BIOSTATISTICS (BIOS)

BIOS 392. Undergraduate Internship. 1-3 Credits.
Academic credit for approved internship experience.

Rules & Requirements
Repeat Rules: May be repeated for credit. 6 total credits. 2 total completions.
Grading Status: Letter grade.

BIOS 396. Readings in Biostatistics. 1-12 Credits.
Directed readings or laboratory study. May be taken more than once. Two to six laboratory hours a week.

Rules & Requirements
Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.
Grading Status: Letter grade.

BIOS 500H. Introduction to Biostatistics. 3 Credits.
Access to SAS, Excel required. Permission of instructor for nonmajors. Introductory course in probability, data analysis, and statistical inference designed for B.S.P.H. biostatistics students. Topics include sampling, descriptive statistics, probability, confidence intervals, tests of hypotheses, chi-square distribution, 2-way tables, power, sample size, ANOVA, non-parametric tests, correlation, regression, survival analysis.

Rules & Requirements
Requisites: Prerequisite, MATH 231 and 232; corequisite, BIOS 511.
Grading Status: Letter grade.

BIOS 511. Introduction to Statistical Computing and Data Management. 4 Credits.
Required preparation, previous or concurrent course in applied statistics. Permission of instructor for nonmajors. Introduction to use of computers to process and analyze data, concepts and techniques of research data management, and use of statistical programming packages and interpretation. Focus is on use of SAS for data management and reporting.

Rules & Requirements
Grading Status: Letter grade.

BIOS 512. Data Science Basics. 3 Credits.
Students will gain proficiency with R, data wrangling, data quality control and cleaning, data visualization, exploratory data analysis, with an overall emphasis on the principles of good data science, particularly reproducible research. The course will also develop familiarity with several software tools for data science best practices, such as Git, Docker, Jupyter, and Nextflow.

Rules & Requirements
Requisites: Pre- or corequisite, BIOS 600 or 500H.
Grading Status: Letter grade.

BIOS 540. Problems in Biostatistics. 1-15 Credits.
Arrangements to be made with the faculty in each case. A course for students of public health who wish to make a study of some special problem in the statistics of the life sciences and public health. Honors version available.

Rules & Requirements
Repeat Rules: May be repeated for credit. 15 total credits. 4 total completions.
Grading Status: Letter grade.

BIOS 600. Principles of Statistical Inference. 3 Credits.
Required preparation, knowledge of basic descriptive statistics. Major topics include elementary probability theory, probability distributions, estimation, tests of hypotheses, chi-squared procedures, regression, and correlation.

Rules & Requirements
Grading Status: Letter grade.

BIOS 611. Introduction to Data Science. 4 Credits.
Topics will include gaining proficiency with R and Python, data wrangling, data quality control and cleaning, data visualization, exploratory data analysis, and introductory applied optimization, with an overall emphasis on the principles of good data science, particularly reproducible research. Some emphasis will be given to large data settings such as genomics or claims data. The course will also develop familiarity with software tools for data science best practices, such as Git, Docker, Jupyter, and Nextflow.

Rules & Requirements
Requisites: Prerequisites, MATH 232 and 416, and STOR 151.
Grading Status: Letter grade.

BIOS 635. Introduction to Machine Learning. 3 Credits.
This course will be an introductory course to machine learning. The goal is to equip students with knowledge of existing tools for data analysis and to get students prepared for more advanced courses in machine learning. This course is restricted to SPH Master of Public Health students.

Rules & Requirements
Requisites: Prerequisite, BIOS 512 or 650; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 641. Quantitative Methods for Health Care Professionals I. 4 Credits.
Course is designed to meet the needs of health care professionals to appraise the design and analysis of medical and health care studies and who intend to pursue academic research careers. Covers basics of statistical inference, analysis of variance, multiple regression, categorical data analysis. Previously offered as PUBH 741. Permission of instructor.

Rules & Requirements
Grading Status: Letter grade.

BIOS 642. Quantitative Methods for Health Care Professionals II. 4 Credits.
Continuation of BIOS 641. Main emphasis is on logistic regression; other topics include exploratory data analysis and survival analysis. Previously offered as PUBH 742.

Rules & Requirements
Requisites: Prerequisite, BIOS 641.
Grading Status: Letter grade.
BIOS 645. Principles of Experimental Analysis. 3 Credits.
Required preparation, basic familiarity with statistical software
(preferably SAS able to do multiple linear regression) and introductory
biostatistics, such as BIOS 600. Continuation of BIOS 600. Analysis of
experimental and observational data, including multiple regression and
analysis of variance and covariance. Previously offered as BIOS 545.
Permission of the instructor for nonmajors.

Rules & Requirements
Requisites: Prerequisites, BIOS 600 or SPHG 711.
Grading Status: Letter grade.

BIOS 650. Basic Elements of Probability and Statistical Inference I. 3
Credits.
Required preparation, two semesters of calculus (such as MATH 231,
232). Fundamentals of probability; discrete and continuous distributions;
functions of random variables; descriptive statistics; fundamentals of
statistical inference, including estimation and hypothesis testing.

Rules & Requirements
Grading Status: Letter grade.

BIOS 660. Probability and Statistical Inference I. 3 Credits.
Required preparation, three semesters of calculus (such as MATH 231,
232, 233). Introduction to probability; discrete and continuous random
variables; expectation theory; bivariate and multivariate distribution
theory; regression and correlation; linear functions of random variables;
test of sampling; introduction to estimation and hypothesis testing.
Students may not receive credit for both BIOS 660 and BIOS 672.

Rules & Requirements
Grading Status: Letter grade.

BIOS 661. Probability and Statistical Inference II. 3 Credits.
Distribution of functions of random variables; Helmert transformation
theory; central limit theorem and other asymptotic theory; estimation
theory; maximum likelihood methods; hypothesis testing; power;
Neyman-Pearson Theorem, likelihood ratio, score, and Wald tests;
noncentral distributions. Students may not receive credit for both
BIOS 661 and BIOS 673.

Rules & Requirements
Requisites: Prerequisite, BIOS 660; permission of the instructor
for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 662. Intermediate Statistical Methods. 4 Credits.
Principles of study design, descriptive statistics, sampling from finite
and infinite populations, inferences about location and scale. Both
distribution-free and parametric approaches are considered. Gaussian,
binomial, and Poisson models, one-way and two-way contingency tables.

Rules & Requirements
Requisites: Pre- or corequisites, BIOS 511 and 650.
Grading Status: Letter grade.

BIOS 663. Intermediate Linear Models. 4 Credits.
Required preparation, BIOS 662. Matrix-based treatment of regression,
one-way and two-way ANOVA, and ANCOVA, emphasizing the general
linear model and hypothesis, as well as diagnostics and model building.
Reviews matrix algebra. Includes statistical power for linear models and
binary response regression methods.

Rules & Requirements
Grading Status: Letter grade.

BIOS 664. Sample Survey Methodology. 4 Credits.
Fundamental principles and methods of sampling populations, with
emphasis on simple, random, stratified, and cluster sampling. Sample
weights, nonsampling error, and analysis of data from complex designs
are covered. Practical experience through participation in the design,
execution, and analysis of a sampling project.

Rules & Requirements
Requisites: Prerequisite, BIOS 650; permission of the instructor for
students lacking the prerequisite.
Grading Status: Letter grade.
Same as: STOR 358.

BIOS 665. Analysis of Categorical Data. 3 Credits.
Introduction to the analysis of categorized data: rates, ratios, and
proportions; relative risk and odds ratio; Cochran-Mantel-Haenszel
procedure; survivorship and life table methods; linear models for
categorical data. Applications in demography, epidemiology, and
medicine.

Rules & Requirements
Grading Status: Letter grade.

BIOS 666. Design of Public Health Studies. 3 Credits.
Statistical concepts in basic public health study designs: cross-sectional,
case-control, prospective, and experimental (including clinical trials).
Validity, measurement of response, sample size determination, matching
and random allocation methods.

Rules & Requirements
Requisites: Prerequisites, BIOS 645 and 650.
Grading Status: Letter grade.

BIOS 667. Applied Longitudinal Data Analysis. 3 Credits.
Analysis of variance and multiple linear regression course at the level of
BIOS 663 required. Familiarity with matrix algebra required. Univariate
and multivariate repeated measures ANOVA, GLM for longitudinal data,
linear mixed models. Estimation and inference, maximum and restricted
maximum likelihood, fixed and random effects.

Rules & Requirements
Grading Status: Letter grade.

BIOS 668. Design of Public Health Studies. 3 Credits.
Statistical concepts in basic public health study designs: cross-sectional,
case-control, prospective, and experimental (including clinical trials).
Validity, measurement of response, sample size determination, matching
and random allocation methods.

Rules & Requirements
Requisites: Prerequisites, BIOS 645 and 650.
Grading Status: Letter grade.

BIOS 669. Working with Data in a Public Health Research Setting. 3
Credits.
Provides a foundation and training for working with data from clinical
trials or research studies. Topics: issues in study design, collecting
quality data, using SAS and SQL to transform data, typical reports, data
closure and export, and working with big data.

Rules & Requirements
Requisites: Prerequisite, BIOS 511 or EPID 700; permission of the
instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 670. Demographic Techniques I. 3 Credits.
Source and interpretation of demographic data; rates and ratios,
standardization, complete and abridged life tables; estimation and
projection of fertility, mortality, migration, and population composition.

Rules & Requirements
Grading Status: Letter grade.
BIOS 672. Probability and Statistical Inference I. 4 Credits.
Required preparation, three semesters of calculus. Introduction to probability; discrete and continuous random variables; combinatorics; expectation; random sums, multivariate distributions; functions of random variables; theory of sampling; convergence of sequences, power series, types of convergence, L'Hopital's rule, differentiable functions, Lebesgue integration, Fubini's theorem, convergence theorems, complex variables, Laplace transforms, inversion formulas.

Rules & Requirements
Grading Status: Letter grade.

BIOS 673. Probability and Statistical Inference II. 4 Credits.
Distribution of functions of random variables; central limit theorem and other asymptotic theory; estimation theory; hypothesis testing; Neyman-Pearson Theorem, likelihood ratio, score, and Wald tests; noncentral distributions. Advanced problems in statistical inferences, including information inequality, best unbiased estimators, Bayes estimators, asymptotically efficient estimation, nonparametric estimation and tests, simultaneous confidence intervals.

Rules & Requirements
Requisites: Prerequisite, BIOS 660; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 680. Introductory Survivorship Analysis. 3 Credits.
Introduction to concepts and techniques used in the analysis of time to event data, including censoring, hazard rates, estimation of survival curves, regression techniques, applications to clinical trials.

Rules & Requirements
Requisites: Prerequisite, BIOS 661; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 690. Special Topics in Biostatistics. 1-3 Credits.
Field/topical/research seminar. Instructors use this course to offer instruction in particular topics or approaches.

Rules & Requirements
Repeat Rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 6 total completions.
Grading Status: Letter grade.

BIOS 691. Field Observations in Biostatistics. 1 Credits.
Field visits to, and evaluation of, major nonacademic biostatistical programs in the Research Triangle area. Field fee: $25.

Rules & Requirements
Grading Status: Letter grade.

BIOS 693H. Honors Research in Biostatistics. 3 Credits.
Directed research. Written and oral reports required.

Rules & Requirements
Grading Status: Letter grade.

BIOS 694H. Honors Research in Biostatistics. 3 Credits.
Directed research. Written and oral reports required.

Rules & Requirements
Grading Status: Letter grade.

BIOS 700. Research Skills in Biostatistics. 1 Credits.
Permission of the department for students with passing grade of either doctoral qualifying examination in biostatistics. BIOS 700 will introduce doctoral students in biostatistics to research skills necessary for writing a dissertation and for a career in research.

Rules & Requirements
Requisites: Prerequisites, BIOS 760, 761 or 758, 762, 763, and 767.
Grading Status: Letter grade.

BIOS 735. Statistical Computing - Basic Principles and Applications. 4 Credits.
Required preparation, one undergraduate-level programming class. Teaches important concepts and skills for statistical software development using case studies. After this course, students will have an understanding of the process of statistical software development, knowledge of existing resources for software development, and the ability to produce reliable and efficient statistical software.

Rules & Requirements
Requisites: Prerequisites, BIOS 660, 661, 662, and 663.
Grading Status: Letter grade.

BIOS 740. Specialized Methods in Health Statistics. 1-21 Credits.
Permission of the instructor. Statistical theory applied to special problem areas of timely importance in the life sciences and public health. Lectures, seminars, and/or laboratory work, according to the nature of the special area under study.

Rules & Requirements
Grading Status: Letter grade.

BIOS 745. Intercellular Signaling in Development and Disease. 1 Credits.
This graduate-level course concentrates on up-to-date views of intercellular signal processing, with emphasis on signal transduction mechanisms as they relate to cellular/physiological responses in both normal development and disease. Signaling mechanisms that will be discussed include autocrine, paracrine, juxtacrine signaling and cell-matrix interactions.

Rules & Requirements
Grading Status: Letter grade.

BIOS 752. Design and Analysis of Clinical Trials. 3 Credits.
This course will introduce the methods used in clinical. Topics include dose-finding trials, allocation to treatments in randomized trials, sample size calculation, interim monitoring, and non-inferiority trials.

Rules & Requirements
Requisites: Prerequisites, BIOS 600 and 661.
Grading Status: Letter grade.

BIOS 756. Advanced Nonparametric Methods in Biometric Research. 3 Credits.
Theory and application of nonparametric methods for various problems in statistical analysis. Includes procedures based on randomization, ranks and U-statistics. A knowledge of elementary computer programming is assumed.

Rules & Requirements
Requisites: Prerequisite, BIOS 661.
Grading Status: Letter grade.
BIOS 759. Applied Time Series Analysis. 3 Credits.
Topics include correlograms, periodograms, fast Fourier transforms, power spectra, cross-spectra, coherences, ARMA and transfer-function models, spectral-domain regression. Real and simulated data sets are discussed and analyzed using popular computer software packages.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; Permission of the instructor for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 760. Advanced Probability and Statistical Inference I. 4 Credits.
Measure space, sigma-field, measurable functions, integration, conditional probability, distribution functions, characteristic functions, convergence modes, SLLN, CLT, Cramer-Wold device, delta method, U-statistics, martingale central limit theorem, UMVUE, estimating function, MLE, Cramer-Rao lower bound, information bounds, LeCam's lemmas, consistency, efficiency, EM algorithm.

Rules & Requirements
Requisites: Prerequisite, BIOS 661; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 761. Advanced Probability and Statistical Inference II. 4 Credits.

Rules & Requirements
Requisites: Prerequisite, BIOS 760; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 762. Theory and Applications of Linear and Generalized Linear Models. 4 Credits.
Linear algebra, matrix decompositions, estimability, multivariate normal distributions, quadratic forms, Gauss-Markov theorem, hypothesis testing, experimental design, general likelihood theory and asymptotics, delta method, exponential families, generalized linear models for continuous and discrete data, categorical data, nuisance parameters, over-dispersion, multivariate linear model, generalized estimating equations, and regression diagnostics.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663, MATH 547, and 416 or 577; Co-requisite, BIOS 760.
Grading Status: Letter grade.

BIOS 764. Advanced Survey Sampling Methods. 3 Credits.
Continuation of BIOS 664 for advanced students: stratification, special designs, multistage sampling, cost studies, nonsampling errors, complex survey designs, employing auxiliary information, and other miscellaneous topics.

Rules & Requirements
Requisites: Prerequisite, BIOS 664.
Grading Status: Letter grade.

BIOS 765. Models and Methodology in Categorical Data. 3 Credits.
Theory and application of methods for categorical data including maximum likelihood, estimating equations and chi-square methods for large samples, and exact inference for small samples.

Rules & Requirements
Requisites: Prerequisites, BIOS 661, 663 and 665 or permission of instructor.
Grading Status: Letter grade.

BIOS 767. Longitudinal Data Analysis. 4 Credits.
Presents modern approaches to the analysis of longitudinal data. Topics include linear mixed effects models, generalized linear models for correlated data (including generalized estimating equations), computational issues and methods for fitting models, and dropout or other missing data.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 762; Permission of the instructor for nonmajors.
Grading Status: Letter grade.

BIOS 771. Demographic Techniques II. 3 Credits.
Required preparation, integral calculus. Life table techniques; methods of analysis when data are deficient; population projection methods; interrelations among demographic variables; migration analysis; uses of population models.

Rules & Requirements
Requisites: Prerequisite, BIOS 670.
Grading Status: Letter grade.

BIOS 772. Statistical Analysis of MRI Images. 3 Credits.
The course will review major statistical methods for the analysis of MRI and its applications in various studies.

Rules & Requirements
Grading Status: Letter grade.

BIOS 773. Statistical Analysis with Missing Data. 3 Credits.
Fundamental concepts, including classifications of missing data, missing covariate and/or response data in linear models, generalized linear models, longitudinal data models, and survival models. Maximum likelihood methods, multiple imputation, fully Bayesian methods, and weighted estimating equations. Focus on biomedical sciences case studies. Software packages include WinBUGS, SAS, and R.

Rules & Requirements
Requisites: Prerequisites, BIOS 761 and 762.
Grading Status: Letter grade.

BIOS 774. Statistical Learning and High Dimensional Data. 3 Credits.
Introductory overview of statistical learning methods and high-dimensional data analysis. Involves three major components: supervised or unsupervised learning methods, statistical learning theory, and statistical methods for high-dimensional data including variable selection and multiple testing. Real examples are used.

Rules & Requirements
Requisites: Prerequisite, BIOS 661; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.
BIOS 775. Statistical Methods in Diagnostic Medicine. 3 Credits.
Statistical concepts and techniques for evaluating medical diagnostic
tests and biomarkers for detecting disease. Measures for quantifying
test accuracy. Statistical procedures for estimating and comparing
these quantities, including regression modeling. Real data will be used to
illustrate the methods. Developments in recent literature will be covered.

Rules & Requirements
Requisites: Prerequisites, BIOS 761 and 762.
Grading Status: Letter grade.

BIOS 776. Causal Inference in Biomedical Research. 3 Credits.
This course will consider drawing inference about causal effects in a
variety of settings using the potential outcomes framework. Topics
covered include causal inference in randomized experiments and
observational studies, bounds and sensitivity analysis, propensity scores,
graphical models, and other areas.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; permission of the instructor
for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 777. Mathematical Models in Demography. 3 Credits.
Permission of the instructor. A detailed presentation of natality
models, including necessary mathematical methods, and applications;
deterministic and stochastic models for population growth, migration.

Rules & Requirements
Grading Status: Letter grade.

BIOS 779. Bayesian Statistics. 4 Credits.
Topics include Bayes' theorem, the likelihood principle, prior distributions,
posterior distributions, predictive distributions, Bayesian modeling,
informative prior elicitation, model comparisons, Bayesian diagnostic
methods, variable subset selection, and model uncertainty. Markov chain
Monte Carlo methods for computation are discussed in detail.

Rules & Requirements
Requisites: Prerequisite, BIOS 762; permission of the instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 780. Theory and Methods for Survival Analysis. 3 Credits.
Counting process-martingale theory, Kaplan-Meier estimator, weighted
log-rank statistics, Cox proportional hazards model, nonproportional
hazards models, multivariate failure time data.

Rules & Requirements
Requisites: Prerequisites, BIOS 760 and 761; permission of the instructor for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 781. Statistical Methods in Human Genetics. 4 Credits.
An introduction to statistical procedures in human genetics, Hardy-
Weinberg equilibrium, linkage analysis (including use of genetic software
packages), linkage disequilibrium and allelic association.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; permission of the instructor
for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 782. Statistical Methods in Genetic Association Studies. 3
Credits.
This course provides a comprehensive survey of the statistical methods
for the designs and analysis of genetic association studies, including
genome-wide association studies and next-generation sequencing
studies. The students will learn the theoretical justifications for the
methods as well as the skills to apply them to real studies.

Rules & Requirements
Requisites: Prerequisite, BIOS 760.
Grading Status: Letter grade.

BIOS 784. Introduction to Computational Biology. 3 Credits.
Molecular biology, sequence alignment, sequence motifs identification by
Monte Carlo Bayesian approaches, dynamic programming, hidden Markov
models, computational algorithms, statistical software, high-throughput
sequencing data and its application in computational biology.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 and 663; Permission of the instructor
for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 791. Empirical Processes and Semiparametric Inference. 3
Credits.
Theory and applications of empirical process methods to semiparametric
estimation and inference for statistical models with both finite and
infinite dimensional parameters. Topics include bootstrap, Z-estimators,
M-estimators, semiparametric efficiency.

Rules & Requirements
Requisites: Prerequisites, BIOS 661 or 673, and 663; Permission of the
instructor for students lacking the prerequisite.
Grading Status: Letter grade.

BIOS 841. Principles of Statistical Collaboration and Leadership. 3
Credits.
An introduction to the statistical collaborative process and leadership
skills. Emphasized topics include problem solving, study design, data
analysis, ethical conduct, teamwork, career paths, data management,
written and oral communication with scientists and collaborators.

Rules & Requirements
Grading Status: Letter grade.
BIOS 842. Practice in Statistical Consulting. 1-21 Credits.
Under supervision of a faculty member, the student interacts with
research workers in the health sciences, learning to abstract the
statistical aspects of substantive problems, to provide appropriate
technical assistance, and to communicate statistical results.

Rules & Requirements
Requisites: Prerequisites, BIOS 511, 645, 650, and 841; Permission of the
instructor for students lacking the prerequisites.
Grading Status: Letter grade.

BIOS 843. Seminar in Biostatistics. 1 Credits.
This seminar course is intended to give students exposure to cutting
edge research topics and hopefully help them in their choice of a thesis
topic. It also allows the student to meet and learn from major researchers
in the field.

Rules & Requirements
Repeat Rules: May be repeated for credit.
Grading Status: Letter grade.

BIOS 844. Leadership in Biostatistics. 3 Credits.
Using lectures and group exercises, students are taught where and how
biostatisticians can offer leadership in both academic and nonacademic
public health settings.

Rules & Requirements
Requisites: Prerequisite, BIOS 841.
Grading Status: Letter grade.

BIOS 850. Training in Statistical Teaching in the Health Sciences. 1-21
Credits.
Required preparation, a minimum of one year of graduate work in
statistics. Principles of statistical pedagogy. Students assist with
teaching elementary statistics to students in the health sciences.
Students work under the supervision of the faculty, with whom they have
regular discussions of methods, content, and evaluation of performance.

Rules & Requirements
Grading Status: Letter grade.

BIOS 889. Research Seminar in Biostatistics. 0.5-21 Credits.
Permission of the instructor. Seminar on new research developments in
selected biostatistical topics.

Rules & Requirements
Grading Status: Letter grade.

BIOS 990. Research in Biostatistics. 1-21 Credits.
Individual arrangements may be made by the advanced student to
spend part or all of his or her time in supervised investigation of selected
problems in statistics.

Rules & Requirements
Grading Status: Letter grade.

BIOS 992. Master's (Non-Thesis). 3 Credits.
Rules & Requirements
Repeat Rules: May be repeated for credit.

BIOS 994. Doctoral Research and Dissertation. 3 Credits.
Rules & Requirements
Repeat Rules: May be repeated for credit.