics (2)
Variability in observations, Frequency distributions and histograms, Stem and leaf and box plots, Population and sample, Probability structure and cumulative distribution functions, Expected values and moments, The family of normal distributions, Statistical inference, Point and interval estimation, Tests of hypothesis, Introduction to Analysis of variance (ANOVA), Linear regression and correlation, Estimation and tests on proportions, Contingency tables and test of associations.

Note: *Both ST 5101 and ST 5102 are prerequisite for all the courses listed below.*

ST 5103. Data Analysis Using Statistical Software (3)
Operation modes of statistical software, Special features with different modes, SAS and its basic features, Writing SAS programs, Creating SAS datasets and modifying created SAS datasets, Permanent SAS datasets, Advanced features in programming with SAS, Implementing common statistical methods using SAS, Analyzing unbalanced data.

Introduction to R statistical software, Basic features, Data input, Data management, Concurrent use of R with other software, Import data functions and foreign data types, Data exploration with R, Graphics using R, Descriptive statistics, Recoding variables and creating factors and new variables, Append and merging files, Implementing common statistical methods using R. Analyzing unbalanced data.

ST 5104. Sampling Techniques (2)
Scope of sampling, Probability and non–probability sampling, Multiple response techniques, Composite scales and reliability, Sampling theory, Sampling proportions, Simple random sampling, Stratified random sampling, Proportional allocation, Optimum allocation, Neyman allocation, Precision of estimates under different allocations, Ratio and regression estimators, Systematic sampling, Multi – stage sampling schemes, Cluster sampling, Spatial sampling, Sampling from animal populations (capture–recapture analysis), Adoptive sampling and their uses, Lot quality assurance sampling (LQAS).

ST 5105. Time Series Analysis (2)
Trend Analysis, Smoothing techniques (Moving averages, Weighted moving averages), Decomposition techniques, Seasonal adjustments, Stochastic process; Stationary process; white noise stochastic process, Markov Chain process. General Linear Process, Auto-covariance and autocorrelation functions, Estimation of Auto-covariance and Autocorrelation functions, Estimation of partial autocorrelation, Backshift operation notation, Stationary and inevitability conditions for a linear process, Autoregressive (AR) process, Moving average (MA) process, Auto-covariance generating function of AR and MA process, Stationary and inevitability conditions for AR and MA process, Mixed autoregressive moving average process (ARMA and ARIMA), ARCH and GARCH models, Diagnostic checking and forecasting, Fourier Analysis, Multivariate Time series.

Practical*: Analysis of large data sets with R.*

ST 5106. Computer Programming (2)
Fundamentals of computer programming, Concepts of structured programming: data types, expressions, loops, control structures, functions, arrays, input/output, running, testing, and debugging. UNIX and Linux operating systems, Programming in C, Object-oriented paradigm, Concepts of object-oriented programming: classes, objects, abstraction, encapsulation, inheritance and polymorphism, Java programming, R programming for statistical computing**.**

ST 5151. Statistical Theory (4)
Probability: Properties of random vectors, Conditional probability, independence. Discrete random variables; Probability mass functions and cumulative distributions. Some common discrete distributions, Continuous random variables: Expected values and moments, moment generating and characteristic functions, Marginal and conditional distributions, Bayes' Rule, Expectations and Central Limit Theorem, Sampling from the Normal distribution, Point and interval estimation, Test of Hypotheses: Simple and composite hypothesis, Maximum likelihood estimation, Generalized Likelihood Ratio Tests, Tests of means and variances.

ST 5152. Exploratory and Robust Data Analysis (2)
Basic data displays, The box-plot, The empirical cumulative distribution plot, Some comments on order statistics, Transformation of data, The symmetry plot and probability plotting, Data mining. Tests for normality, Review of some concepts of statistical theory, Least squares and weighted least squares estimation in the location model, Approximate variance of functions of random variables, Parameters and the estimation as functional, The influence curve, The general concepts of Robustness, Robust efficiency, L-estimators, M-estimators, The Monte Carlo method, The Bootstrap method. Comparing two or more groups of data: Exploratory, Classical inference and other forms of analysis, One way ANOVA, Transformation in one way ANOVA, The box-cox transformation, Robust estimation in the SL, Multiple linear and nonparametric regression.

ST 5153. Modeling Binary Data (2)
Experiments with binary outcomes, Distributions for binary data, Fitting distributions of binary data, Goodness of fit tests, Testing two proportions; Approximate tests and exact tests, Methods of parameter estimation for binary data, iteratively weighted least square and maximum likelihood estimates, Profile and conditional likelihood, Fitting models for binary data; logit and probit models, Strategies in model selection, Conditional logit model and exact inference, Overdispersion with binomial data, Random effects and mixed models, Quasi–likelihood methods, Generalized estimating equation method, Multilevel modeling, Mixed models for longitudinal data analysis, Multivariate binary data.

ST 5154. Statistical Genetics (2)
Genetic structures, Hardy-Weinberg equilibrium, Estimation of gene frequencies, Sex linked gene, Inheritance of quantitative characters, Covariance among relatives Coefficient of inbreeding, Estimation of genetic variance components, conventional crossing systems, Index selection, Genotype-environment interactions, DNA micro-array analysis, Mapping QTL.

ST 5155. Design and Analysis of Experiments (2)
Principles of experimental design, Completely randomized, Randomized Complete Block, and Latin square designs, Covariance analysis, Transformation of data, Factorial Experiments. Fixed effects and random effect models, Subsampling, nested factor designs, Confounding in 2^n factorial experiments, Fractional factorials (2^n), split-plot designs, Incomplete Block Designs, BIB and PBIB designs, Analysis of repeated measures.

ST 5198. Directed Study (5)

ST 5199. Seminar (1)

ST 6101. Vector Analysis (2)

Vector Algebra: Scalars and Vectors; Addition and multiplication by a scalar; Unit vectors; (i,j,k) Components of a vector; Linear dependence and independence; Scalar and vector fields; Scalar product of two vectors; $\underline{a}.\underline{b}$) Vector product of two vectors; ($\underline{a} \times \underline{b}$) Triple scalar and vector products; Solution to vector equations.

Vector Analysis: Ordinary derivative of a vector; Unit tangent vector and principal normal to a space curve; Partial derivatives of vectors; Differentials of vectors; Differential geometry and applications; Gradient, Divergence and curl operators; in rotational and solenoidal fields; Line, Surface and volume integrals, Stoke's theorem and Gauss' divergence theorem; Tensors and their fundamental operations.

ST 6102. Measure Theory (2)

Lebesgue measure on the real line and its properties; Abstract measure space and measurable functions; Lebesgue integral; Fatou's Lemma, the Monotone and Dominated Convergence Theorems; L^p-space; Models of convergence; convergence almost everywhere, convergence in norm and in measure; Signed measures; product measures and Fubini-Tonelli Theorems.

ST 6103. Group Theory (2)

Introduction to Groups, Cyclic Groups, Abelian Groups, Permutation Groups, Normal Subgroups, Factor Groups, Homomorphism and Isomorphism theorem on Groups, Class of Groups, Radicals and residuals, Action of Groups on sets, Semi-direct products, Series, Soluble Groups, Sylow theorems, p – Groups, and Nilpotent Groups.

ST6104. Graph Theory (3)

Introduction: Types of Graphs, Isomorphism of Graphs, Adjacency Matrix, Incidence Matrix, Paths and Cycles; Eulerian and Hamiltonian Graphs: Euler's Theorems and Properties of these Graphs; Applications : Shortest Path Problem, Chinese Postman Problem and Travelling Salesman Problem, Graph Coloring: Four Color Theorem, Timetable Scheduling and Planar Graphs, Trees: Spanning Trees, Kruskal's and Prims' Algorithms and Tree Searching, Line Graphs : Properties, Total Graphs, Block Graphs and Cutpoint Graphs, Directed Graphs: Isomorphisms and Applications, Menger's Theorems: Transversal Theory, (0, 1)- matrices and Network Flows, Infinite Graphs **:** Introduction and Examples.

ST 6151. Variance Component Estimation (2)

Pre-requisite*: ST5151 & ST 6201*

Mixed and random effect models, Properties of quadratic forms, Methods of variance components estimation; Henderson methods, MIVQUE, EM Algorithm, Maximum likelihood, Restricted maximum likelihood, Derivative free methods, Bayesian Estimation, Gibbs sampling, Emphasis on application and computing strategies.

PGD 5101. Basic Mathematics (2) ***prerequisite***

Preliminaries, Polynomials, Limits and concept of derivative, Rules of differentiation, Applications of derivatives, Integration, Matrix algebra.

PGD 5102. Basic Statistics (2) ***prerequisite***

Frequency distribution and histogram, Measurement of central tendency and dispersion, Stem and Leaf plots and Box plots, Expected value, Normal distribution, Statistical inference, Point and interval estimates, Concept of hypothesis testing, Test for means and variance, Analysis of variance.

PGD 5103. Experimental Techniques (2)

Principles of experimentation, Basic experimental designs, Factorial Experiments, Mean separation, Covariance analysis, Split-plot type designs, Incomplete block designs, Nested designs, Confounding in factorial experiments, Fractional factorials.

PGD 5104. Regression Analysis (2)

Simple linear regression, Correlation, Multiple regression, Test for goodness of fit, Heteroscedasticity and Autocorrelation, Model selection, Introduction to Non-linear regression.

PGD 5105. Sampling Techniques (2)
Population and sample, Simple random sampling, Stratified random sampling, Proportional allocation, Sample size determination, Cluster sampling, Systematic sampling, Multistage sampling, Nationwide surveys, Non-Probability sampling techniques

PGD 5106. Use of Statistical Software (2)
Introduction of different statistical software, Basic features of Minitab, SPSS and SAS, Data entry and Analysis using statistical software.

Second Semester

ST 5201. Advanced Calculus (2)
Determination of maxima and minima with two variables, Maclaurin and Taylor series, N^{th} derivative test for relative extremum. Indeterminate forms, Curve tracing, Advance integration techniques, Application of integration. Constrained optimization with Lagrange multipliers.

Differential equations of the 1st order; Definitions, formation of differential equations, particular integrals and complementary functions, methods of solution, Clairaut's equations, Orthogonal trajectories, Differential equation of higher orders: Linear equation with constant co-efficient, Linear differential operators, Simultaneous linear equations with constant coefficient., Elementary partial differential equations; Numerical solutions., Mathematical modeling for biological systems.

ST 5203. Regression Analysis (2)
Matrix approach to linear regression, Multiple linear regression; General Linear Models, Least Squares procedure, Inferences in regression, Model selection procedures, Analysis of residuals, Influence diagnostics, Detecting and combating multicollinearity, Nonstandard conditions, Violation of assumptions, Transformations. Non-linear regression; Non-linear least squares, Gauss-Newton procedure for finding estimates, other modifications of Gauss-Newton procedure.

ST 5204. Nonparametric Statistics (2)
Scales of measurements, Parametric vs. nonparametric statistics, One sample test: Sign test, Two sample tests: Wilcoxon Rank Sum and Wilcoxon Signed Rank, Multi sample tests: Kruskal-Wallis, Friedman, Aligned Rank and Durbin test for IBD, Rank correlations, Empirical cumulative distribution function, Kolmogrov and Smirnove one sample and two sample tests, Tests for Randomness, Randomization (permutation) tests, Introduction to nonparametric regression, LOWESS

Practicals: *Analysis of nonparametric data using SAS*.

ST 5205. Categorical Data Analysis (3)
Probability distributions for multi–category responses, Partitioning of χ^2 and G^2, Testing independence for nominal, ordinal two–way tables, Analysis of Multi–dimensional Tables and log–linear models, Parameter estimates from log–linear model, Log–linear models for ordered categorical data, Logit models for multinomial data, Logit models for ordered multinomial responses, Generalized estimating equation method for multinomial responses, Bayesian models for categorical data, Analysis of multi–response categorical data, Overdispersion with multi–category responses, Generalized linear mixed models for multinomial data

ST 5251. Statistical Methods for Analysis of Spatial Data (3)
Introduction to spatial data, Co-ordinate / projection systems, Raster data, Vector data, Dimensions of spatial data, Statistics and spatial data, Probability concepts related to remote sensing theories, Network data, Quantitative geometry of stream network. Problems of descriptive statistics for spatial data, Temporal analysis of spatial data, Processing of spatial data (image data), Enhancement techniques, Spatial sampling techniques,

Spatial data classification, Resampling techniques, errors of spatial data, Other applications statistical techniques for spatial data.

Practical: Use of Statistical and Spatial information system software, SAS, SPANS, GIS, ERDAS

ST 5252. Designs and Analysis of Epidemiological Studies and Clinical Trials (2)
Measuring risk factors, Intervention and observational studies, Response and assessment bias, Assessing diagnostic tests, Receiver operating characteristic plot of sensitivity and specificity, Designs for aetiological studies; cross sectional, cohort and case–control studies, Matched case–control studies, Clinical trial protocol and management, Design for clinical trials: Cross over trials, Parallel group trials, Cluster randomized trials and Equivalence trials. Meta–analysis of clinical trials, Models for data from observational and intervention studies, Confounding and interaction, Analysis of infectious disease and longitudinal data, Survival curve and survival curve estimation, Survival function and hazard functions, Models for survival data.

ST 5253. Crop Experimentation (1)
Selection of site, Size, shape and orientation of plots and blocks, Systematic spacing designs, Design and analysis of intercropping experiments, Use of control, choosing levels of a factor, Number of replications, Yield density models, Growth curves, Sequential and partial SS., Partial correlation, Experimentation with perennial crops.

ST 5254. Animal Experimentation (2)
Experimental units (large and small animals), Selection of animals for experimentation, Adaptation period, Preliminary and sample collection period, Carry over effects, herd %, year %, Seasonal effect, Covariates in animal experimentation, Lactation and growth curves Exercises using Statistical Analysis System (SAS).

ST 5255. Statistical Quality Control (2)
Introduction to statistical quality control and quality system, Basic quality tools, Statistical Process Control using Variable charts; X bar, S, R and MA charts. Attribute Charts; P, NP, C, U charts. Operating characteristic curve, Acceptance Sampling Plans by Attributes and Variables: single, double, multiple and sequential sampling plans (AOQL and LTPD plans). Capability and Reliability analysis using capability and performance indices. Practical exercises using MINITAB

ST 6201. Linear Models (3)
Matrix concepts, Distribution of quadratic forms, General Linear Models (Full rank); Estimation and Hypothesis testing, Less than full rank models, Methods to combat Multicollinearity; Ridge regression.

ST 6202. Multivariate Statistical Methods (3)
Pre-requisites*: ST 5155*
Aspects of multivariate analysis, Mean vectors and covariance matrices, Mean vector and covariance matrix for linear combinations, Marginal and conditional distributions, Expected values, Generalized variance, Multivariate normal distribution, Sampling distribution of $\bar{\mathbf{x}}$ and $\mathbf{S}$, Inference about $\bar{\mathbf{x}}$ and Hotelling's T^2, Confidence regions, Principal component analysis, Factor analysis and structured covariance matrices, LISREL models and path analysis, MANOVA, Canonical correlation analysis, Discriminant function analysis and classification, Cluster analysis and ordination, Multidimensional scaling, Correspondence analysis, Multivariate regression analysis.

ST 6203. Stochastic Processes (2)
Pre-requisite*: ST 5151*
Markov chains on discrete space in discrete and continuous time (random walks, Poisson processes, birth and death processes) and their long-term behavior. Branching processes, renewal theory, Brownian motion.

ST 6251. Statistical Computing (2)
Pre-requisite: *ST5151 & ST 6201*

R programming language. Numerical computations and algorithms with application in statistics; Solution of equations, Matrix Computations, Linear algebra applications, Numerical integration, Linear and nonlinear least squares and regression computations, random number generation, application of Monte Carlo methods in statistical research, Optimization methods; Newton- Raphson, Linear Search and Gradient Methods, Direct Search: Neider-Mead Simplex Algorithm, Gauss-Newton Algorithm, Levenberg-Marquard and other modifications of Gauss- Newton. Computations associated with estimation; EM Algorithm, Maximum Likelihood Estimation: N-R and Scoring, Robust Regression Computations, Re-sampling Methods: Bootstrapping.

ST 6253. Statistical Methods for Behavioural Sciences (2)
(only for students registered in the BS of Agric. Extension)
The role of statistics and other quantitative techniques in behavioural sciences; Data collection in behavioral science studies; Uniform, Binomial and Poisson distribution; Simple and multiple linear regression; Identifying direct and indirect relationships; Nonparametric procedures in behavioural sciences; Analysis of nominal data; Construction of indices; Grounded theory methods, Semiotic conversation analysis.
Practical exercises using SPSS.

ST 6254. Advanced Designs and Analysis of Experiments (2)
Pre-requisite*: ST 5155*
Incomplete Block Designs, Extended Block Designs, and modifications, Construction of designs (BIB and PBIB), Confounding and fractional factorials in 2^n, 3^n, and p^n experiments, Asymmetric factorials, Lattice designs, Unbalanced designs.

PGD 5201. Categorical Data Analysis (2)
Two-way table, Testing for goodness of fit and interdependence, Structural models for count data, Log linear models, Maximum likelihood and weighted least square estimation, Model selection, Residual Analysis.

PGD 5202. Nonparametric Statistics (2)
Scale of measurement, Rank correlation, other measures of associations in ranked data, Rank tests to compare two treatments, Tests to compare more than two treatments, Blocked comparisons.

PGD 5203. Multivariate Data Analysis (2)
Multivariate normal distribution, Variance and Covariance metrics, Principle component analysis, Factor analysis, Cluster analysis, Descriminant function analysis, Multivariate analysis of variance, Canonical correlation.

PGD 5204. Binary Data Analysis (2)
Binomial distribution, Odds ratio and relative risk, Testing two proportions, Logit and Probit models, Conditional logistic regression, Model diagnostics.

PGD 5205. Studies in Medical Research Investigations (2)
Sampling in clinical sciences, Sampling in epidemiological studies, Case control studies, Survival data analysis, Reference intervals, Analysis of mortality and population structure.

PGD 5206. Statistical Applications in Business (2)
Forecasting in business, Analysis of productivity and efficiency, Quality control, Conjoint analysis, Use of multivariate statistical methods in business.

PGD 5207. Special Topics (1)
(Special topics may vary from year to year). Suggested topics are: project analysis, linear programming, statistical analysis of genetic designs and epidemiological modeling.

PGD 5208. Seminar/Independent Study (2)